Knowledge Production through the Process of Digital Reconstruction: Simulation of Greek Neolithic Space

by

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To my mother
&
To the memory of
my grandfather
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Archaeological research and practice is based on a paradox; the excavated three-dimensional data are transformed into two-dimensional representations in an attempt to create a sustainable record, which will act as a reference back to the process of excavation. These two-dimensional products, which carry interpretations, ambiguities and contradictions are restored to three-dimensional information, and are utilised in computer graphic simulations in an attempt to visualise, research and understand past experiences, attitudes and structures. This thesis examines the variable and dialectic processes among excavation, recording, perception, interpretation and simulation in order to understand how knowledge is produced in any project that aims to model three-dimensional aspects of the past.

Koutroulou Magoula, a distinctive Middle Neolithic tell site in Phthiotida, Greece, provides a case study to problematise the process of reconstruction and contributes a novel three-dimensional approach to the study of Greek Neolithic space.

The contributions of this thesis are:

- The examination and analysis of the concept of three-dimensionality through the different stages of knowledge production in the archaeological process.

- The enhanced understanding of knowledge production in computer graphic simulations through the analysis of the modelling process.

- The evaluation of 3D modelling as a means to augment three-dimensional understandings of Greek Neolithic spaces.
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List of Accompanying Materials

A DVD with a PDF file of the thesis.
Declaration of Authorship

I, Konstantinos Papadopoulos

declare that the thesis entitled

*Knowledge Production through the Process of Digital Reconstruction:
Simulation of Greek Neolithic Space*

and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

this work was done wholly or mainly while in candidature for a research degree at this University;

where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

where I have consulted the published work of others, this is always clearly attributed;

where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

I have acknowledged all main sources of help;

where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

none of this work has been published before submission.

Signed: ........................................................................................................

Date: 11th April 2014

Signed: ........................................................................................................
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Introduction

Reconstruction and the Paradox of the Archaeological Process

Digital reconstructions\(^1\) play an integral role in the interpretation of archaeological datasets, and three-dimensional modelling as a process\(^2\) can provide a fertile field for discussing the influence that it has in the understanding of the past. Computer graphic simulation projects, including the author’s own (Papadopoulos and Earl 2009, Papadopoulos 2010, Papadopoulos and Earl 2013, Papadopoulos and Sakellarakis 2013), have only acknowledged the issues related to the origins of these products, their biases, perceptual leaps, as well as the diverse ways that interpretations are formed and negotiated. Failing to further investigate and critically evaluate the actual constraints that affect the process of reconstruction, which have their roots in various often neglected perceptual, physiological and technical factors, leads to research outcomes being undervalued and the production of a limited reflection of the past. The complexity of the archaeological project, a product of historical processes and of excavation, is increased by the ways archaeologists approach excavation itself, the recording mechanisms employed and the methods used to organise the documentation. These factors transform the material world as it is experienced, flattening both the qualities of three-dimensional space and archaeological chronotopes\(^3\), therefore affecting the process of reconstruction.

\(^1\) The term ‘reconstruction’ and in the case of computer graphics ‘digital reconstruction’, implies an attempt to revive the past. However, such attempts can never be accurate, as they comprise interpretations of past reality in the present, which encompass different sociocultural agendas (also see footnote 3). In both cases the result is a simulation of the past, via a new construction. Therefore, the use of the terms ‘digital construction’ or ‘(re)construction’ and ‘computer graphic simulation’ are preferable in this context. The argument that the term ‘reconstruction’ is misleading and should be abandoned is not new, as it was described by Taylor in 1948 and 1972 and came to the forefront recently in Clark’s paper *The Fallacy of Reconstruction* (2010). The problem of this terminology has also been briefly discussed by Papadopoulos and Kefalaki (2010), where they proposed the term virtual construction as the most appropriate. In the course of this thesis, the proposed terms will be used interchangeably, while the term ‘process of reconstruction’ and its derivatives will be used to describe a series of theoretical approaches, methods and techniques that aim to produce a computer graphic simulation of the past.

\(^2\) The term modelling process (or process of reconstruction) does not only refer to the construction of 3D models within a 3D graphics software package. As the noun process indicates, a series of interrelated actions that lead to an end, i.e. the production of 3D models, are involved. Therefore, the term regards the whole procedure of gathering, recording and evaluating archaeological evidence, and then, at the last stage converting them into three-dimensional models. All stages involved are of equal importance and merit careful consideration and assessment.

\(^3\) The term chronotope has been coined by Mikhail Mikhailovich Bakhtin, a Russian philosopher and novelist, in his *The Dialogic Imagination* (1982) to define the ways that time (from the Greek word chronos) and space (from the Greek word topos) are described in literature. Archaeology explores a palimpsest of chronotopes; although archaeologists are primarily interested in the time and space of the initial destruction and deposition, our work involves not only the chronotope of the past, but also the chronotopes of present and future. Archaeological remains are translated into different chronotopes, both at the moment of excavation (present) and the study, presentation, simulation etc. of the excavated material (future), incorporating...
Working as a field archaeologist for a decade, also studying archaeological material to produce three-dimensional computer graphic simulations, I came to realise that our work is primarily based on a paradox. Although the real world is three-dimensional, in archaeology we perceive reality as two-dimensional. This is because archaeological reality is turned into a two-dimensional production by the conventional recording mechanisms employed, attempting to preserve the excavated information, to create a sustainable record which will act as a reference back to the process of excavation and assist directors and team members to write reports and make the final publication. In turn, these two-dimensional records have to be restored to their three-dimensional qualities – either verbally or visually – in order to be used in any research, analysis, presentation or methodological approach. Therefore, the paradox that I am writing about is the fact that the material world is flattened by the various methodologies employed, while as 3D visualisation specialists, we have to rely on the products of this paradox to produce three-dimensional simulations and understandings of the past. This transformation of evidence from one form to another is problematic, since we lack both the tools and the knowledge (or awareness), which could help to minimise the loss of data and/or the inflow of information that might have never existed.

The process of excavation produces a record of both finds and their relationships in space and time, which however, is by definition biased due to different excavation strategies, theoretical backgrounds, recording procedures and interpretive leaps (see for example Tilley 1989; Gero 1996; Hodder 1999b; Andrews et al. 2000). However, barely any research focusing on the visualisation and simulation of the past has considered the great range of variables in the various stages of production. How do different excavation methods, archaeologists and ways of recording affect the understanding of the evidence? To what extent do the various recording methods manage to accurately capture the three-dimensionality of archaeological reality by using established conventions? How is the perception of three-dimensional data influenced by established practices? To what extent do individuals' perceptual capacities affect their understandings? Do technological constraints impinge the recording and reproduction of information? And finally, how do all these parameters affect the process of visualisation? In other words, where does our knowledge of a particular site come from? Is the visualisation of an archaeological site the result of a thorough and rigid process, or is the evidence gradually altered in the various stages

multiple levels of complexity highly depending on the conditions, people and methods involved. The different parameters that contribute to the formation of archaeological chronotopes are interdependent and the outcomes vary in different spatial, temporal and cultural contexts making their decipherment a difficult and sometimes impossible task. These chronotopes interpenetrate the material evidence, therefore obscuring the traces of past and present, subjective and pseudo-objective and a series of other antitheses that come together in archaeological practice. In this context therefore, it is important to analyse the construction of archaeological chronotopes and fully comprehend how the various parameters, influence the computer graphic simulation of the Neolithic past.
of visualisation resulting in erroneous perceptions, and consequently flawed transformations of the past? (fig. 1).

Summarising the former, the purpose of this PhD thesis is: 1) To understand and consequently analyse how different strategies and procedures affect the production of archaeological knowledge and the depiction of three-dimensionality throughout the process of digital reconstruction; and 2) To assess to what extent this process enhances understandings and enables the production of new knowledge about Greek Neolithic space. In order to do this, Koutroulou Magoula in Phthiotida, a distinctive case study from the Greek Neolithic has been chosen, which offers great potential in this context.
Fig. 1 A diagram showing the multiple levels of complexity in the process of 3D visualisation (image author’s own).
The Case Study and Archaeological Comparators

Koutroulou Magoula, located in central Greece, is an excavation that was started in 2001 by the Greek Archaeological Service, and is still in progress in collaboration with the University of Southampton. It is a remarkably well-preserved Middle Neolithic tell site, consisting of several houses and areas related to domestic activities. The excavation is ongoing, and I have participated in the last three years in the whole process of knowledge production, a crucial factor for the interpretation and understanding of the site. Numerous supervising archaeologists have worked in the project, employing variations of the established recording system, mixed with individual styles of writing and perceiving the archaeological information; this has resulted in the creation of a diverse record. The latter makes to some extent, the unification of data a difficult task, especially after the introduction of Single Context System (Westman 1994) by the team from the University of Southampton.

Koutroulou Magoula is an ongoing project; as such, it provides the chance to follow from the beginning its excavation and the recording methods, to get in touch with the various people that worked, and are still working on the assemblage, and collaborate with the experts and the directors to form a reflexive visualisation and multivocal visual interpretation. My participation in this project ensured that the process of reconstruction was informed by the input of both the evidence and the scholars involved, and that the resulting computer graphic simulations could provide insights into the biases that field practice and its components bring to the record and its interpretations. Modelling the site in three dimensions allowed the evaluation of the impact of the modelling process on me (the modeller) and on my understanding of Neolithic space. Moreover, the process and the outcomes were presented to the members of the project and the students who have participated in recent years in order to canvass their responses regarding the use of 3D visualisations as heuristic sources and scientific tools in archaeological reasoning. Besides, their comments and ideas were used to produce additional 3D models and discuss to what extent the visual stimuli augmented their understanding of Neolithic space and its three-dimensionality.

In addition to Koutroulou Magoula, textual and visual evidence from other Neolithic sites, and especially from Makriyalos in Pieria, a unique Neolithic flat-extended settlement, are used as reference points for comparative purposes in order to highlight the diversity of the methods employed and the records resulted, and consequently the distinctiveness of the knowledge produced from these. Makriyalos, in northern Greece, a site that cannot be revisited, is one of the first identified, thoroughly excavated, documented, studied and published flat-extended settlements in Greece. Makriyalos is
quite a distinctive case; on the one hand, its rescue excavation, carried out in the 1990s, facilitated the preservation by record of a significant part of it, since the site does not exist anymore. Although only 6 out of 50 hectares were investigated, the quantity and quality of information revealed for such a site provided insights regarding both the formation and organisation of a Neolithic extended settlement. On the other hand, the scale and speed of excavation, along with the participation of a great number of supervising archaeologists, specialists and workers, posed several issues regarding the excavation itself, the recording strategies employed and the knowledge produced. Moreover, the fact that access to this material has been granted by the Greek Ministry of Culture and the excavator, provided the chance to thoroughly study the site and the related evidence, making it an ideal comparative source. For the above reasons, the incorporation of particular examples from its textual and visual records was deemed necessary in order to augment the discussion about the records and the methods of recording and excavation, as well as the mechanisms of perception, and highlight the uniqueness of each case study and the diversity of knowledge production in the process of digital reconstruction.

Aims and Objectives of the Thesis

This thesis will not compose the biography of a Neolithic site based on the stories derived from its excavation, recording, interpretation and simulation. The concept of sites’ and objects’ biographies has been well-covered in the related literature in the last twenty years within a series of different processual and post-processual approaches (see for example Shanks 1998; Schiffer and Miller 1999; Tilley 1999; Gosden and Marshall 1999). As Holtorf (2002) has vividly shown in his work about the life history of a pot sherd, an object comes to life at the moment of its exposure and its history starts to be written afterwards. Although this research follows the story of a Neolithic site as being projected from the study of field notes, the actual material, the publications, the people involved in the project and their ideas, the aim is not to record that course as an end in itself. This research project, by adding one more layer to the palimpsest of information for this site in the form of computer graphic simulations, attempts to create a mise-en-abîme and discuss the problems and perspectives of the process of three-dimensional modelling and its products, which incorporate the stories derived from all stages of knowledge production.

Architecture, town planning and the establishment of settlements are of major importance in the study of human behaviour and social organisation, and are a means through which humans organise and structure their public and private space, and shape and renegotiate social roles and order. This is valid particularly for the Neolithic
period, which corresponds to people’s first attempts for sedentary habitation and extensive shaping of the surrounding landscape. However, most of the research completed to date has approached Neolithic architecture, and the organisation of space and human interaction within it, through the use of conventional means, such as drawings, photographs and two-dimensional plans. Each one of these has certain drawbacks regarding the depiction and understanding of Neolithic life, and the way that the knowledge of the past is produced, therefore failing to consider fundamental elements that might have influenced perception and human behaviour. With the above in mind, this project also contributes a three-dimensional perspective to the study of Neolithic structures by deconstructing the process of reconstruction and incorporating a reflexive and multivocal approach in the interpretation of Neolithic space.

Knowledge Production: Processes, Definitions and Problems

Aspects of this research resemble Roveland’s work (2006) in Pennworthmoor 1. By drawing on a Neolithic dataset and its archives, and also using examples from another Neolithic site, I certainly had to critique archaeological practice and archaeologists. Although this may sound reasonable, criticising others work in a Greek context, even if criticism is constructive, is rarely welcome. The study of field notes reveals mistakes and omissions, which are not obvious in the often censored excavation reports and publications. Although the problems we experience when excavating, recording and interpreting the data are known, we hush. When the results become public, everything should be neat, non-ambiguous and without errors. I was recently criticised (Bonney-Miller 2011), because in the results of my research for the Minoan cemetery at Phourni, Crete (Papadopoulos 2010), I admitted that because of the various issues posed by the data and the methodologies employed, my interpretations are open to discussion. Working as a field archaeologist, and realising this attitude, even by people who are on principle against it, I started questioning my own practice as well. My participation at the excavation at Koutroulou Magoula, gave me the chance to criticise not only the previous work of others, but also myself, and reflect on my excavation strategies, choices and recording methods, and discuss how established and to a great extent black boxed practices (Latour 1999; Lucas 2012: 239), pose limitations to the understanding and preservation of data.

At the core of this thesis is the process of knowledge production. In this context however, the use of the word knowledge does not go beyond its usual meaning. Therefore, knowledge of something means that through perception, memory, consciousness and reason (Audi 2002: 71-94), a theoretical and/or practical understanding of a subject is acquired. It is out of the scope of this research to
philosophically define the word knowledge or refer to epistemological debates regarding the types and nature of knowledge (see for example the debate over innate and acquired knowledge – Mackie 1969; Chomsky 1966; Skinner 1957; and, rational and empirical knowledge – Reichenbach 1948; Kenny 1986; for a thorough coverage of the theory of knowledge see Moser 2002), since such a discussion would have drifted the focus of the thesis to the philosophical nature of knowledge production, which will not be examined in this context.

There are several different types of knowledge, some of which marginally vary, as well as different words to define the properties of knowledge. Although such a consideration falls beyond the scope of this thesis, there are two particular types which need to be taken into account: explicit and tacit knowledge (see for example Hildreth and Kimble 2002; also see Polanyi 1967; Nonaka 1991). Explicit is the knowledge which can be communicated and shared, since it has been articulated in forms that can be easily understood. This type of knowledge is often found in academic contexts in the form of argumentations. On the other hand, tacit knowledge is less structured and formalised and therefore difficult to be expressed or transferred to other people. This type of knowledge is usually in forms, such as ideas, beliefs, values, as well as know-hows, which have been learnt by experience. In archaeology, both types are apparent; for example, the way that a Neolithic house was built is an explicit knowledge acquired from textual descriptions and visual information. However, building a Neolithic house is tacit, since this has not been learnt by any articulated forms, and experiences do not usually help towards this matter. Tacit is also the modelling of a Neolithic house in a computer graphics software, since the principles of its construction cannot be easily communicated to others without previous knowledge or experience. Both explicit and tacit knowledge are evident in this thesis; however, their boundaries often become blurry.

The production of knowledge in archaeology, is a complicated subject which wavers between the objective truth/facts recovered by authoritative agents (Kruglanski 1989; Raviv et al. 2003), i.e. archaeologists, and the situated, socially contingent knowledge, where the ‘facts’ are produced as a result of choices, actions, relations and negotiations (Latour and Woolgar 1986; Latour 1988; Pickering 1995; Law 1992, 1999, 2000). The notion of objectivity is a survival from processual archaeology, which pushed aside the previous culture-historical approaches to create new scientific standards to practice an objective archaeology. On the other hand, the idea of social contextualisation and situatedness can be traced three centuries earlier in the work of the Italian philosopher, Giambattista Vico, the German philosopher, Immanuel Kant, and later on at the works of the sociologist and political economist, Max Weber, and
the sociologists, Karl Meinnheim and Émile Durkheim. These ideas gave birth to the so-called social constructivism, according to which reality is socially constructed. In other words, the construction and progression of the social world neither rely on natural laws, nor exist independently of the ideas and the people involved in it (Kukla 2000: 1-18).

It is usually argued that archaeologists’ work is dominated by constructions (Chadwick 2003: 104-105); excavation for example, constructs records, narratives and meanings. The word construction however, and especially in the cognitive dimension of constructivism, implies that something is made from nothing; in other words that the past does not really exist but is constructed by archaeologists. Yet, what archaeologists essentially do is not a construction per se, since the material past directs our creation (Shanks and McGuire 1996: 81-82), but an embodied production of materiality through which, remains of the past are brought to the present. In fieldwork for example, different modes of production are implemented (e.g. excavation, photography, drawing etc.) which interact and produce different forms of material culture. However, each mode and process of production is unique, since it highly depends on several factors that influence the outcomes, such as the context and/or the individuals involved (see chapters 1 and 2).

Since knowledge is built through perception, and individuals’ perceptual abilities vary, the mechanisms of knowledge production, and consequently the resulted knowledge, vary too. Perception is a complex mechanism, influenced not only by our senses, but also by our experiences and memories. Besides, it is our body, which is the decisive factor in the formation of understandings, by providing the sensoria through which experiences about the world are structured (see for example Ignatow 2007; Sørensen and Rebay-Salisbury 2012; also see Tilley 1994; Tilley and Bennett 2004, 2008; Brück 2005; Hamilton et al. 2006 for the phenomenological approach to the subject ). As it will become apparent in the course of the thesis, there are also numerous other variables, which independently or in various combinations, influence in all different processes how knowledge about the past is comprehended, internalised, externalised and produced.

Digital Reconstruction: A Phenomenological Approach?

As it is going to be argued in the course of this thesis, conventional two-dimensional representations of the material world cannot provide an understanding about the spatial elements of the past. Space is three-dimensional and can only be experienced as such, also involving the mediation of the human body and the senses (Tilley 1994:
Introduction

Although this is a phenomenological approach to the subject, phenomenological research had originally emphasised visual modes of perception, following the paradigm of the Western culture, which has significantly undermined multisensory engagements with the world (Thomas 1993, 2004:199, 2009; Hamilakis 2002; Cummings and Whittle 2003). Due to the spatial limitations of the thesis, the discussion will focus on the visual aspects of perception, capture and reproduction of archaeological evidence, addressing, however, in the process of digital reconstruction the elements that give variability and produce diverse experiences of materiality. This work will also consider how other sensory modalities, the human body and individuals’ existing experiential packages shape knowledge (see for example MacGregor 1999; Cummings and Whittle 2003; Tilley 2004;), as well as how social and cultural contexts, and networks among the various components can produce in the present new meanings, interpretations and multiple experiences about the past (Thomas 2004: 149-170, 216-217). Therefore, what matters most in this process is not to interpret the past according to the principle of universality (Tilley 1994, 2004; for a critique on the universal human body see for example Meskell 1996, Brück 1998, Fowler 2002, Hamilakis et al. 2002b) but to think critically about how modern situadness moulds understandings (Shanks 1992). In other words, this research lays emphasis on the process of three-dimensional reconstruction by simultaneously highlighting and demonstrating through examples the human point of view and the fact that perception is synonymous to interpretation (Jones 2001; Thomas 2004: 143).

Through the process of digital reconstruction, it is attempted to stimulate discussion, produce creative responses, encourage an imaginative formation of Greek Neolithic space and augment the understandings about human experience in the past. The visual stimuli delivered by the 3D visualisations and the process of producing them will provide innovative ways to overcome the problematic aspects of the two-dimensional record; however, this thesis will only borrow some of the concepts of the phenomenological discourse, since it will not be attempted either to draw links between present and past human experience (Tilley 1994, 2004) or to fuel the critiques regarding the use of 3D modelling as a means to reconstruct a real past, transforming multifaceted spaces into places abstracted from their real properties and particularly the human factor (Chadwick 2004: 21; Thomas 2004: 198). The purpose of this PhD is primarily to problematise the process of digital reconstruction in order to understand the mechanisms of knowledge production and demonstrate the power of 3D visualisation as an inseparable element of fieldwork projects that has a transformative impact on archaeological sense-making, reasoning and understanding.
The Black Box

According to the post-processual school of thought in archaeology, facts and objective truth are not valid terms in the pursuit of the past, since history is not formed on its own accord, but is contingent on individual understandings, ideas and concepts. Post-processualists elaborated further on these concepts, also encompassing approaches from postmodern social theory, such as gender (Conkey and Spector 1984; Gero and Conkey 1991; Wright 1996), agency (Shanks and Tilley 1992/1987: 101-134; Bell 1992; Dobres and Robb 2000; Pauketat 2001), reflexivity ( Hodder 1999a, 2000, 2003; Chadwick 2003), multivocality (Hodder 2008; Habu, Fawcett and Matsunaga 2008), authenticity (Holtorf and Schadla-Hall 1999; Smiles and Moser 2005; Moser 2010) as well as protection and management of cultural heritage (Lowenthal 1998; Skeates 2000; Howard 2003; Smith 2006) giving emphasis on how researchers and the social context affect both the collection of data and their interpretations. It has nowadays become common thought that archaeological interpretations cannot be seen outside from their social, political and cultural contexts. However, the main issue that remains under-explored and should be examined in the production of archaeological knowledge in the process of digital reconstruction is what Latour (1999) defines by the term ‘blackboxing’. 

A black box is a device that can be viewed only in terms of its input and output, while its internal workings remain unknown. Latour appropriated the idea of a black box in the sociology of science arguing that ‘when a machine runs efficiently…one need focus only on its inputs and outputs and not on its internal complexity’ (Latour 1999: 304). Therefore, ‘blackboxing’ is ‘a process that makes the joint production of actors and artifacts entirely opaque’ (ibid.: 183). How can this be relevant to the production of knowledge in archaeology and particularly in computer graphic simulations?

Archaeology is a system that, despite the various problems emerging either from the current social, political and economic crisis or the nature of the methods and processes involved, works extremely well. Hierarchical divisions dictate the ways that roles and relationships are maintained, and manifest archaeology’s authoritative nature (Pruitt 2011). Archaeologists, meticulously produce their input through fieldwork and excavation, which gradually turns into an output, in the form of either verbal or visual interpretations. However, all the underlying factors that influence this process, especially in the realm of archaeological computing, remain largely neglected or under-explored.

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4 For the use of the term in the archaeological process see Lucas 2012: 239-257.
The production of these inputs and outputs, highly depends on a network of human and non-human actors. This interrelation has been examined in the context of Actor-Network Theory developed by Science and Technology Studies researchers to follow the process of knowledge production (Callon 1986; Latour 1987, 2005; Law 1992; Law and Hassard 1999). However, such studies are not interested in investigating how such networks are formed, but rather in the ways through which those networks define and direct the production of knowledge. Part of this thesis is related to such observations, since it identifies the variables that should be considered when studying or producing an output. This is particularly interesting in the case of computer graphic simulations, since they are usually seen as outputs, often leaving aside, not only the black box, i.e. the process through which they became an output, but also the inputs, i.e. the data and the processes that resulted in particular inputs. Thus, researchers on computer graphic simulations have to deal with multiple black boxes in the course of a reconstruction.

The decision-making process in the production of computer graphic simulations, usually acknowledges the existence of a network that permeates and affects all aspects of knowledge production. However, considering the implications that computer graphic approaches have to the theoretical and practical scaffoldings of archaeology, it is problematic to limit our discussions and critiques only to the fact that networks exist. This thesis attempts to map the relationships and variables that act in the process of knowledge production and critically discuss the role of the various agents and their networks which mould both the inputs and outputs of archaeological practice. By dismantling the black boxes of the computer graphic visualisations of a Greek Neolithic site, this thesis is trying to define where the knowledge built in the various stages of the process comes from, and construe how/if the understanding of the process of digital reconstruction enables the enhancement of Greek Neolithic space and augments knowledge production itself.

The Concept of Three-dimensionality

As mentioned at the beginning, archaeologists’ work is based on the paradox of a two-dimensional three-dimensionality. This is apparent in all aspects of archaeological research and practice, from excavation and recording to conventional publications and computer graphic simulations. Therefore, the most appropriate link between the chapters is the concept of three-dimensionality. Although this concept will be extensively defined in the relevant chapters, I ought to give an initial definition and discuss the parameters that render an object three-dimensional. All objects have the spatial property of having three dimensions, i.e. length, width, and depth (or height).
Depth is actually the main property that enables the visual perception of three-dimensionality by utilising monocular and binocular depth cues that appear in the retinal images to understand depth in three dimensions. However, beyond the actual measurements in three dimensions, there are certain elements which make up a three-dimensional form and are of particular interest in archaeology; these are micromorphology and macromorphology: in other words, texture, colour and geometry. A combination of various factors in the perception of these elements, such as perspective, changing light position, the relative position of the viewer, retinal disparity and convergence influence the ways that these are perceived, therefore leading to diverse understandings of reality. Using the concept of three-dimensionality as the foundation of this thesis, each chapter includes information related to three-dimensional information and understandings derived from the various sources: literature, conventional and modern recordings, discussions with specialists, visualisations etc. In each case, the extent that the different sources enable the creation of three-dimensional understandings, and the various underlying perceptual, physiological and technical factors affect the process of knowledge production, are discussed and evaluated.

Outline of the Thesis

The first chapter of this thesis examines excavation methods and the conventional recording systems employed in archaeological field practice, namely text, photography, drawing and video. At the same time, it extensively considers, through specific examples from Koutroulou Magoula and also Makriyalos, all technical and perceptual factors that affect the understanding of three-dimensional properties of the excavated data. In addition, an extensive review of the available literature regarding the underlying theoretical concepts has been undertaken. This chapter demonstrates the fact that the knowledge produced by archaeological fieldwork is the result of several factors that are rarely taken into account in the process of reconstruction.

The realisation of the paradox of three-dimensionality renders imperative the scrutiny of how three-dimensional perception works in the real world. For this reason, the second chapter primarily discusses issues related to the perception of three-dimensional space by examining the factors that influence how objects’ three-dimensional properties are perceived, captured and reproduced. The discussion focuses on the three main elements of three-dimensionality, i.e. colour, texture and geometry, also looking at the perception of depth, especially in relation to two-dimensional visual products, which are commonly produced in archaeology. The discussion is contextualised in archaeological fieldwork and associated practices using
examples from Koutroulou Magoula, as well as Makriyalos. Since the perception of three-dimensional elements is a topic of an enormous depth for the spatial limitations of a thesis, as it involves all the sensory organs of the human body, the discussion here will be limited to aspects related to vision.

The third chapter of this thesis is an introduction to the spatialities of the Greek Neolithic in an attempt to highlight the sources of knowledge in the process of reconstruction. Firstly, it provides fundamental information related to architecture and uses of space in the Greek Neolithic. Additional details regarding tell sites and flat-extended settlements, and a theoretical discussion on their role and meaning in Neolithic life can be found in Appendix I. This chapter also examines the contribution of Neolithic house models in the process of reconstruction. In addition, it discusses the contribution of ethnographic observation and experimental archaeology in the process of reconstruction, also referring to characteristic examples that offer new insights into Neolithic materiality. Lastly, it addresses the tradition of (re)construction by looking at (re)constructed Neolithic houses, illustrations, as well as computer graphic simulations. This chapter leads to the next section, where the archaeology of Koutroulou Magoula is presented.

The next chapter (four) is dedicated to the presentation of the archaeology of the case study, Koutroulou Magoula, and the discussion of its problematic aspects. The information has been mainly derived from my interpretation of the recordings, the discussions with the excavators and the various specialists, and my participation at the excavation as a visualisation specialist, supervising archaeologist and photographer in the last three years.

The next two chapters (five and six), based on the three-dimensional visualisation of various features from Koutroulou Magoula, extensively discuss and evaluate the processes and outcomes of 3D modelling. In chapter 5, the tools designed in 3D graphics software interfaces to condition the interactions of human and computer in three-dimensional space are discussed and critically examined. Also, modelling choices in the process of reconstructing the Neolithic dataset, the decision-making process, as well as the various products of this process are presented and evaluated in order to explore their impact on the understanding of the actual dataset.

In chapter 6, the various structural and lighting models presented in the previous section, are used to investigate the impact of 3D modelling and its products, as well as that of the process of reconstruction on the modeller (myself) and the members of the project. In order to do this, two electronic surveys were implemented and participants
were asked to evaluate and express their comments and ideas about the process and the products, as well as the use of 3D visualisations as heuristic sources and scientific tools in archaeological reasoning. All questions and answers of the online surveys can be found in Appendix II.

The concluding chapter of this thesis is a thorough discussion regarding issues related to the origins of the knowledge incorporated in three-dimensional models, as well as to the understanding of archaeological spaces through the modelling process. Based on the computer graphic simulations of Koutroulou Magoula, and considering all the parameters discussed in the previous sections, this chapter discusses the origins of three-dimensional understandings in visualisation projects, and, the augmentation of knowledge through the process of reconstruction. Fundamental issues in every 3D visualisation project, such as the formation of knowledge, the understanding of data, the compression and the (de)fragmentation of information, and the diverse ways that all these variables affect the construction of new understandings are addressed.

Contributions of the Thesis

In either real or in three-dimensional digital environments, in different spatial, temporal and cultural contexts, archaeologists face the same problems during the process of interpretation. Although the variables that should be considered are numerous and the biases abundant, careful examination of all options, problems and perspectives can provide a conceptual framework for opening a dialogue, asking specific questions and suggesting new avenues of research. By utilising computer graphic simulations to construe the understanding of a Greek Neolithic site, this thesis aspires to become one of the first visualisation projects that deconstructs the process of reconstruction, considers the diverse inherent constraints in all different stages of knowledge production, assesses where the knowledge incorporated in three-dimensional images comes from, and employs the process of digital reconstruction as a means to augment spatial understandings.

novel contribution to the understanding of knowledge production through the process of digital reconstruction.

Unlike other discourses on the production of the archaeological record which barely address the paradox of three-dimensionality, this thesis 1) critically examines the multiple levels of complexity in the concept of three-dimensionality in the different stages of knowledge production through the archaeological process, discussing the complicated variables that should be considered, while establishing a framework for similar approaches. Contrary to existing research on computer graphic simulations, which only investigates the impact of various methodological and technical factors on the processes and outcomes of 3D modelling, this work 2) utilises the process of digital reconstruction for a Greek Neolithic site to address issues of knowledge production throughout the various modelling procedures and strategies, and enhance understandings on the role of computer graphic simulation as heuristic sources in the production of archaeological knowledge. Finally, 3) it uses the process and the products of 3D modelling as a means to evaluate the augmentation of three-dimensional understandings for Greek Neolithic spaces.
Chapter 1
Excavation and Recording Processes in Archaeology: Understanding Three-Dimensional Space

Introduction

Archaeology is almost synonymous with excavation (Tilley 1989: 275). Excavation, a fundamental method in archaeological practice which influences the way we understand the past (Edgeworth 2011), is a transformative technique, which, according to Lucas (2001a), has an ambiguous meaning. On the one hand, excavation means the recovery of past remains, whereas on the other, in order to understand and materialise these remains, their context and coherence is shattered and a new material reality produced. The archaeological sites are chronotopes (Bahtin 1981: 84-258; also see p. 1-2), having spatiotemporal references to the past and present. This means that the excavated chronotopes not only reveal information about the past, but are also translated to other chronotopes, defining new relations between the archaeologists and the data. These chronotopes interpenetrate the material evidence, therefore obscuring the traces of past and present, subjective and pseudo-objective and a series of other antitheses that come together in archaeological practice. For this reason, archaeologists employ a series of processes to capture the archaeology of a site, and make it sustainable for the future and accessible to other researchers, facilitating its fictional re-excavation, re-analysis and understanding at a later date.

As Barker aptly argues (1993:13) excavation is an experiment that happens only once. Since an excavation is the last stage of fieldwork and the first part of any research regarding the production of a site’s life, any available techniques are used to allow further examination of the evidence. In the short-term this will lead to a reflexive report, and in the long-term to the site’s interpretation and consequent publication. However, these recording mechanisms comprise the third level of interpretation in the study of the archaeological assemblage, as the alteration of the remains by the formation processes, which gradually turn a place into an archaeological site, and their consequent excavation, comprise the first two levels. This means that in order to critically use this information in any research or methodological approach, in our case three-dimensional computer graphic simulations of past built spaces, we should ensure that we are aware of the various neglected, underestimated or not perceived parameters that affect the recorded evidence and invalidate the utopian term.
'objective record'. In this context, the various recording mechanisms, considered as a way to immortalise a site’s life history, should be critically evaluated. They provide flat, two-dimensional information of three-dimensional evidence, and our work is based on this contradiction; we produce three-dimensional data by using two-dimensional information, which has been produced by flattening three-dimensional evidence. Finally, this three-dimensional work is presented in two-dimensional formats.

Although the term archaeological record has been used in different ways by processualists and post-processualists, and its validity challenged, since fragmented material realities cannot comprise any kind of record or evidence (Patrik 1985; Barrett 1988, 2006; Hamilakis 1999; Edgeworth 2006: 22-26), the recording processes developed over the years have become the means through which the past is preserved to the eternity (Bateman 2006: 68). Conventional recording methods, such as architectural drawings and text, as well as photography and even video, depict three-dimensionality with a series of conventions that are usually accessible only to specialised audiences. These conventions attempt to separate the people who excavate from the material that is being excavated in order to produce an objective outcome. However, is it possible to turn subjective into objective? (Yarrow 2003: 72).

None of the conventional recording techniques can stand on their own as sufficient sources of data, and in several cases the information presented in two-dimensional recordings is hardly adequate to understand the archaeology of a site. Even when an amalgamation of these is used to draw conclusions, their inadequacy to capture and represent the original three-dimensional evidence renders the comprehension of archaeological reality deficient. As a consequence, observers cannot become embodied into a site and experience its materiality through these, since they represent codified and compressed information, often perceived as abstract entities. This however, does not mean that we could ever have a complete understanding of the evidence, even by using cutting-edge technologies to record the data. The fact that numerous variables are interposed in the different stages of research make this impossible; but an awareness of these variables in relation to the recording techniques, would enhance our readings of the archaeological evidence.

These processes, employed by archaeologists in the field who are striving for objectivity as a crucial component of sustainability, have three essential elements: a written record, drawings of the excavated trenches and finds, and a photographic record. Video recording can also supplement these practices. In the following sections, each of these components is going to be examined, and their contribution to the understanding and interpretation of archaeological knowledge will be critically approached.
1.1. Fieldwork, Excavation and Recording through Time

Although recording processes are employed and adapted to ensure that the archaeology of a site could be simulated after its excavation, it is worth briefly discussing and critically approaching the excavation as a method for revealing the past. Since the seventeenth and eighteenth centuries, when antiquarians were studying the environment and its natural history, excavation was used as a supplementary practice for recovering artefacts, mainly prehistoric, usually without keeping any written records regarding their context or exact location (Lucas 2001b: 3-4). However, the pursuit of antiquity was developed differently in each country, also reflecting national and political trends (Malina and Vašíček 1990; Trigger 2006; Díaz-Andreu 2007). Excavation gradually became an integral part of fieldwork, and more careful techniques and records were utilised. However, the focus of several expeditions, even in the nineteenth century, was the artefacts and the acquisition of collections, their classification and the foundation of public museums (cf. Greene 1995: 8-36; Schnapp 1996: 122-219 for a history of antiquarians, collections and fieldwork). Even when material remains were examined in situ, the main aim was to answer questions related to these collections, thus involving research in institutions, records and other collections, rather than fieldwork as it is understood today (Lucas 2001b: 5). This attitude gradually changed in the nineteenth century, especially with Thomsen’s Three Age System, which emphasised the contextual parameters of the artefacts (Malina and Vašíček 1990: 36). It was in the late nineteenth century when the notion of culture emerged and collectors started to think about their antiquities as part of cultural groups and areas. At that time, several collections were rearranged, and the focus of research was not limited to museums and records, thus leading to fieldwork as a means of understanding the context of these finds.

Since the beginning of the 20th century, excavation has been regarded as the appropriate activity for recovering and producing material culture. Since the 1950’s excavations tried to achieve as much objectivity, precision and scientific technique as possible, by being rigid and standardised, separating information recovery from processing and interpretation (Chadwick 2003: 99). However, Piggott argued (1965: 166) that the attempt to achieve objectivity was not only connected to the scientificity of the discipline, but also aimed at minimising any variations in knowledge, experience and skills, thus emphasising the human element in the process.

The earliest examples of the development of excavation and recording techniques in Greece, are evidenced by the foundation of The Archaeological Society at Athens in 1837, and especially the excavation of the Acropolis in the mid-19th century, which became the focus of activity for the new nation-state (Hamilakis 2001: 6). The two opposing ideas, i.e.
excavation as record and excavation as interpretation, developed through the 19th century, and especially at the second half of the 20th century. Recently, the processual and post-processual schools of thought, led to the use of different recording methods, and their gradual modification to materialise these notions. Although interpretation is an indissoluble part of excavation, it has been rarely considered an active, reflexive and multivocal process (Shanks 1992; Hodder 1997, 1999; Andrews et al. 2000; Berggren and Hodder 2003; Chadwick 2003); it is a practice that normally takes place at the end, after the processing and analysis of finds by alienated (Shanks and McGuire 1996: 77; Chadwick 2003: 99), non-autonomous labourers (Hamilakis 1999: 68), whose feedback aids directors’ interpretations rather than having its own significance. Tilley’s apposite remark (1989: 275) that archaeology is similar to baking a cake, except that often the cake remains unbaked, vividly illustrates the fact that interpretation normally happens at the end of a project, but quite often is a stage that is never, apart from the essentials, completed. Hodder (1997: 694) quotes the response of the New Age Women’s Movements when they were told that they will be provided with the data in order to produce a less male-driven interpretation of Çatalhöyük: ‘...when you hand over the data to us, they have already been interpreted by you’. This response by non-specialists amplifies the notion that interpretation is an active process that starts at the trowel’s edge (ibid.); if not, we get to practice ‘bad archaeology’ and ‘bad science’ (Berggren and Hodder 2003: 426). However, this is in contrast to Bakhtin’s notion that neither the author, in our case the archaeologist, nor the addressee can construct meaning on their own, as it is a joint, dialogic process (Morson and Emerson 1990: 129).

Several advocates of the notion that excavation is an interpretation of material culture and past lifeways, have argued that there is no passive observer, as any data can only be critically approached and understood after their correlation with the observers, as they determine the interpretation, even prior to the excavation (Hodder 1999a: 81-83). As humanity should be understood through the archaeological evidence, objectivity cannot be achieved by the exclusion of human presence (Andrews et al. 2000: 527; Lucas 2001a: 38). Or, I would say, that objectivity cannot be achieved at all, since there is no practical way to separate people, and consequently, their world-views, from their interactions with material reality. Similarly, data (constructs according to Chadwick 2003: 104-105), are subjective entities and cannot be approached by a set of laws as in natural sciences (Adams and Brooke 1995; cf. Schiffer 1987). As a consequence, although the various conventions employed in archaeological practice attempt to make people, actions and thoughts the same (Yarrow 2003: 67-68), interpretations momentarily change, as a network links all the participating objects, contexts and media (Hodder 1997: 694). However, as Lucas appositely notes (2012: 72), although the notion of objectivity has been repeatedly acknowledged and discussed as a very problematic concept and the arguments shyly conclude that recording, under the
principles that it takes effect today, is futile, the will to preserve the results of excavation has given birth to an increasing number of methods, disciplines and technologies to record the most of what lies in the ground.

Proponents of the notion that excavation is synonymous to a record, consider that objectivity is feasible through the use of objective methodologies, conventions and neutral terms (Barker 1993: 163), which identify when subjective information, such as personal choices, uncertainties and interpretations are applied to the records (Andrews et al. 2000: 526). The phrase archaeological record is of course deceiving in this context, since it can be read either as the remains (material record) or the results of the process of recording. Therefore, by this twofold meaning, the message is that archaeologists have achieved to equate material record and the recording of it. In other words, the archaeology of a site is equally understood either by reading the records of the excavation or studying the material record itself (Edgeworth 2006: 23).

Preservation by record, as an alternative to preservation in situ, thrived in the 1960s and 70s in the UK, as infrastructure work and consequently rescue excavations dramatically increased (Lucas 2001a: 36-37). The need for fast and accurate records dictated the creation and use of various methodological tools, which could ensure the virtual rescue of a site. In line with this way of thinking, recording processes were gradually modified to ensure that even in cases when the archaeological resource is completely destroyed or uniquely transformed (ibid.: 41), the ostensibly objective record that will replace its existence will make feasible the understanding and interpretation and/or re-interpretation of the site at a later date. Personally however, I have rarely seen radical re-interpretations occurring in archaeological assemblages based on old data. In this context, it should also be emphasised that recording is only one link of the chain; thus, any objectivity cannot compensate for a bad excavation or an unskilled archaeologist (Piggott 1965: 166). It is excavation itself, and not only the recording of the process that invalidates the concept of objectivity. However, this has been underexplored; despite the fact that archaeology is almost synonymous to excavation ‘writing, not digging, is regarded as the real material practice of archaeology’ (Edgeworth 2006: 28).

The standardisation that emerged from the increasing needs in the field caused a great degree of homogenisation, turning observation to mechanical recording (Reynolds and Barber 1984: 97) and often resulting in reluctance towards creative approaches and interpretations (Shanks and McGuire 1996: 85). However, even when codified methods are used for recording, it is useful to apply them in a reflexive context, enabling the understanding of the ‘hows and whys’ of the interpretations, and if needed to re-interpret the data according to the original agenda. Therefore, it is important not only to record data,
but also record the processes by which these data were produced (Shanks 1992: 145; Berggren and Hodder 2003: 430), since they cannot be satisfactorily depicted either on site reports or other recording methods. Archaeology is all about process, and not the end result that is usually consumed by the various recipients. Nevertheless, it is inevitable that when interpreting the past in the present, any particular version of the past can never be accurate, since past reality is produced by ‘re-inscribing it into the face of the present’ (Tilley 2000: 425-426).

In the next section I will briefly refer to the general principles of the excavation and recording mechanisms employed in Koutroulou Magoula, also contrasting them to those of Makriyalos, mentioning the advantages and constraints in each case. Then, through a critical evaluation of the theoretical implications of each recording method, and an examination of indicative examples from the two archaeological sites, I will assess the extent to which the mechanisms employed in archaeological practice enable, or not, the production of three-dimensional understandings.
1.2. Excavation Methodology and Principles of Recording at Koutroulou Magoula and Makriyalos

1.2.a. Koutroulou Magoula

The excavation at the Middle Neolithic site of Koutroulou Magoula, which started due to the opening of a rural road in the area, has, with the exception of two intervals in 2003 and 2007, been ongoing on a yearly basis since 2001. A grid was formed to facilitate the identification of the areas where the excavation will take place. The grid used the Greek alphabet, and for the excavated trenches the relevant letters were used (Trench H, Trench Θ etc.). Since 2010, it has been also integrated with the National Coordinate System (GGRS 1987) while the levels are assigned by the sea level.

The pace of work is only dictated by the available means, including the archaeologists and workers involved. The excavation followed the German system, with several variations depending on the archaeologist who supervised the trenches. Each trench was 5X5 metres, while a micro grid divided this area into 25 smaller areas named with a Greek letter and a number (A1, A2, B4, Γ3 etc.). In several cases due to spatial constraints the trenches were smaller, namely 4X4 metres, and consequently this area was divided into 16 smaller squares following the same naming conventions. The excavation is done based on the principles of units/groups (omades) and layers (pases), and each trench has its own notebook. A unit is a group of excavated material, whether it is soil, stones, finds etc. or a combination of these, which gets a running number (unit 1, unit 2, unit 3 etc.), and changes for the areas with special characteristics (unit 1 for an accumulation of finds, unit 2 for a posthole etc.), which resembles to some extent the Single Context System (SCS). On the other hand, a layer only describes the method of excavation and not the content (the English translation of the Greek word pasa (sing.) as layer must not be confused with stratigraphic layers. The word 'spit' is used in English to describe the same process), and is related to the removal of a particular amount of soil, usually 10cm each. It gets a running number (layer 1, layer 2 etc.), which changes for each layer removed (layer 1: 0-10 cm., layer 2: 10-20 cm. etc.). After 2009, when the University of Southampton became involved in the excavation, the SCS was used in their trenches, whereas the Greek trenches gradually adapted to using context numbers instead of layers and units, and filling in context sheets along with keeping notes in a notebook. According to the SCS system, each context (cut, fill, deposit, structural feature) is excavated separately and gets a unique context number. All relevant details are entered on formatted sheets, which also allow for references, standardised descriptions, measurements and sketch drawings. In the case of Koutroulou Magoula, and in order to have an
amalgamation of SCS and note taking, there is a field for discussion and interpretations. The latter does not normally exist in SCS.

In total, five archaeologists have supervised the work on this site from 2001 to 2010, while five more archaeologists have supervised the trenches excavated by the University of Southampton team in the years 2009-2012. As far as the workmen are concerned, their number is always dependant on the available resources of the Ephorate. Their number ranges from 2-7, which also reflects the pace of work, though when archaeology student volunteers participate under the direction of the English team the number of people excavating on site rises to 20-25. The field notes are mainly kept by the supervising archaeologists, but students also help in the process for training purposes. On the other hand, single context sheets are filled in either by the supervising archaeologists or the students, but are always checked for their consistency by the field director.

During the first years of excavation, in 2001 and 2002, units and layers were used (omades and pases respectively – pl.). Although the level of detail presented should be considered
adequate taking into account the conditions under which the excavation was carried out, interpretations of the excavated data are rarely attempted. However, a Munsell Color Chart is used to describe the colour of the soil for each unit and layer of the micro grid which may prove helpful for the recovery of some information. The various finds are recorded based on the unit number, while the figurines (*eidolia*) get a special number which oddly enough seems to start from E4449. Probably, this is a running number of figurines located at the Ephorate in charge. However, no separate catalogues of finds seem to have been kept. In the field notes there are sketches, as well as coloured drawings of characteristic decorated sherds and figurines, which is quite convenient as photographs are not incorporated (fig. 2). Despite the fact that photographs are not included in the notebooks, there is a reference to the number of the photo in the photographic archive which has been provided electronically (in the first years photographs are in analogue format; they have been scanned for the electronic archive).

![Fig. 3 Koutroulou Magoula field notes – 26/10/2005 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).](image)

After a gap year, the excavation continued in 2004, under the direction of the same archaeologist, whereas in 2005, when another archaeologist was in charge of the trenches, the use of units was abandoned, and the excavation was conducted following the principle of layers. The field notes include useful information and a high level of detail, clearly categorised in pottery, soil, bones, stone artefacts and clay (fig. 3). It is noteworthy that interpretations of the data are attempted throughout, while detailed descriptions, for example for the mud bricks with corners, fibre fossils and wood impressions, facilitate the simulation of some aspects of the dataset. Each square of the micro grid as well as each excavated layer had its own bag, while all finds were categorised under the prefix AME.
(Small Find Number) and a running number, as there was no distinction depending on the material or nature of the finds. Many samples for water sieving were taken, while dry sieving, although not mentioned in the field notes, might have been also used. Lastly, limited use of Munsell Color Chart was made, while a useful addition is that apart from sketches, some photographs have been included in the notebooks (fig. 4).

Fig. 4 Koutroulou Magoula field notes – 20/10/2005 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

In 2006 another archaeologist oversaw the trenches, following the same techniques as the previous archaeologist. The numbering of finds continued from the previous year, while it is the first time that dry sieving is mentioned. However, there are not any photographs in the notebooks and the sketches are limited, while there is not always a reference to the photographic archive. In addition, it seems that the archaeologist is not fully aware of earlier data, as the previous year’s field notes are cited for the correct numbering of finds. The notes were categorised per layer and date, and the level of detail should be considered adequate.

In 2008 another archaeologist took over, who followed the numbering, levels and measurements of the previous year. Moreover, the excavation and recording strategies
remained unchanged. This means that to a certain extent the field notes from 2005 to 2008 follow the same principles, which can facilitate the unification of the data.

In 2009, the excavation continued under the direction of another archaeologist, who to a great extent continued the recording and excavation techniques of her predecessors. The finds were categorised under the prefix ME (Small Find) and a running number (instead of AME and E in previous years), while stone artefacts got the prefix B. However, the involvement of the English team brought several changes regarding not only recording, but the techniques employed as well. The numbering of the trenches changed in order to make the expansion of the excavation easier in the foreseeable future. In addition, the soil from all the trenches was sieved, while separate sheets were filled in for water sieving, in Greek and English. In addition, all finds were washed the same day to facilitate the work of a conservator who was simultaneously working on site. Lastly, it is the first time that lists of finds, as well as registers for photographs, drawings and contexts, are recorded.

As 2009 was a pilot season for an intended expansion of the project, the Greek supervising archaeologist also kept notes for the trench where the University of Southampton team was working. Although small in scale, the purpose of this collaboration was to develop accurate, readily accessible data that was easy to integrate with database strategies. All records were consolidated into digital format and initial processing was carried out. All contexts were sampled for archaeobotanical study and some of these samples were also processed. As far as the excavation strategy is concerned, it followed the SCS, and the codes employed allowed for the recording of samples and finds with numbers unique to each context. Records were entered on formatted sheets (fig. 5) accompanied by scale drawings, with pre, mid and post excavation photographs. Also, three-dimensional coordinates were taken for finds of particular interest, while at the end of the season the records were entered on a digital database. Plans and drawings were also digitised and added to the digital archive. At the end of the season a report was composed, which described the methodology and techniques employed, and provided a comprehensive summary of all contexts, an extensive description of finds, a preliminary study of pottery, as well as a broad discussion regarding the possible interpretations of the features revealed. It also included the results of the Greek trenches as well. Lastly, all lists of finds and samples were delivered through the appendices. As far as the Greek team is concerned, they followed their normal excavation and recording strategies.

The 2010 season, further refined the recording procedures, while a topographical survey was undertaken both on the magoula (tell) and the surrounding landscape. A great number of specialists in several fields were involved, including lithics, ceramics, archaeobotany, computer visualisation, bones and survey. The principles followed were similar to the
previous year’s, whereas the Greek team adapted their recording methods employing context numbers instead of layers. Respectively, the English team adapted the context sheets to include fields for a more descriptive record of the archaeology and interpretations of features and finds, but the supervisors of each trench also maintained notebooks (fig. 6), corresponding to an extent to the descriptive records kept by the Greek Archaeological Service. However, notebooks duplicate in most cases the information of the field ‘discussions/interpretations’ of the context sheets, without providing any additional information. In 2011 and 2012, the excavation followed exactly the same principles.

Fig. 5 Koutroulou Magoula Single Context sheet – 05/09/2011 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
It was decided to extend the Trench Θ3 of the 2009 season eastwards by one metre. The purpose was to determine the shape and extent of the structure found previously in Trench Θ3. The new trench, Θ3 EXT, is laid immediately to the east of Θ3, with its dimensions being 4m north-south x 1m east-west.

The grid was set out as follows: SW corner of trench: 351.409, 288.4391 and SE corner of trench: 351.991, 288.439. The initial levels of the trench were taken at 6 points: 1.000 corner, 2.000 corner, 3. middle of eastern edge, 4. middle of western edge, 5. SE corner, 6. SW corner. (The specific readings can be seen both in Drawing No 1 in the sketch on the left page).

A surface cleaning followed that included the collection of random pottery sherds, plaster & metal items. All the finds, including the modern ones, were put in one bag, under one finds number: (1201/02) without any further sorting.

The uppermost layer was a hard, very course sandy clay with moderate aerially sorted inclusion of stones, minerals & roots.

It was removed as one spit and its depth was approximately 6-8 cm.

The removal of c 15L was completed in one day and was conducted by Tom Laughton (TAI), Fotini Salitrou (FR) and Southampton University students: Lloyd White (IW) & Pip Haigh. At the end of the day, the next context (C1202) was fully exposed throughout the trench.

Weather conditions: dry, sunny, hot, direct sunlight

It was decided that future grid reference readings will be taken consistently from the SW corner (as close as possible) of each context.

Fig. 6 Koutrouloú Magoula notebook – 05/09/2011 (Koutrouloú Magoula Archaeology and Archaeological Ethnography Project).
All records from the beginning of the excavation are in analogue format. They are written in Greek, and have been scanned to facilitate access for the various scholars. The Greek analogue archive is located at the Ephorate of Palaeoanthropology and Speleology of Southern Greece in Athens. On the other hand, the team from the University of Southampton maintains a fully digital archive, including all plans and sketches, as well as photographs and databases. Their context sheets and notes are written in English.

It is obvious that different people, with a diverse range of backgrounds and knowledge, bring different ideas and excavation techniques, which are all reflected in their recordings. However, since excavation is not an end product, but a link in a chain, which will be reused, adapted and consumed by a series of researchers to study, present and publish the archaeology of a site, a certain level of consistency is required to ensure the sustainability of the resources. In Koutroulou Magoula there have been three different excavation and recording approaches employed to date, which pose a number of issues regarding the unification of the data as well as the level of detail required for any post-excavation work. Nevertheless, it is not only the use of different methodologies that complicates any research based on these, but also their inherent limitations which dictate what will be recorded, and how, by using means that conventionalise the real world.

**1.2.b. Makriyalos**

The site was divided into two areas by the existing national highway. Across the eastern section the area was investigated for the construction of a new railway line, whereas the western section was excavated for the construction of the second part of the national highway (fig. 7, 8). A grid aligned according to the axis of the public works was plotted and the settlement was divided in 21 sectors (100X100 metres), named after the Greek alphabet. Each one of these was divided into 100 trenches (10X10 metres), ordered from 001-100, and each of those was, in turn, divided into four smaller 5X5 metre squares. As a result, each sector had 100 trenches, and each trench had four squares (fig. 9). Each 5X5 square had a baulk at the north and east sides, unless there was some kind of obstacle, such as a ditch (Pappa 2008: 103).

Since a total excavation was not possible, the archaeologists had to choose the areas where the field research would focus. The urgency and the scale of the excavation dictated a series of test trenches so as to trace the extent and density of the most important features of the settlement. On this basis, only parts of the fills were systematically investigated. The infrastructure works were progressing in parallel to the excavation, which forced the pace of research as well as the excavation methodologies; for example, part of the surface layers were removed by wheeled mechanical excavators (Pappa 2008: 102-103). In addition, it
should be taken into account that a project that has to run all year long would be affected by adverse weather conditions; long periods of summer draught did not facilitate the identification of data, while, in several cases, excessive winter rain made the excavation impossible.

Fig. 7 Topographic map of Makriyalos region with Grid A-Ψ. The arrows indicate the location of the New National highway and the Railway line New (Pappa 2008).
Fig. 8 Aerial photo of Makriyalos during the excavation (Pappa 2008).

Fig. 9 Makriyalos divided into 100 X 100 metres sectors named after the Greek alphabet. Each one of these is divided into 100 trenches (10X10 metres), ordered from 001-100, and these are also divided into four smaller 5X5 metres squares (Pappa 2008).

The excavation followed the English system (Single Context with variations). Each square had its own notebook and its designation derived from the sector, the trench and the square, and also a unique context number (e.g. A-045-3-002). Even when there were features belonging to two or more squares, they were excavated as such and not as a unity. Since the two parts of the excavation had no direct contact, there were separate lists and
numbering for pits and finds. However, these two lists were unified afterwards, during recording at the laboratory. All finds unearthed from the contexts, namely pottery, bones and shells have local coordinates based on a metal meter and a hose level. Archaeologists were taking photographs for the trenches they were in charge of, while one of the directors was taking general photos and video. Photography however took place in specific cases and not for each removed layer.

Fig. 10 Pages from Makriyalos’ notebooks. Each trench is divided into different categories (depths, work, soil, finds) and a drawing is produced for each excavated context (Courtesy of Dr Maria Pappa).

In total there were approximately 20 archaeologists supervising six workers, two in each square, a scheme adapted based on various needs. Each page of the notebook (fig. 10) is devoted to a single context, and is divided into three parts: work, soil, finds and samples. There are not any predefined fields, but descriptive narrative is used for each of these categories. Apart from descriptions, the archaeologists were writing down their own interpretations. There is also a sketch regarding the position of the context and levels at the beginning and the end of the excavation, which resulted in accurate stratigraphies. At the end of each notebook, the archaeologists compiled catalogues for finds, layers, pits and other features. Also a more general, but informal diary was kept by one of the directors, including unified information as well as the most important visits and social events.
Along with the archaeologists and the workers, four draughtsmen took part. In parallel with the dig, water sieving took place when there was an indication of burnt material. The fact that no dry-sieving was used, due to time constraints, resulted in the loss of a considerable amount of data, as many fish bones, beads and infant bones were found during water sieving (Pappa: pers. comm.). All the records are in analogue format and are stored at the 27th Ephorate of Prehistoric and Classical Antiquities, Northern Greece.

Because of the large scale of this excavation a large number of archaeologists and other experts were involved. There are cases where more than one archaeologist excavated and took notes for the same feature, whereas there was a supervising archaeologist that did not keep any field notes for the excavated material. Although writing style and the level of detail recorded varied among different people, it is significant that the same methods were used throughout the project, as an essential practice for the consistency and sustainability of the records. The fact that a personal diary was also kept by Maria Pappa, one of the directors, in which the composition of information was attempted on-site, helped to overcome some constraints posed by the information gathered by the supervising archaeologists and the recording system employed.
1.3. Recording Methods: Practice in Koutroulou Magoula and Makriyalos

1.3.a. Text

As mentioned above, the recording system employed in Koutroulou Magoula was quite diverse through the years, depending on the supervising archaeologists that were in charge of the excavation. It is a system adopted in German excavation practice, but it is interesting that although it has already started to become codified, the Greek Archaeological Service, which in most cases employs this system, continues to use its initial form. The great number of people involved in Koutroulou Magoula used different vocabulary to describe the evidence, as well as varying levels of detail. The record is in the form of descriptive narrative, more as a temporal sequence rather than a unification of the excavated data. When attempted, interpretations are often mixed with descriptions, while personal style of writing can be seen throughout. On the other hand, the use of a Single Context Recording system from 2009 onwards, when the University of Southampton became involved in the project, the splitting of the context sheet into four different fields (cut, fill, structure, feature), as well as the formatting of the sheets that make the user fill in three types of drawings (location of context in trench, detailed sketch of the actual feature, section drawing) so as to give more detail than they used to, are all tailored so that the final report will be more standardised and easier to write. Also, the fact that descriptive field notes are kept in parallel to the context sheets provides not only a more accessible system for the users who are not used to the SCS, but also gives space for further discussion and interpretations, which is not feasible in the limited space of the context sheets.

Contrary to Koutroulou Magoula, in Makriyalos’ recording system, each context had its own sheet of paper, in which all details were recorded in a descriptive format with distinctive paragraphs for different pieces of information (e.g. soil, finds etc.). Since a great number of people were involved in the recording, considerable variations can be observed. We cannot assume predefined standardisation, since the supervising archaeologists were freely recording and consequently interpreting the data. This was moderated by the clear and very structured excavation method, which used context numbers for each excavated layer.
1.3.b. Photography

In both Koutroulou Magoula and Makriyalos, photography has been mainly used as a recording practice, rather than to capture the social dimension of the excavation, or as artworks and ethnographic installations (see 1.4.b.). In Koutroulou Magoula, especially during the first years of excavation, photography played an auxiliary role, as the unearthed features were selectively captured. In these records various problems can be observed, such as the lack of scales, thus not providing a reference for the size of the depicted objects, in a few cases the absence of north arrows and descriptive boards, as well as over- and under-exposed subjects. It is only during the last four seasons that photography assumed an integral role in all stages of excavation, recording not only the revealed structures but all phases of this process. Photography is now also used as a form of experimentation, which attempts to creatively capture all aspects of the project. On the other hand, it should be taken into account that during the first two years of excavation the photographs were in analogue format, whereas they have been digitised for the needs of this research, therefore adding another level of distortion to the already distorted image of the past (Sassoon 2004: 208).

In the case of Makriyalos, all photographs have been provided in digital format, although they have also been captured in analogue. Considering the pressure exerted by the infrastructure work and the number of people involved, it is understandable that photography was only used to capture the complete unearthing of a feature and not intermediate stages, or when the excavation had reached a satisfactory stage that could provide a clear indication about the character of the evidence. In general, most of the established archaeological conventions were followed.

1.3.c. Drawings

The application of drawings in the archaeological practice at Koutroulou Magoula and Makriyalos is quite diverse. In Koutroulou Magoula, the drawing principles change when a new supervising archaeologist comes to the site. Most drawings follow the general guides to good practice, although there are a few examples in which scales and north arrows are missing. In the notebooks consulted, it seems that only plans were drawn during the excavation, while elevations and stratigraphies have not been recorded. During the first years of the excavation, drawings attempted to depict colour variations based on the values obtained from the Munsell Color Chart, while colour has been used throughout to distinguish different features, such as clay, burnt materials and pottery (see 1.4.c.2). Black and white drawings have been also used, which make it difficult to distinguish different features, such as stones and ceramics, without any descriptive text or legend. Since the
involvement of the University of Southampton many of the drawings are produced digitally by the use of an Electronic Distance Meter (EDM), which gives accurate measurements which are then imported in an architectural design software package. Although different colours are employed to make architectural features distinct, they do not show visually any variations in texture, colour or other real world attributes.

In Makriyalos, the drawings used in the final publication (Pappa 2008), including plans, sections, elevations and stratigraphies, were prepared using an architectural design software package, whereas the drawings included in the notebooks were hand-drawn on-site, using the established conventions for levels, scales, slopes etc. In both cases, although drawings have their own validity as they comply with the guides for good practice, they are mainly used to supplement the text, which cannot adequately depict all the data. For example, none of the drawings has any indication about colour or texture, but they mainly record architectural features and artefacts.

1.3.d. Video

Only Makriyalos’ excavation made use of video recording. The operator was the director of the excavation, and no recording principles were observed in the 11 hours of film provided. The content was recorded during the whole working day, based on the importance of the subject-matter, namely the structures and/or finds revealed, their preservation and their contribution to the understanding of the archaeology of the site. The recordings include the excavation of features and their description by the supervising archaeologists or other specialists, the recording of cleaned and/or finished trenches described by the operator, everyday tasks, captures of the wider region, close-ups of special finds, discussions of team members and lastly, the social aspect of the excavation. An interesting feature that is recorded neither in the photographs, nor in the textual record, but is vividly captured in the videos, is the co-existence of archaeologists with the infrastructure work crew, providing an indication of the pressure exerted by and to either side. These recordings often include people, which give an excellent indication of scale, in contrast to photographs, while the narration by the excavator or the presentation of features by other archaeologists comprise a valuable audio-visual record which supplements the other recording mechanisms, compensating for the overall quality resulted in from an amateur operator. Regardless of the problems and constraints described in the next sections, e.g. depiction of colour and texture (see 1.4.d), the amount of archaeological or other information that can be derived from these recordings provides valuable information about the site. The fact that the site cannot be revisited makes video recording an invaluable resource, as visitors and researchers have the chance to walk and experience the same ground, and become embodied in the excavation of a virtual site (cf. Witmore 2005).
1.4. Recording Methods: Theoretical and Practical Considerations

1.4.a. Text

The most common recording method in archaeological practice is text and actually the discipline of archaeology is dominated by the production of texts in various forms and for different purposes (Lucas 2012: 246). By definition, any kind of text cannot be considered an objective source of information, since each person has his/her own style of writing, way of expressing and also understanding things. Even before the establishment of archaeology as a discipline, when antiquarians were in pursuit of ancient objects, written records, often accompanied by drawings, were the only means of keeping details for the various events in these quests. As Hodder mentions (1989), archaeological texts have been written in very different ways through time, which is related to the aims of the records, the people these were addressed to and various social, political and economic circumstances. Before referring to specific examples from the two sites, it is worth mentioning how and why written records changed through time.

1.4.a.1. Field Notes through Time

Field notes and site reports started, in the 18th century, as letters sent to a Society or read in meetings and events. Their structure, which was far from what we understand and practice today, included descriptive narrative in the first-person, little quantitative data and imprecision. On the other hand, they provided spatial and temporal sequences, involving participators, actions and thoughts, enabling the interpretation of the site through its description (Hodder 1989: 268-270). A century later, although field notes retained their main characteristics, they gradually became more specialised, with rigorous classifications of artefacts and terminologies to describe the various details. The excavation process gradually started to be described in the third-person passive, therefore providing a sense of pseudo-objectivity (Pluciennik 1999: 667). The death of the author\(^5\) was employed, as it was thought that any kind of rigorous recording can only be achieved after the segregation of the subjective elements and the objective truth (Edgeworth 2006: 27). The narration in the first-person is rarely used, and when it happens, apart from an indication of authority, highlights the fact that a particular description is a production or interpretation of the person that keeps the notes and supervises the excavation.

Over the last several decades it has been realised that distant field notes and monologues could offer very little to the recording and dissemination of evidence and to the discipline in

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\(^5\) cf. Barthes 1977a: 148 for the use of 'the death of the author', which is not about separating truth from subjectivities, but about adding more subjectivities - those of the reader.
general. Several advocates of multivocality and reflexive methodologies in archaeology have tried to incorporate multiple voices, concepts, ideas and arguments, both in field notes during the excavation, and also in final publications and the process of knowledge dissemination and interpretation. To mention a few examples, Flannery attempted to include dialogues between archaeologists (1976, 1982), Bender included dialogues of people in Stonehenge’s publication (1998) and Hodder emphasised the importance of such an approach and extensively employed similar methodologies at Çatalhöyük (Hodder 1997, 2000; http://www.catalhoyuk.com/). Also, the use of hyper-media to explore the dialogic creation of knowledge, such as in ‘Crafting Cosmos’ (Lopiparo 2002: 68-99); as well as the so-called ‘interactive digs’, where the visitors can post their comments, discuss things with members of excavation teams, give their own opinion and ideas and learn by inquiring (Papadopoulos and Kefalaki 2010: 50); these are new approaches to enhance the reflexive character of archaeological practice.

However, from the methodologies employed in the various research projects, particularly in Greece, it seems that ‘lyrical reflexivity’ (Hamilton 1999: 5) cannot gain ground over more conventional and well-established approaches. Besides, there have been concerns regarding the real nature of multivocality in archaeology, as it may be a veneer of polyphony, and just represent ‘multiple instances of the same language assigned to multiple versions of the author’ (Joyce 2002: 11). In this way text turns into a paradox, becoming a single-voiced polyphony or a one person dialogue. The new, persistent trend for distant, pseudo-objective, timeless and impersonal field notes, which are part of archaeological practice up to the present day, started in the 19th century and gradually evolved to the codified sheets enabling a rigorous system of control and standardisation.

According to Hodder (1991: 10), in order to achieve an interpretive approach, one of the essential aspects is ‘guarded objectivity’. Because of the ambiguities of the written records, archaeologists tested and finally employed a series of different recording systems to ensure that any text left after the excavation can reconstitute not only the information revealed during the process, but also the understanding and interpretation of the records. As Shanks argues (1997: 82), this objectivity is strengthened by the accompanying sources of knowledge, e.g. diagrams, photographs and references, which render themselves scientific (and consequently objective), by delivering information in established formats. However, according to Tilley (1989: 278), site reports, and consequently, any other written record is just an interpretation of the excavation, in the same way that a theatrical play interprets the script. This is what Hodder (1991: 15) and Shanks (1992:104) call translation (also see Lucas 2012: 237-243). As a play cannot reflect and communicate the text, written records, and especially these in the form of descriptive narrative, cannot express the excavation as a neutral and scientific record, as it is purely subjective and socially determined. For that
reason, Single Context Recording and Harris Matrices were employed, partially replacing the basic textual field practice, the notebook. However, these systems are not universally employed, and great variations can be found depending on the country, excavated period and project.

1.4.a.2. Harris Matrices, Single Context Recording and Notebooks

The Harris Matrix, invented in 1973, is based on the fact that a stratigraphic unit can only have three physical relationships to another (Harris 1989: 36): equivalent, superposition (earlier or later), none. The innovation of this method is that from two-dimensional sections, which try to depict a three-dimensional world by conflating physical and stratigraphic relationships (Lucas 2001b: 57), the Harris Matrix transforms it into a four-dimensional unit, by visually describing the three physical dimensions and time, which is usually neglected in the archaeological record (Harris 2006: 143). However, one of the critiques for this system lies in the fact that the schematic representation of the contexts in a diagram, with equal size and status, neglects the real relationships of these features (Barker 1993: 229). In addition, it is often neglected that real-world relationships of stratigraphic units cannot be strictly assigned to any of the relationships that a Harris Matrix suggests (Chadwick 1998: 7). Harris Matrices are believed to cover the complexity of the evidence by turning the dynamic interplay between humans and a series of external factors into a static two-dimensional display. Thus, they have been exalted to representations of the sites under investigation, often without questioning or critically approaching their inherent problems and limitations.

It is via the Single Context System that the immediate relationship of any context to another, i.e. the principle of the Harris Matrix, can be established. The main idea on which SCS is based is that ‘any single action, whether it leaves a positive or negative record within the sequence, is known as a ‘context’’ (Westman 1994: §1.2). Pro forma sheets and cards came about in 1975 at the Department of Urban Archaeology at London Museum (now Museum of London Archaeology Service - MoLAS), a period when rescue excavations and preservation by record were growing rapidly in the UK, and the systematisation of recording was considered the ideal solution to the increasing needs of the field. Each stratigraphic unit or context identified is recorded in a separate sheet. Since there is not one established form, these pre-formatted sheets always have a section for measurable attributes, while in some cases there is a section for interpretation, attempting to distinguish facts and the subjective part of the process (Spence 1993: 25-26). In addition to that, since context sheets are completed during the excavation and by people who are actively involved in digging, a sense of facts and objectivity is also conveyed by the actual traces of the excavation on the context sheets, such as blemishes made by soil, smudges and crinkles (Yarrow 2008:13-14;
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see fig. 5). The same applies to field notes (also see fig. 2, 6). However, even though interpretations can be made in various levels (Pearson and Williams 1993: 100-101), they are often limited to the essentials since the initial interpretation has taken place prior to the recording.

SCS was primarily established as a way to achieve coherence, homogeneity and some kind of objectivity. The predefined forms and detailed guidance provided attempt to ensure that, even if more than one person is involved in the recording of the same feature, the result will retain the neutrality, integrity and sustainability of the records. This of course presupposes that the agents of excavation do not produce material culture but in a mysterious way unearth objects which are independent of their actions (Edgeworth 2006: 256). To date however, there is no way to separate context sheets from the subjectivity of the actions involved; and although users of SCS acknowledge that, since there is room for an interpretive approach of the contexts excavated, various levels of detail as well as differences in the language used can be found, they argue that as long as there is a standardised system of recording the basic characteristics of the contexts, free expression cannot affect the quality of the records.

During the last decade, SCS was developed by various institutions into a more dynamic system, by providing more information regarding, for example, the characteristics of horizons, formation of deposits, assessments of their recordings etc. (Adams and Brooke 1995: 102-103). On the other hand, there are alternatives of this recording system that are employed in various projects in different parts of the world. For example, Makriyalos' excavation, as well as many excavations of the prehistoric period in Greece, are recorded following the principles of SCS, though without the use of forms and predefined fields.

For all reasons presented above, SCS has many advocates and opponents. The critiques are mainly based on the interpretive nature of archaeological fieldwork, and the fact that any attempt to interpret the archaeology of a site is limited to the excavated contexts, which are only a fragment of the actual features. The critique primarily focuses on the fact that although the excavated features are a unity, SCS, divides this unity into smaller pieces (contexts); then, these contexts, which are chronologically related, are also shattered in other forms of data (drawings, photographs etc.) and as a consequence, an entity, which can be only understood as an entity and as part of the whole, is divided into several components (Edgeworth 2006: 249). However, even though this division relies on the idea of temporality, contexts are substantially a-temporal (Lucas 2001b: 58). In addition, it should be noted that these predefined forms constrain the actions of those excavating as they do not only control the way that information is recorded, but also how the excavation progresses. My experience in excavations that implement SCS has shown that archaeologists often dig...
having in mind how this information will fit in a predefined field of SCS, also referring to archaeological deposits and structures with the conventional names assigned to them by SCS, i.e. feature, fill, cut etc. In other words, SCS does not only direct the recording of data, but also the people who record, and the excavation itself. Therefore, context sheets become artefacts and archaeologists are the tools that participate in this materialisation.

On the other hand, the proponents of this recording system argue that the division of the excavated features into contexts provides clear steps in the phasing of the site, while the codification of information provides coherence and sustainability. However, through various examples presented below, it can be seen that individuals give different answers even in cases where step-by-step guidance is provided. Based on my experience in archaeological fieldwork, I have observed that if the system is not used by highly trained and experienced staff, constrained recording may have the opposite results. Individuals should be free to express their thinking in a way which will not be codified and predefined. It is believed that this descriptive manner will allow them to enunciate their impression of the site in a way that can be comprehended by themselves, and most probably by other users of this information. Forcing them to constrain their understanding to fixed terms and interpretations might not always be feasible and of benefit to the archaeological information.

1.4.a.3. Writing about Real-world Properties

There has been a great deal of scholarly work regarding archaeological narrative, in terms of knowledge production and dissemination to the research community and the public (e.g. Joyce et al. 2002; Fagan 2006; Galanidou and Dommasnes 2007). Some of this work draws on literary theory and philosophy (e.g. Mikhail Bakhtin, Roland Barthes), and even psychology, but hardly anyone has focused on the narratives employed and produced in the textual recording methods used in archaeological practice (e.g. Hodder 1989), and the way that these compressed two-dimensional records affect the subsequent retrieval and production of interpretation.

The information that can be described through text is literally limitless. The four basic dimensions of narrative: time, structure, voice and point of view (Lamarque 1990: 131) are all represented in archaeological field notes in various ways depending on the recording system employed. However, the way that the evidence is presented in each case depends on several factors, which will be examined in relation to specific recording practices and the sites under examination. One of the most crucial kinds of information that can be derived from textual sources regarding the perception of three-dimensional space is colour and texture, as well as the size of objects and structures, and consequently scale. In addition,
temporality is a crucial variable, which can justify the sequence of layers. However, depending on the recording system used, this information varies; for example, in notebooks where descriptive narrative is mainly used, the identification of colour and texture is largely dependent on the individual. Hodder has rightly argued that 10 archaeologists would give, even under the same conditions, 10 different soil colour gradations (Leibhammer 2001: 83). For instance, what is considered light brown soil by one person may be dark brown for another, and so forth. Although this is rather simplistic, it gives an indication of how elusive and subjective the boundaries between different categories may be. The following examples from Koutroulou Magoula will further illustrate this discussion:

‘(transl.) the colour of the soil is auburn (brown-red) with small pieces of brown – orangish-brown clay’ (Tuesday 1/11/2005, Trench Θ, p. 86);

‘(transl.) at the moment, we are not in possession of a Munsell to check the colour of the soil. In general, it is dark brown’ (15/10/2004, Trench Θ, p. 6);

‘(transl.) at the south part (Γ47) a small area was excavated as an orange-coloured hardened surface was detected’ (Tuesday 9/05/2006, Trench Θ1, Pasa #60);

‘(transl) The soil is compact, clayish orange-pink, fine-grained and locally brownish gray’ (Monday 10/11/2008, Trench Θ1, Pasa #150).

From the vocabulary used by the authors to describe the colour properties of the excavated contexts it becomes apparent that it is not possible to draw any clear distinctions between these descriptions, and to base our recordings on such approaches. Who can really define orange, orange-pink and brownish gray? Is their difference readily apparent to the human eye? How would different people have defined the same colour? In other cases in Koutroulou Magoula, and also in Makriyalos, a Munsell Color Chart was employed to define the colour of the soil and other features:

‘(transl.) It is not clear if it was a hearth...The soil in the interior is dark brown-black (10YR 3/2)’ (28-31/01/1994, Trench H0104, Pit 413 - Makriyalos);

‘(transl.) The soil is 10YR 4/2 dark greyish brown’ (25/05/1993, Trench Θ0122, surface - Makriyalos).

It is also interesting that when a Munsell value is accompanied by a free description of the colour, there is always a piece of information missing or mistaken. In the following example
the fact that, according to the Munsell, the soil is yellowish brown and not plain brown, is not included in the free description:

‘(transl.) The soil is hard, compact, light brown - Mun 10YR 6/4 light yellowish brown (Thursday 3/09/2009, Trench Θ1, Pasa #185 – Koutroulou Magoula)’.

Colour classification is an important issue which has been extensively discussed in the realm of cognitive anthropology (see for example Berlin and Kay 1969 for colour terms and language variability). In archaeology, Goodwin (2000) examined the process of defining the colour of soil in excavations suggesting that it is not only a mental task, but also a situated activity which involves physical tools and embodied practices. Although he suggests that the products of this process are trustworthy classifications, the examples above have shown exactly the opposite. Munsell provides an out of context standard, which is constrained by a series of contextualised spatiotemporal variables. It is not only the glossiness of the samples which are in sharp contrast to the flat colours of the soil, and the way that users perceive these, but also the embodied practices during the process of classification (also see 2.2.b.3).

In the course of this section it became apparent that people use different vocabulary to describe material properties. Since there is the factor of personal judgement, either in free descriptions or with the help of a Munsell Chart, people perceive and describe colours differently. This was also crosschecked with an experiment in which three archaeologists were asked to describe the colour of a patch of soil outside the Archaeology building at the University of Southampton. Apparently, they gave three different responses, and also assigned different Munsell Chart values to the same feature. A similar situation also occurred at the Koutroulou Magoula excavation, when three students from the University of Southampton were asked to assign Munsell values to the context under excavation. Although why their perception of colour differed was not investigated further, it was realised that various factors might have affected their answers; the time of the day and ambient colour, the angle of view, sensitivity to sunlight and any sight disorders to mention a few. Cognitive approaches, such as memory colour (Hering 1964), were not considered at this stage (see 2.1, 2.2.a.).

The description of texture should be considered quite a subjective process as well. In both Koutroulou Magoula and Makriyalos there are descriptions of the various features with words such as relatively soft, relatively hard, softer, harder, moist, brittle etc. In several recording systems though, such as the one employed in Koutroulou Magoula from 2009 onwards, there are step-by-step guides that help in the identification of the texture of soils and sediments by finger testing (fig. 11). Although this should be considered subjective as
well; as the identification of what is rough and gritty or smooth and silky is determined by the individuals that record the evidence; such flowcharts offer greater consistency in comparison to the free descriptions in notebooks.

![Flow chart determining texture of soils and sediments by finger testing from the Koutroulou Magoula Site Manual (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).](image)

On the other hand, although it can be argued that the description of size is equally subjective, in all recording systems employed in archaeological practice, measuring equipment is used, such as scales and measuring tapes, which accurately define the dimensions of the excavated features. Similar to the flow charts mentioned above in the determination of texture, there are similar charts, all of which are employed at Koutroulou Magoula, which help to identify the coarse components, not only regarding their size, but also their density, sorting and shape. However, there is some level of inherent subjectivity to these as well. In addition, to prevent the use of diverse vocabulary regarding the excavated features, there are similar guides that ensure the consistent description of walls and their various characteristics by the team members.

Time, either as duration and succession or continuity and change in one, two, three or more dimensions, is a theme that has been extensively discussed through the years both in
philosophy and social studies, as well as in science. In archaeology, on the other hand, time has only been recently introduced in relation to theory and method, regarding its perception by past societies and archaeologists (Lucas 2005; for an earlier approach to time on a case study basis see Murray 1999). The multi-layered nature of time that defines archaeological interpretation is a complicated issue that presupposes a high level of understanding of the evidence. The identification of time, both in terms of stratigraphical sequences and the steps followed in the actual excavation process can be satisfactorily defined via written descriptions:

'(transl.) After the removal of a narrow strip of soil, part of the cobbled floor was revealed' (Monday 5/12/2005, Trench 0, Pasa Λ'' - KM)

'(transl.) We excavate part of pit 413 in which structure 1 exists (18/3/1994, Trench H0104, Pit 413 - MK)'

![Structural Feature Sheet](image)

**Fig. 12** Structural Feature Sheet - 15/09/2010, Area Θ4. At the low right corner there is a predefined field to specify the temporal relationships of the various contexts (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
In SCS on the other hand, the sequences are defined by the different context numbers and the filling, cut and feature sheets, which have fields to identify the physical relationships with other contexts (fig. 12). In addition, temporality can also be defined via Harris Matrices, which simplify the arrangement of contexts (fig. 13). In that case, however, they only show the temporality of production (e.g. pit 413 was built before the construction of structure 1 in it) and not the temporality of use (e.g. although pit 413 was abandoned, structure 1 continued to be in use for a long time) (Lucas 2005: 39). Yet, all these approaches are limited to the presentation of data, and in no way can compensate for misjudgements or bad excavation techniques and archaeologists. Finally, different excavation methods would have resulted in different spatial and temporal sequences (Tringham and Stevanović 2000).

1.4.a.4. Digital Recording and Management Methods in the Field

Both descriptive narrative and preformatted sheets, and in general any paper-based work in the field, have been replaced lately by digital recording and management systems. Examples are the Archaeological Recording Kit (ARK) and the Intra-site Information System (Intrasis) which are used to record, store, organise, manage, analyse, visualise and publish a diverse range of archaeological research data (for examples on these recording systems and their
principles see: Dufton and Fenwick 2012; Jansen 2013). Also, the Institutional Data management Blueprint (IDMB) aims to produce a framework for managing research data based on current data management requirements of various disciplines (Earl et al. 2011). Digital recording and management systems, which have been designed for capturing spatiotemporal data, impose structures in the way users navigate to the information, determining new ways of exploring, accessing and understanding data. Although none of these systems have been employed in either Koutroulou Magoula or Makriyalos, these systems significantly affect the conceptualisation of three-dimensional information in comparison to traditional paper-based or digital database systems. Dufton and Fenwick (2012: 163) point towards this direction: ‘By manipulating and grouping the elevation distribution of skeletons originally recorded in only two dimensions, and displaying this information in a 2.5dimensional figure, a pattern of possibly discrete grave alignments with matching depth begins to emerge’. However, not only the visualisation of this information, but also basic recording and management processes, such as navigation and linking of data, imposes certain variables to the comprehension of data.

The implementation of Apple’s iPad devices in archaeological fieldwork in Pompeii was a great step towards an alternative approach to hand drawings and printed forms, as all processes in archaeological field practice were replaced by ready-made apps from the Apple Store (http://paperlessarchaeology.com/). However, this is not the first attempt to incorporate Information and Communication Technologies in archaeological fieldwork, and associated research; recently The Virtual Environments for Research in Archaeology (VERA) project (Fisher et al. 2010), and the earlier WearCAM and Chi-3 systems (Cross 2003), managed to significantly replace the necessary paperwork on-site with spatiotemporal entries in databases, making it easier to edit, search and distribute the data. Also, photographic evidence, sketch and advanced drawings, as well as site surveys were also carried out by technologies and mobile platforms already available by that time.

Conclusion

When a big team is involved in the recording, the written descriptions in the form of narrative may range from generic languages to professional jargons, as well as idioms of different generations and age groups, thus diversifying the content and undermining its consistency. Such differences are apparent in both sites, since a great number of people are involved in the projects. However, as the practice of note-taking is currently examined only from the aspect of producing three-dimensional understandings, it is beyond the scope of this thesis to further discuss any general differences observed in the recording of the two sites. Text as a recording method, either in the form of descriptive narrative or context sheets, poses several constraints, since perception is always dependent on the individual.
Moreover, the authors of this information try to transform something which is mainly experienced by vision and touch into a textual description, thus attempting a perceptual leap which is rarely feasible.
1.4.b. Photography

As was demonstrated in the previous section, text permeates all aspects of archaeological recording and research. Although the same is true for photography, its application was initially limited due to several constraints posed by the medium itself, especially closer to its invention in 1839 (Clarke 1997: 12). It was soon adopted by observational sciences, such as archaeology, as it was believed that in that way any subjectivity could be overcome by becoming the memories of the past gradually destroyed in the excavation (Locatelli et al. 2011: 329). Photographs have been used in archaeology as the official archaeological record, which also encompasses the social dimension of archaeology (Bateman 2005: 195), and triggering the memories regarding the processes followed in the excavation (Locatelli ibid.); also as creative-ethnographic installations (Castañeda 2009; Hamilakis et al. 2009). Lastly, photography has also been extensively used as a research tool in archaeology, with characteristic examples being the use of satellite imagery and aerial photography to obtain three-dimensional data and locate archaeological features (also see Pink 2007 for the use of images in ethnography; Collier and Collier 1986 for the use of images in anthropology; Prosser 2005 for image-based research).

1.4.b.1. The Adoption of Photography in Archaeology

Photography as a recording mechanism immortalises the finds by capturing a moment of their exposure. These recordings which are the sole visual witness of the finds’ existence, and therefore comprise records on their own, are also used to support the narrative in the textual records (Shanks 1997: 74). However, they do not only supplement the archaeological process by illustrating textual descriptions, but in fact create narratives of the past which are central to the production of knowledge (Bateman 2005: 193, 2006: 68). The first photograph in Greek archaeological contexts is the Athenian Acropolis taken by Gaspard-Pierre-Gustave Joly de Lotbinière in 1839 and published in Excursions daguerriennes, vues et monuments les plus remarquables du Globe by Noël-Marie-Paymal Lerebours in 1841. The next known photographs are depicted in Conze’s reports (1875, 1880) about the excavations in Samothrace. Archaeologists however were taking photos even earlier, but they were used for the production of wood-engravings (Dorrell 1989: 5-6). Black and white images were considered the standard for archaeological publications, not only because of the technical constraints and costs, but also as black and white conveys truth and objectivity. Colour images were only supplementing these records, since they are associated with subjectivity, emotion and distraction (Scott 2005: 143). However, it was only until the advent of digital photography that archaeologists extensively started using photography as an integral part of their practice.
Archaeologists adopted photography not only because it was attractive as a new medium, but also because it was thought that techniques based on automation and chemistry could achieve objectivity, something that textual descriptions and drawings which always depend on the individual could not do (Shanks 1997: 74). In addition, the fact that photography was invented in a period when nation states emerged, and antiquities could not be easily transported to the metropolitan centres, meant that photographs were the ideal means to facilitate the construction of national identity and the monumentalisation of the past (Hamilakis 2001: 10, 2009: 285). Since accuracy and precision were two of the factors that led to the wider adoption of photography in archaeological practice, scales and measuring equipment were gradually employed for the materialisation and further objectification of these images (Lucas 2001b: 208). Also, strict codes of practice were established dictating the exclusion of objects, people or any other background 'noise' (Witmore 2009: 530), producing decontextualized archaeologies, as the subjects were isolated from their contexts. This practice started much earlier, and not even as part of excavation recording, as can be seen in the photographic record of Félix Bonfils, who attempted to capture a sense of eternity by excluding from his photographs any elements that could distract the audience from the image of the Acropolis (Hamilakis 2001: 9). As Bateman argues (2005: 194), objective distance is increased by burying elements of these archaeologies to history’s anonymity, while the fetishisation of sophisticated photographic equipment is also linked to the attempt to associate archaeological practice with scientific and credible recording.

Photographs create meaning by a series of language codes, which involve their own grammar and syntax. We not only see photographs, but we read them as text, which ingrains meaning, ideology, complexities, power, authority and ambiguities. Additionally, photographs are usually accompanied by words, which often change their meaning (Berger 2005: 4). The latter actually influences the language of photography, as its apparent independence is masked by the textual supplements (Burgin 2003: 131). To an extent, photographs turn into textual objects, since their production, and especially in archaeology, is oriented towards the reader and the activity of reading. Images are also reflections of the photographers, since their intentions, as well as their understanding of the subject-matter play a crucial role in the depiction of the evidence. However, photographs also are a reflection of what cameras are technically capable of capturing. Thus, what we see/read in a photograph is very different to what we are asked to see, something that Barthes (1977b) refers to as denotation and connotation, while the underlying polysemy allows viewers/readers to choose and ignore the signifieds as they see fit (ibid.: 38-39). Barthes in his Camera Lucida (1980) distinguishes two types of responses to photographs: i) studium, which refers to the main point or message of the photograph, the obvious meanings that are available to everyone, and, ii) punctum, which inspires a private and subjective experience, unique for each viewer, without utilising a symbolic system.
1.4.b.2. Capturing Real-world properties

Photography can capture colour, texture, perspective, size and scale, all of which are qualities of three-dimensional space. On top of these we can potentially add time, therefore turning three-dimensional space into a four-dimensional entity. Photographs – *en abîme*, a concept appropriated by Owens (1978) – contain references to the process of photography, and the results always depend on several aspects which are summarised in Stephen Shores’ book *The Nature of Photographs* (1998: 3) ‘*much of this image is a product of lenses, shutters, and emulsions?*’.

While it has been argued that photography’s value lies in the fact that it produces, to a certain extent, an objective pictorial record in comparison to other illustrative techniques (Ivins 1953: 137; Conlon 1973: 55), there are numerous factors that should be taken into account. Lens quality, the medium, the format and processing (digital or chemical) affect the way that reality is captured. The resolution of the image is defined by the detail that the camera can capture; and although the difference between two photographs with a different resolution is barely noticeable on a standard imprint or on a computer screen, high resolution is needed for research purposes, since archaeological features are often visible only as slight variations. In addition, although a standard lens should deal with most situations, a lens of longer focal length does have advantages, the main one being that the working distance can be greater. On the other hand, a lens of wider angle of view would seem useful, when, for example, a group of features needs to be photographed. However, lenses, especially those of wider angle of view, tend to produce distortion at the edge of the field by both steepening perspective and curving straight lines (Dorrell 1989: 25).

Cameras are inherently limited in distinguishing subtle colour/tone changes, which is integral in archaeological practice. Tones are recorded as a fixed series of discrete steps, while poor exposure latitude, i.e. the range between the lightest and darkest parts, should also be taken into account (Hester *et al.* 1997: 166). Gamut, i.e. colour reproduction, depends on the type and quality of films or sensors, as each one has different colour sensitivity (see 2.2.c.1). Even though the latter can be fixed via manipulation of the images in a software package (see Wheatley 2010 for High Dynamic Range Imaging examples from archaeological excavations), these alterations may affect research outcomes. In *figure* 14, the subtle colour variations of the soil can be clearly seen. Although the colours can be described, these variations are not measurable and cannot be calibrated. In other words, the colour response of a particular device cannot be measured or adjusted to a known state. In addition, the colours observed are not the actual colours that would have been seen on-site. This is the result of chemical processes and the reproduction of the photograph through the projector or a computer monitor, but also because of the way that human eyes work under
different lighting conditions. This means that the same image would have been seen
differently at different times of the day (see 2.1., 2.2.a.3.). On the other hand, when black
and white images are used (fig. 15), the idea that somebody gets about the site, especially
regarding colour, is not related to the real world. This can be also observed in figure 16,
where the same picture is presented both in colour and black and white format; it becomes
apparent that colour adds another dimension to the perception of the real world, providing
a sense of three-dimensionality.

Fig. 14 Colour variation of soils. A: Makriyalos’ excavation #K028 2040 - 06/09/1993
(Pappa 2008). B: Koutroulou Magoula excavation Trench H - 2002 (Koutroulou Magoula
Archaeology and Archaeological Ethnography Project)
Fig. 15 Black and white photograph from Makriyalos’ excavation H018-Θ001. Thermal structure 7 at the back (Pappa 2008).

Fig. 16 Colour and black and white photograph from Koutroulou Magoula excavation Trench Θ3 – 18/09/2009 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

Michael Ashley, a professional photographer in Çatalhöyük has mentioned that the captured colour ranges from the ‘mildly inaccurate to the grossly misleading’ (as cited in Leibhammer 2001: 82). Taking Ashley’s words as a starting point, I would like to open a parenthesis about the nature of photography in archaeology. Photography in archaeology has been rarely used as a form of cultural production. At least in Greek contexts, archaeologists only utilise photography’s documentary role – the same applies to drawing – attempting to
capture a moment of eternity and preserve it to perpetuity, rather than to convey memories and feelings or use photographs as forms of experimentation. Photographs' documentary role is exactly what this thesis critically discusses without attempting to include a wider discussion on the nature of photography and its role in the discipline. This is mainly because, the way that photographs have been incorporated in field notes and publications (including Koutroulou Magoula, and also Makriyalos), proves that the notion of cultural production has not yet been assimilated in Greek archaeological practice. This however does not mean that photographers in archaeological excavations only capture neat trenches and clean artefacts; these are the photographs that the directors choose to bring forward.

For example, the photographer and lyrist Yagkos Chairetis at the archaeological dig at Zominthos, Crete, where I work as a supervising archaeologist and IT specialist, is in charge of taking all the usual archaeological photographs; however, he also captures portraits and spontaneous photos of the team members during work (fig. 17). These photographs, although not included in the official field notes, are stored in the excavation's photographic archive, while a few, accompany the weekly reports that are sent to Archaeology Magazine US, Interactive Digs (http://www.archaeology.org/interactive/zominthos/). Thus, in this case as well, the prominent role of photography is to document the evidence; conventional photographs become official, and the rest are either archived, or accompany the public character of archaeology facilitating the dissemination of knowledge to the public.

Fig. 17 Photographs taken by Yangos Chairetis during the 2010 excavation season of Zominthos Central Building, Crete (Courtesy of Zominthos Project).

It is true, however, that in order to get the information needed for a computer graphic simulation, we cannot merely rely on images that depict the social dimension of the excavation (fig. 18), or work as ethnographic installations (fig. 19) and evoke past life ways and structures. Nevertheless, there are certain images that, although not intended to serve strict archaeological purposes, can provide valuable information for a site (fig. 20). These
include things such as scale, additional angles or morphology, because of a potential collage of images, in a way that can be useful for our interpretations regarding lived experience.

**Fig. 18** Photograph from Koutroulou Magoula excavation at the end of 2010 fieldwork season (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

**Fig. 19** Photograph from Kalaureia Project, Poros, Greece used as an ethnographic installation (Kalaureiainthepresent.org – Photo by Anagnostopoulos/digitally processed by Ifantidis).
Going back to the depiction of real-world elements, I will examine the depiction of texture. Photography can give a good approximation of surface detail; however, it usually produces diluted versions because of the way that light is distributed on the subject in conjunction with the angle of view. Although the human eye and touch can clearly identify variations in texture (both visual texture and material texture; see 2.2.a.1), cameras are usually not adequate to capture the whole breadth of information, and therefore produce more even surfaces, in much the same way that diffuse filters work. As far as the depiction of size and scale are concerned, it is obvious that if there is no measurement tool, it is doubtful that they can be accurately estimated (fig. 21). Scales for example are used to enable viewers to construct a sense of three-dimensional space. However, they have been used as a replacement of real-world data, such as human figures and trees, since the latter are usually prohibited in excavation photographs. However, even if scales or other objects of reference are depicted in the images, spatial properties can rarely be accurately estimated, since the distance, the lenses, the angle of view and perspective distort the actual spatial properties (fig. 22).

The relative position of the photographer has a high impact on the consumption of the scene, as the perception of an environment changes when you are lower or higher in relation to it (fig. 23). In addition, the angle of view of the image and the distance from the subject are parameters that should also be taken into account, since they cause various types of distortion. In figure 24A for example, the excavated context is an oven. The way that light interacts with it, in conjunction with the angle of view, results in an incorrect perception of its actual three-dimensional properties; its depth, the actual dimensions, or its
texture in certain areas cannot be really understood. On the other hand, **figure 24B** is a photograph that was actually set up to reveal as much of the evidence as possible. Therefore, it becomes apparent that the angle of view of the image, as well as the distance from the subject, causes perspective distortion, and therefore the apparent relative distances and sizes differ from what would have been experienced on-site. Also, photographer's choices regarding lighting and framing, as well as the stored file format, result in a photograph that is very different from what we would have seen in reality (Savedoff 1997: 202).

Fig. 21 Photograph from Makriyalos’ excavation without a scale - Borrow Pit K (Pappa 2008).

Fig. 22 Photograph from Makriyalos’ excavation with a scale - Ditch A, phase I. Multiple Pits (Pappa 2008).
The way that each person experiences a photograph, and becomes embodied into the archaeology of a site, also depends on the way that they virtually position their body in the scene. The position of the viewer coincides with the position of the photographer, while the perception of the site is enhanced by brain’s ability to compute standard cues of perspective, such as the size of the objects and the texture of the surfaces (Snowden et al. 2006: 214-216). To the latter, we should also consider Gombrich’s notion (1969: 56) that meaning is constructed ‘from the elements of possible solutions we have stored’. Gombrich suggests that the meaning of visual information is automatically constructed by drawing from frames of reference that we already have. This means that the perception of the world is formed, without actually knowing the individual components that influenced this process. The example of a marble statue of a human wearing a garment can be applied in most cases. Although what we see is a block of processed marble, we perceive the human body underneath, since we are familiar to this information (also see 2.2.a.2). This kind of automated interpretation, which involves the notion of imagination as well, is apparent in archaeological practice; for example, when we excavate a Neolithic settlement, the discovery of mud bricks indicates a house. This is not because we see the house, but because we know that in Neolithic settlements we expect, among others, to find houses made of mud bricks.

![Images of Koutroulou Magoula excavation from different viewpoints](Fig. 23 Photographs from Koutroulou Magoula excavation taken from different viewpoints – Building 1 (Images author’s own).)
It is also worth mentioning the issue of time. Primarily, photography provides a sense of time through the depicted subjects and the implied actions. Also, viewers provide their own sense of time, as soon as photos are contextualised within their own history. However, it has been argued that photography lacks temporality (Shanks 1992: 147; Wollen 2003) and although it captures situations that have certain qualities related to time, these moments are depicted without duration or any other reference to time; thus, photographs fix a moment in time, capturing a moment of eternity (Hauser 2007: 83). In order to achieve the temporality that text achieves through narrative, photographs need contextualisation. Trying to contextualise and consequently interpret an image, involves the collage and montage of information, which result in a photowork, which is not an innocent translation of evidence (Shanks 1997: 80-88).

The technique of photomontage was adopted in the 1920s by Russian Constructivists and Dadaists as a political practice, while Heartfield in the 1930s produced photomontages to illustrate that a photograph cannot tell the truth, and any facts are in reality social constructs. However, their point was not to annul the fact that photographs integrate some evidence, but to argue that their truthfulness has been overrated (Rosler 1991: 59). On the other hand, it has been argued that photographs work as evocative media, recalling memories, evoking multisensory experiences and even movement, implying the passing of time. Photo albums, for example, construct narratives based on the possessor’s self-reflexion on the passing of time (Walker 1989; Hamilakis 2009: 289). Lastly, time can also be tracked through the patterns of light and shadows. This is clearly observable in time-lapse photography which is often used in archaeology as a way to capture excavation as a process and not as a series of discrete steps with the intermediate information missing (Cole 1972).
While we look at photographs as historic records, they actually isolate the objects from their history, only preserving the moment of their own making (Shanks 1992: 146; Clarke 1997: 24). This has been criticised by Meyer (1995:21) as reality being richer than an isolated moment. Even though the objects, people and sceneries depicted no longer exist, as this moment has passed, photographs can reveal evidence both about the world captured, but also about the world that produced these images (Clarke 1997: 25). In the case of archaeology, photographs can ‘speak’ about archaeologists, fieldwork practices, as well as the social dimension of fieldwork. However, although images by definition are considered realistic, they only provide a mental picture of things, hiding more than they reveal. The depictions of reality are filtered through the lenses, becoming flat, a-temporal, enclosed in a frame and focused on particular subjects. As these four elements cannot be applied to the observation of the real world, photographs’ relationship with reality is only superficial (Szarkowski 2005: 23-24; Shanks 1997: 80). Sontag on the other hand (2003: 60, also see Kracauer 1960), contends that photography not only metamorphoses reality, but actually cannibalises it, producing art, rather than recording facts. However, taking into account photography’s use in Greek archaeological practice, delving into the debate on its nature as art or non-art is out of the scope of this research.

This discussion on capturing real-world data suggests that the motto that ‘camera never lies’ is actually incorrect. Both in the photographic and post-photographic (Ziff 1991: 150; Mitchell 1992) or digital era, images always lie about what they capture, as they are ‘une brutalité concluante’ (Salzmann 1856, as cited in Bohrer 2005: 181). The latter means that photographs do not objectively capture, but they possess an interpretive role which derives from both the photographer and his/her choices, as well as the depiction of the subject. A photograph not only proves that the depicted subject happened/existed for a moment in the past, but also helps the viewers to recall memories regarding other moments close to these of the photograph (Bardis 2004: 209). Still, even these evoked memories are affected by the different kinds of gaze ingrained in the photograph and accrued from its context (Lutz and Collins 2003). This brings to mind the different ways that photographs have been manipulated in advertising and journalism to engage audiences (see for example Page 2006; Schroeder 2008). Surrealists also exploited the power of photographs, dislodging them from their context and assigning new roles to them. By using different techniques, such as multi-exposure and a variety of lenses, the images were rendered uncanny, in a way that made viewers feel manipulated and confused (Krauss et al. 1985). In archaeology, the situation is relatively the same: photographs are used out of context, along with other images and text focusing on specific aspects, and therefore are to a certain extent manipulated to represent in a seemingly unbiased manner the remains in a particular moment in time. The latter has been intensified in the New Information Age, where the integrity of photographs is dubious, as all of them are retouched, even though the result remains naturalistic (Shanks 1997: 92).
1.4.b.3. Photography in the Digital Age

Technological innovations are moving the very nature of photography towards electronics, turning photographs, which once existed as multi-dimensional objects in time and place, into a series of electronic pulses and intangible substitutes (Edwards and Hart 2004: 1; Sassoon 2004: 200). Photography, which has now moved from the chemical darkroom to the electronic interface, has started to replace more traditional methods of documentation, such as hand-made drawings. In the digital era there are conflicting views arguing for the nature, use and manipulation of photographs under this new prism. On the one hand, it is suggested that in contrast to photographs’ traditional manipulation techniques, which did not provide the means to affect their integrity, new imaging technologies can alter their content and meaning (Ritchin 1990: 29). Since digital photography provides endless ways to construct visual information and understandings – electrobricollage according to Mitchell (1992: 7) – the boundaries between the principles that distinguish painting and photography fade out (Savedoff 1997: 212). This is also enhanced by the fact that in the digital era, we increasingly think of them as manipulable, in the same way that a painter can alter colours, sizes, perspectives and views. In several cases, my initial discomfort due to a not so good picture that I have taken, gives place to a sense of relief, since some processing with a computer software can make it presentable. On the other hand, there are rational voices that argue that computer simulated photography can result in no loss, since the qualities of the real world have been already lost by the photographic representation (Kember 2003: 202) and what is actually faked is photographic realism and not reality (Manovich 2003: 246).

These discourses regarding the nature of photography did not derive from the so-called digital era, as the age of mechanical reproduction (Benjamin 2007) had primarily brought to the forefront this diversity. Images or works of art were no longer dependent upon their original contexts, and were open to multiple meanings and interpretations, in the same way that digital photographs are produced, reproduced, transformed and simulated, therefore becoming isolated in space and time (Lister 1996: 267). I would argue that this discussion has become dated, not only because digital photography has dominated practice and any manipulation is integral to it, but also because it has been realised that the alteration of reality does derive both from the manipulation of the images and the medium itself. As it became apparent in the previous pages, a series of variables that depend on the limitations of the medium, as well as photographers’ choices distort reality; photographs, either in the analogue or in the digital era, were never an objective and unbiased way to view the real-world.
Some of the constraints already described in the previous sections, such as the effect of distortion, can be partially or completely overcome when computational methods, such as rectification and orthophotography are applied, which can amend any problems caused by conventional practices. The resulting measures can be fairly accurate if such processes are followed, allowing an improved perception of three-dimensional space and precise dimensional data (Locatelli et al. 2010: 165-166); however, most of the perceptual issues that photography poses will persist. For example, although it is possible for a photographer to manipulate a photograph to vividly depict textures, either during the capturing of the image or in post-processing, it is not usually done, as the pace of the excavation does not allow these seemingly unnecessary tasks.

This chapter is mainly dedicated to the theoretical debate regarding the constraints that the various recording methods pose, and most of this section is focused on the fact that photography diminishes, or at least alters, the archaeological evidence. It is worth mentioning, however, that it can also have an enhancing role by turning the images into artefacts, in a process that Bohrer (2005: 183) calls ‘archaeologisation’. Computational photography has provided the means to enhance recording and consistency, often overcoming the issues posed by more conventional methods. An example of that is the application of raking light, such as Polynomial Texture Mapping (Earl et al. 2010a, Earl et al. 2010b; Goskar and Earl 2010), which produces interactive photographs providing flexibility to the viewers and augmenting surface details. Laser scanning and especially photogrammetry applications have also been used in archaeological projects in an attempt to enhance the recording of the evidence by capturing all three-dimensional components of artefacts and structures. Although laser scanners produce a much higher level of detail in comparison to photogrammetry (though photogrammetry can produce highly accurate results with low-cost equipment when a rigid workflow is followed), the implementation of each technique depends on the resources of the project, as well as the purpose of such applications and the desired outcome (for details on the application of RTI, photogrammetry and laser scanning see 2.2.b.1., 2.2.b.2., 2.2.b.3.).

Conclusion

The fact that the perception of three-dimensional space is formed by our binocular vision, and a photograph actually flattens the captured space, results in relationships between the depicted subjects that did not exist beforehand. Therefore, as there is almost no way that we can overcome the various constraints that photography poses, we have to learn ‘seeing photographically’ (Weston 2003), rather than perceiving our subjects as self-explanatory realities. Though I agree to some extent with the concept of evocation, and the fact that photography is an evocative medium that should be perceived in an embodied view,
archaeological practice has shown that photographs should be treated as signs to be deciphered, rather than anything else. Although the recreation of the past by evocation is an interesting heuristic source, it should be carefully employed, as it cannot be applied to everyone and in all contexts, since in order to achieve some kind of evocation presupposes that the individual should have experienced a similar feeling at least once, or he/she has something in common with the evoked context.
1.4.c. Drawings

When we hear the word drawing, especially in relation to archaeology, our mind goes to a sheet of permatrace or millimetre paper often blemished by soil, and a pen. As it will be highlighted in this section, most literature to date focuses on this quite narrow conception of drawing; especially in the context of Greek fieldwork projects, drawing has been rarely seen as a transformative practice which can creatively engage and produce experimentations and alternative understandings. However, recent developments in archaeology and the social sciences, have given emphasis to several, often neglected aspects of its practice. It is not only the technological dimension of drawing, i.e. drawing in digital environments with computer-aided design and drawing software packages that thrive in archaeology, but also its artistic dimension, as well as its creative power (see for example Ingold 2011a). Thus, drawing nowadays encompasses notions of sound, video and performance. In these contemporary practices, the human body has a distinctive place as a means through which visible or invisible marks are produced (see for example Ingold 2007, 2011a, 2011b). Even in archaeology, drawing is nowadays seen as a learning process which can generate new questions and understandings (McFadyen 2011; also see Wickstead 2013 for archaeological drawing in the context of contemporary art). However, as the practice in Koutroulou Magoula and Makriyalos, as well as in other field projects in which I have participated, shows, drawing in archaeology is quite anachronistic, since it is limited to the established view; drawing is synonymous to pen and paper, helping archaeologists to produce a record after practice, i.e. excavation, and decipher material relationships which are not understandable by any other means. For this reason, the discussion will only focus to the fetishisation of conventional drawing practice and the conventionalisation of three-dimensional information.

Drawing dominates archaeological practice, both in excavation and post-excavation stages, existing as plans, sections and elevations for archiving, reports and publications. Although drawings have their own essence, most often accompany text and photographs, offering a visual summary of information, and demonstrating excavation processes and interpretation through a series of conventions. These established conventions, however, result in a great loss of information, which has also being voiced by the people that extensively produce these genres in their everyday practice (Leibhammer 2000: 129). Drawings can be schematic, interpretative or pictorial/naturalistic (for a brief discussion on schematic and naturalistic approaches of drawing in British field archaeology see Bradley 1997: 68-70), translating three-dimensional information and transforming a colourful and freely defined real world, into a flat, linear and colourless production (Piggott 1965: 165). The process of communicating information by drawing, is similar to using words in textual description and verbal skills in discourse (Hope-Taylor 1966: 109). The schematic drawings – usually
referred to as scientific (see Topper 1996: 236 for a definition of scientific illustration) – are most often these used in recording and research, while the most appealing and naturalistic images are mainly aimed at the public in museums, popular magazines and the internet.

1.4.c.1. Drawing Fetishism

Although current archaeological practice indicates that drawings are considered one of the most objective sources of information, probably because of the analogue media used in their production (e.g. paper and pencil), in fact they are highly subjective, as they depend on individual skills and decisions about what to capture and how. Drawings have their own essence both during and after an excavation, comprising a materialising strategy through which ideas and concepts can be explored and discovered (also see 5.2.c). Especially in academic contexts and particularly in archaeology, drawings supplement text and vice versa, as they both convey information that cannot be easily presented by other means. Moreover, they are often understood only after they have been seen in parallel with it (Knight 1985: 106-107; Baigrie 1996: xviii-xix). In the section on photography I briefly talked about the fetishisation of the medium, arguing that photography has been turned into an artefact. In the case of drawings, the same or even greater fetishism exists, as they are treated as a ‘valuable social currency’ in the discipline (Bateman 2006: 80).

While archaeological thinking and interpretations always change, drawings remain intact. Thus, archaeological drawings act as a reference when returning to the initial considerations, and trying to understand issues that were originally omitted or neglected (Wickstead 2008: 27). The draft drawings completed on-site on millimetre and permatrace paper are gradually turning into inked drawings for the year’s reports and final publications. Therefore, the known subjective and interpretive nature of this recording mechanism is transformed into a pseudo-objective entity that provides integrity to the completed work, while establishing its content as facts and knowledge. In contrast to photography, which draws the viewers into the scene as they virtually place themselves at the position of the photographer, drawings enhance the sense of pseudo-objectivity by not incorporating any information about the position of the draughtsman. In that way, viewers become disembodied observers of evidence captured by people, who have not left any sign of their own positionality in the image.

The nature of visual imagery, especially concerning the methods employed to construct popular images of the past, the conventions used and their impact on public perception, have been extensively discussed in the past decades, mainly in the work of Moser (1998, 2001, 2003, 2012; also see Waterton and Watson 2010 on culture, heritage and representation). On the other hand, the problematic aspects of scientific illustration have
been largely neglected. Drawings were employed in parallel to written descriptions, as a way to enhance scientific objectivity. The level of clarity was gradually increased and adapted to facilitate the growing needs in the field by establishing a visual vocabulary, in order for the drawings to be comprehensible by everyone regardless of their language, area of interest or the country that they are working in (Hope-Taylor 1967: 181). Drawings were employed as a recording practice long before photography, and are ranked higher in the list of good practice, as the human eye can distinguish subtle details that the camera cannot. The latter can also be seen in everyday archaeological practice, where important finds are photographed to render fairly accurate position and arrangements, and thereafter, are drawn to make up for the salient information not captured through the lens. A characteristic example is archaeological stratigraphy which is primarily based on the details that the human eye can pick and then translate it into a drawing. Although it is not possible to identify the first drawing ever produced in this context, it is not in question that drawing was, and still is, a convenient practice to accompany any textual information, providing a chaff that asserts the validity and objectivity of the record; this is what Moser has described as the ‘fascination, indeed obsession, with the visual’ (2001: 266). This notion is also supported by early English archaeological practice, where both Flinders Petrie (1904: 114-115) and Pitt Rivers (Piggott 1965: 174) were arguing that a site can be best described by illustrations, and secondarily by text, to let the readers make their own decisions and use text only to co-ordinate their thoughts.

Fig. 25 Drawing from Koutroulou Magoula excavation Trench H - 21/05/2002. The use of pencil along with the amount of information and the common patterns used throughout for all the finds make the understanding of evidence difficult (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
In spite of the complete integration of digital technologies in archaeological practice, the status of conventional drawings is unharmed, not only supplementing it, but also asserting their own independent status. In the same way as field notes and photographs, drawings encapsulate three-dimensional information, presented with a series of two-dimensional conventions, which render schematically the original, therefore resembling an abstract relation to the real. This means that the deciphering of these drawings requires familiarity with the conventions and specialised skills. The most usual convention is a high contrast depiction, with black ink singular lines on white background, leaving no room for ambiguities and arbitrariness. Most often, only the outline of the features is depicted, while areas with special interest are shaded, hatched or patterned in the same colour. Beyond the basic information that is captured (shape, position, arrangement etc.), essential details, such as colour, texture, light and shadow are completely lost, which however, are partially depicted or described in the other recording mechanisms. Also, archaeologists’ choices on what to include and omit in these records, in conjunction with external perceptual factors, such as lighting conditions, further affect the integrity and the presumed objectivity of the data. Because practitioners are well aware of the various constraints of these methods, they often try to include as much information as possible to compensate for the loss of data. However, the collection of such a large amount of data in a single drawing by means of labelling, legends and textual clarifications in an attempt to maintain the integrity of the work (fig. 25), may confuse or mislead the readers, rather than clarify the evidence presented. Different categories of information may not be easy to absorb in a cluttered drawing, especially if the dataset is dense.

1.4.c.2. Drawing Real-world Properties

As in field notes and photography, drawings are used to describe certain qualities of the three-dimensional world, which are transformed and lost during the excavation process. Depending on the accuracy needed, the shape and size of the features can be derived from techniques such as triangulation or simple measurements, which are in turn translated into lines which flatten their form into two dimensions. As can be seen in any drawing manual or guides to archaeological excavation, the edges of the objects become fixed, their silhouette is clearly defined and the black lines used delineate space (Ford 1993: 319). This is something that human binocular vision cannot do, as outlines are diffuse and multiple, objects are moulded with their background and surrounding objects, and lines never actually close; in the real-world, objects do not have clear edges and their surfaces are continuous, while the notion of flatness cannot be really applied. The sense of three-dimensionality is completely diminished by the conventions employed, while personal choices, the angle of view and perspective distortion cause further misjudgements regarding shapes and edges (Griffith et al. 1996: 97). On the other hand, spatial information, such as
holes in the ground, levels or slopes can be adequately depicted, as the conventions used are well established and understood in archaeological practice. In cases where these conventions are not followed, the information may still be comprehensible at intra-site level, but most probably it will not be the same for readers who are not part of the team.

Fig. 26 Drawing from Makriyalos’ excavation Trench Ө026 – Pit 57 (Pappa 2008).

In the drawing of Pit 57 from Makriyalos (fig. 26), all these established conventions become apparent. Black and white colour is used throughout, while patterns and shadings are employed to provide a sense of volume, as well as an idea of the objects’ attributes, as there is no accompanying legend. Levels and the North arrow are included, while from the various finds depicted, only the stones, pottery, a figurine and probably some stone tools can be clearly identified. The rest of the finds cannot be easily recognised, since they do not resemble the real-world equivalents. If the drawings are seen side-by-side with the textual description someone can read:

‘(transl.) At the north part of the pit there is a pile of unworked stones. It contains many finds, clay and horns…near the pile of the north part, an intact marble female figurine was found, along with clays, pottery, a black carinated vessel and a few smaller finds (1 flake, 1 blade, 1 quern stone, 1 ground stone, a bracelet made of spondylus *gaederopus* and 1
arrow head). The pit also contained many bones and shells, as well as lots of coarse pottery’ (Pappa 2008: 242).

Even with the above description, most of these finds cannot be identified in the drawing, at least by the people who were not involved in the production of this record. Therefore, it is clear that even when the conventions are followed, drawings cannot depict the full range of real world information, thus limiting their use to authoritative presentations of an ostensibly accurate method.

The accurate documentation of colour variation in soil or other features is essential in the understanding of slight changes in contexts; however, this cannot be satisfactorily depicted in drawings, since most illustrations are in black and white format. On the other hand, coloured plans and sections, a practice coming from Germany, which has also been followed at Koutroulou Magoula, is a method to overcome several of the perceptual constraints described so far. In most of the drawings from Koutroulou Magoula (fig. 27, 28), colour has been used to separate information and give visual acuity, so as to more easily distinguish different objects and subtle variations. In figure 27 the colours used, along with the informative legend, provide a relatively clear indication of the features depicted, in contrast to black and white and the more naturalistic drawings. This is partly because of the ‘memory colour’ (Hering 1964), according to which people can more easily identify objects which are connected with a particular colour; for example, soil is expected to be brownish and not purple. However, the fact that orange is used for clay, on the one hand may give a good initial indication that a particular feature is made of clay, whereas on the other, the colour used does not depict the actual values. In figure 28, a similar colour drawing is depicted; in this case, the colours used (purple, red, yellow, orange) have an opposite result. The strong and unnatural colours, in conjunction with the complex pencil-drawn silhouettes, and the fact that a legend does not accompany the drawing, cause confusion to the viewer, providing almost no indication of the actual features that are schematically depicted.

A way to overcome the constraints posed by colour coding is by adding textual information in the drawing, such as the values obtained by the Munsell Chart or a legend explaining the equivalents for the colours used (fig. 29). Although we cannot argue that the inclusion of colour in the drawings provides a three-dimensional perception, it, at least, offers an enhanced understanding of the various features (for the use of colour to augment two-dimensional information see Tufte 1990: 81-95).
**Fig. 27** Drawing from Koutroulou Magoula excavation Trench Θ – #IE – 11/11/2005 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

**Fig. 28** Drawing from Koutroulou Magoula excavation Trench Θ1 – #30-33 – 01/12/2005 (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
The depiction of texture is equally problematic, as any indications heavily rely on conventions, which most of the times are site-specific, since there are not any established patterns for all textures that can be found in an excavation. Although stippling, hatches, lines, gradations of tone and other conventions can be used to indicate a particular type of texture it is doubtful that the viewers can understand the real-world equivalent. In this case too, apart from the descriptions included in the field notes or any other indications portrayed in the photographs, labelling can be employed to partially overcome that constraint. In most cases from both Koutroulou Magoula and Makriyalos, it was observed that no indication of texture was included in the drawings, while the information presented in the field notes were hardly adequate to construe the tactile properties of the excavated features. For example in figure 30, where a thermal structure found in Makriyalos is depicted, it can be clearly seen that the illustrator tried to give a sense of volume, with different tones of black and white used for the filling of the outline. In addition, this gives a sense of irregularity and roughness, which however cannot be examined if not seen in conjunction with text and especially photographs. In the case of thermal structure 14, no photographs exist, and the textual evidence does not preserve any information related to the actual properties of this feature. Therefore, this piece of information is lost.
As far as the depiction of time is concerned, the same principles as in the other recording methods apply to drawings as well. Harris Matrices, which can be considered part of textual recordings or drawings, as they are interrelated, are used to depict the spatial and relative temporal sequences of the excavated pasts, with the various constraints presented above. The progression of time is represented by the successive strata, which are illustrated individually in plans, in sections as slices of time, or in stratigraphies. Sections follow similar conventions, although it cannot be said that these are universally applied and understood, as to a great extent they are site specific or even depend on the individuals (Marshallsay 2008: 32-33). The sense of time cannot be depicted in any other comprehensible way in drawings, and therefore their simultaneous examination with textual data is essential. In cases where section drawings or stratigraphies are not produced, relative time sequence can only be understood via the written records, and the sequence and interrelation of contexts in the Harris Matrix. In figure 31 from Makriyalos, one can observe the successive layers found in the square P0424 in Ditch Γ. The law of superposition makes it clear that the oldest strata are at the bottom, while the youngest are at the surface of the trench, therefore highlighting the chronological order of the finds. This can also be contrasted with a photograph of this feature (fig. 32 – this is a photograph of Ditch Γ in phase I; there is not an image of this particular square) and the written description:
‘(transl.) Under the large superficial layers (1, 2), a layer with many finds and shells exists (3). In this layer, there are stones from a well which was probably built across the east part of the trench. The shells are many, and they locally form layers. The lower deposits where the bedrock and stones have collapsed, do not give lots of finds’ (Pappa 2008: 147).

However, in cases where the strata are disturbed, or the horizontal layers of the sites are ignored (Harris et al. 1989: 1), accurate chronological interpretations cannot be provided. In figure 32, which depicts a finished context of Ditch Γ, it is difficult even for an experienced eye to distinguish the sequence of different layers, or any other temporal indications.

![Fig. 31 Drawing from Makriyalos’ excavation Ditch Γ, P0424 (Pappa 2008).](image-url)
Similar to the notion of evocation in photography, it can be argued that the memory of the people who experienced a site can constitute the essential information lost in the drawings. Although this is partially true, Leibhammer (2001: 72) has argued that the concept of spatial and temporal recreation by recollection can only be applied to individuals, since experiences and memories are personal and cannot be shared with others. Therefore, this concept may be useful only for the individuals that have experienced the site, but it is of no use to the discipline in general, where access to the knowledge should be uniform.

Although in the real world, colour, texture and volume is enhanced by the interplay of light and shadow, in drawings this information is completely lost, as the guides for good practice suggest that light and shade should be omitted, otherwise the drawing may be misty and confusing (Griffith et al. 1996: 100). An interesting approach regarding drawings in archaeological practice can be found in Leibhammer’s Rendering Realities (2000: 129-142), where she contrasts the drawings of a wall rendered according to artistic and scientific conventions (ibid.: 139). Although the conventions used in the scientific rendering are well
known in archaeological practice, an unfamiliar viewer can hardly describe the three-dimensional properties of the wall, therefore compromising the utility of these established conventions (Baigrie 1996: xxi). On the other hand, people that are aware of the conventional way of drawing can easily distinguish the areas of the wall that are flat, shallow or hollow. However, looking at the artistically rendered drawing, and observing the use of light and shadow to highlight surface variations, and also the inclusion of highly detailed textured surfaces, it becomes apparent that the three-dimensional sense, even in black and white format, is much more enhanced in comparison to the diagrammatic version.

Conclusion

From the examples presented above, it becomes apparent that rarely can a drawing on its own be considered an adequate mechanism for the depiction of three-dimensional information, as there are various constraints that pose several limits to the perception of the real world. Apart from the various perceptual factors, and the weaknesses in attempting to depict the real evidence on a two-dimensional surface, we should also consider that drawings always vary, as they are personal responses to the perception of a trench, contexts and finds. This means that different archaeologists would have chosen other features to include and omit, and possess another style and view point, and thus their own interpretations. Contrary to Bateman (2006: 72) who argues that ‘excavation plans are very physical things, unwieldy to unwrap and view and sensual to touch, sight, and even smell’, under the principles examined so far, drawings cannot adequately give an idea of the third-dimension, and can only evoke that sense to the people who are familiar with the sites. In addition, because of a gradual depreciation of the practice, drawings have been relegated to almost an honoris causa role; Although they comprise artefacts of the excavation, their role is diminished to the reproduction of the pseudo-objective presentation of the evidence, and the authority of the archaeologist, implying a precise excavation method that resulted in an accurate and sustainable record.

Until a few years ago, it was suggested that the conversion of three-dimensional information into a ‘flatland’ is a necessary step (Tufte 1990: 12-35) to make the recovered information widely available to the research community and the public. Although it is not anticipated that drawing will be abandoned in the foreseeable future, the growing application of computational photography and the encouraging results show that we steadily move on to a new era, where conventional practices will be gradually replaced by more sophisticated approaches that provide the means to overcome the ambiguities of established practices. At the moment, however, that drawing is fundamental in archaeological practice, it might be worth incorporating as much of the available evidence as possible in a comprehensible way, such as layering and separating information, adding colours and tactual properties, and also
attempting an interference of light and shadow. Although this does not guarantee that we will escape from the flatlands we produce, we can at least, add another element to the second dimension, augmenting the perception of the recorded information and, consequently, coming closer to the real world.
1.4.d. Video

Contrary to other branches of the social sciences, such as visual anthropology, where video recording, along with more conventional recording methods, has been extensively used and debated as part of the research process (see Rosenstein 2002 for a literature review on video recording in the social sciences; White 2009 for the introduction of the term Ethnography 2.0), archaeology has made use only of text, photography and drawings as its main recording practices. Moving pictures, on the other hand, have been shyly employed in a few cases to enhance on-site recording.

1.4.d.1. Video in Archaeological Excavation: Problems and Perspectives

Hanson and Rahtz (1988: 108) refer to several field projects that have employed video recording in the 1980s, while the most prominent example comes from Çatalhöyük, where video recording has been used since 1995 (Brill 2000; Stevanović 2000b) and films from the 2004 to 2008 seasons are available online at the official website (http://www.catalhoyuk.com/media/video/index.html). In this case, the videos recorded comprise a diary, in which discussions with the field directors and members of the team, as well as simple recordings of the excavation process are presented. More recently, Looxcie wearable cameras have been used at Çatalhöyük and also at Portus, Italy to document thoughts and discussions during the excavation. In a Greek context, video recording has been applied only in a few projects, such as in Makriyalos’ excavation in the 1990s and in the Zominthos Project from 2005 onwards (http://www.archaeology.org/interactive/zominthos/), in which it has been mainly used as internal archival record rather than for public consumption. However, a Looxcie wearable camera was used in Zominthos’ 2012 and 2013 field seasons, in order for the supervising archaeologists to record the process and progress of the excavation; however discussions or other background noises were kept to the minimum while capturing was in progress. Therefore, video recording turned out to be a fast sequence of silent photographs. Some of these videos have been uploaded in American Archaeology’s Interactive Digs section (http://interactive.archaeology.org/zominthos/category/video/).

Lastly, apart from archiving, videos have been also used to produce educational films, such as in the Sphakia Survey Project (Nixon 2001) and the excavation at the peak sanctuary of Vrysinas, Crete.

The employment of video recording, a relatively recent invention, most probably derived from the desire to capture all aspects of excavation in a way that is not feasible with the other recording methods examined above. It is understood that crucial information may be missed during the excavation of a feature, and photography will not always be able to capture that moment, considering the fact that photographs are mainly used to record
intermediate or finished states (Hanson and Rahtz 1988: 107). In that way, video recording is potentially useful for the recording, interpretation or even publication of the site at a later stage. This is because it does not merely transform the same evidence into another format, but actually has an integral role in the reasoning and interpretive process, in the same way that narrative and contexts work in field notes or visual information in photographs and drawings (Stevanović 2000b: 238). Therefore, video recording provides another type of data, preserving evidence from a different point of view regarding the history of the multidimensional dialogic process between recording and explanation (Farid 2000: 26).

Although video is considered an auxiliary recording practice, and for this reason there are not any established conventions that can ensure the consistency and standardisation of the record, it can be used as part of the main visual archive, and be supplemented with audio and/or textual information. However, it does not only work as a recording mechanism for the process of excavation itself; it can also capture other work, visits and discussions, immortalising the social aspect of archaeology in a way similar to photography, also involving the arousal of more senses, by incorporating sound and contextual information. Discussions in or by the trenches during the excavation, around topics closely related to the archaeology of the site or not, are a source of ideas and information concerning the excavation, not only as a method for revealing the past, but also as a social arena where relationships, status and politics are produced, moulded and shattered.

In contrast to textual records, which in an attempt to create an unbiased archive, eliminate the use of the first person narrative, video recordings always have a connotation of the person involved, therefore creating an immediate connection with the audience (Brill 2000: 232). The moving images provide a better sense of reality, as viewers subconsciously position themselves behind the camera. Since video is *par excellence* a temporal medium, it can offer choices that even real experience cannot (Hall 2000: 657). By pausing, slowing down or going back to a previous frame sequence, viewers can observe, detect and clarify details that might have been impossible in real time experience, as each moment is unique and cannot be ever repeated. In this way the various events can be followed retrospectively, which is very practical, especially in excavation projects such as Makriyalos, where a large team was spread across different areas, thus making it difficult both for the directors as well as other team members to keep track of the changes, which due to time constraints cannot be always described textually or recorded visually (Brill 2000: 231). In addition, as frames consist of camera movements, which over time change the field of view, perspective, resolution etc., viewers’ attention can almost simultaneously focus on particular scenes or features, which is not always feasible in real-world experiences (Teodosio and Bender 1993: 39).
Video recording has certain advantages over the use of photography, but there are also several constraints. As it is only a supplementary practice it involves extra cost, not only for the equipment, but for the operator as well, who, if not a professional camera-operator, or possessing relevant experience, may produce results that are far from those expected. As in photography, the quality of the captured sequence depends on the person that uses the video camera, as well as the quality of the equipment. However, the advent of digital cameras has not only significantly reduced the cost, but also provided solutions regarding the format of the records and their sustainability. Because of time and other constraints involved in large excavations, such as in Makriyalos where the infrastructure work was exerting great pressure to the team, certain features are selected to be presented or omitted according to their significance and archaeological importance (Brill 2000: 232). The selective process works the same way as in the other recording methods, where the photographer, illustrator or archaeologist intentionally or unintentionally chooses the details that are going to be preserved or discarded. Consequently, the chosen feature will be recorded out of its full context (e.g. recording only two of the three pits that belong to the same cluster of dwellings), the same way that photography isolates the subject from any contextual information. Although under these circumstances video recording creates fragments of the already fragmented archaeological evidence, if it is used consistently along with the other methods, the final archive can be of great significance, as any data would be cross-checked with these produced by other means, resulting in a multivocal record (Stevanović 2000b: 236).

In Makriyalos’ case, the product of video recording is not the capturing of the process or the progress of the excavation, as the film mainly depicts clean and finished contexts and not the action. In several cases it also becomes a record of people telling us what they did (fig. 33), which poses a series of other constraints to the ‘immortalisation’ of the data (Hall 2000: 655). A supposedly objective capturing of the progress, where viewers can observe the process and the revelation of data, and make their own hypotheses and judgments, turns into a subjective presentation of the evidence in retrospect. In addition, the presence of the camera distracts the subjects, changing their behaviour and making them act and talk unnaturally (Brill 2000: 232; Loizos 2000: 106). This can be clearly seen in several videos from Makriyalos, where the interviewees express their shyness and discomfort either in words, or via their facial expressions, gestures and posture (Whittaker 1995: 509). In addition, the language used (transl.) obviously, certainly, definitely etc.’ imply in many cases that no alternative interpretation can exist for the data presented, while the person interviewed becomes the agent of this pseudo-objectivity.
Apart from the cases where the supervising archaeologists present their work, only the invisible operator, i.e. the director of the excavation, has an active role in these videos. As no other is involved in this process, the director infuses a sense of authority and objectivity, which however, does not allow either a reflexive or a multivocal content. However, there are
several interesting examples where the video has captured lengthy discussions with scientists and other researchers, while workers have also been asked to give their own explanations and ideas, thus providing a valuable insight into a collaborative interpretive process. Because of the temporal and spatial constraints posed by the work itself, the operator was restrained only to present the name and position of the features on the grid, rather than any details of the excavated data, as the scale of the excavation renders impossible familiarity with all the finds, prior to studying the field notes. As a result, videos are turned in several cases almost into photographs (fig. 34), and the accompanying audio information replicates the textual data. Lastly, several features have been recorded without any spatial or other indications, therefore making it impossible for people not involved in the excavation to identify them.

![Fig. 35](image)

**Fig. 35** Video still from Makriyalos’ excavation. The quality of the equipment and its operation by the user affect the level of detail of the captured scenes (courtesy of Dr M. Pappa).

### 1.4.d.2. Recording Real-world Properties

As far as the level of captured detail is concerned, it is affected by the same factors that alter the relation of a photograph with reality. Colour, for example, is also altered by the angle of view, time of the day and lighting, as well as the capability of the device to capture a wide range of colours (colour sensitivity and tonal/high-dynamic range). In Makriyalos’ recordings, which are about 20 years old and have been converted from analogue to digital format, the colours look faded, while any variations cannot be adequately defined. Texture, on the other hand, is not only related to the ability of the medium to capture a certain level
of detail, but also to the proper incorporation of light, colour and contrast that will evoke a sense of texture, which will not only be visually appealing, but will provide the amount of information needed for the subject-matter. The amateurish use of the camera, and the quality of the equipment, often make it impossible to exactly identify factual information (fig. 35). Additionally, information such as scale and size cannot be accurately depicted or measured for the reasons described in the photography section. However, the potential incorporation of human figures (fig. 36), as well as a voice over, can provide more contextual information in contrast to the solitary, silent and still photographs that cannot deliver any additional evidence, unless annotated or accompanied by text.

Fig. 36 Video stills from Makriyalos’ excavation. Human figures as an indication of scale (courtesy of Dr M. Pappa).

Conclusion

As the discussion has shown, video recording faces similar constraints to photography and the other recording methods, which transform perpetuity into a momentum. Video does not only capture a momentum, but a temporal sequence as well, accounting for the work in progress and the stages of the excavation, as well as its social character. Wollen (2003: 78)
describes this inherent difference in moving images and photography by a metaphor; film is compared with fire and photography with ice, in terms of their liveliness and motion, as well as their ephemerality and decay. Makriyalos’ video recordings, with their visual and auditory qualities, stand in contrast to the static and timeless photographs, thus destroying to an extent their power and action (Metz 2003: 141). In contrast however to Çatalhöyük, where videos are part of a multivocal and reflexive methodology, there is not yet clear concepts, or consistency and principles in this process, other than to record as much of the evidence as possible in a way similar to photography.

Video recording is not often employed in archaeological excavations. The main reason may be that video cannot be standardised similarly to photography and therefore, since a level of objectivity cannot be obtained, it is considered a medium that does not enhance the scope and the result of a scientific excavation. Also, video recording produces a sizeable archive which either cannot be stored due to restrictions of equipment and/or cannot be appropriately presented to the target audience. In the first case, a large number of excavations are carried out by universities with very low budgets to purchase the equipment needed. In the second case, the end product of an excavation is a report, a paper in an academic journal or a presentation at a conference. In none of these cases, videos comprise a format that can be adequately presented in the available means, and as a consequence it is considered an inappropriate, time and money consuming application that does not serve the purpose of archaeological practice. In several cases however, the information that can be derived from video recording is of high importance, since it cannot be adequately captured by the other mechanisms. Audio-visual recording proved to be a method that augments the available information on a site that no longer exists, not only refreshing the memory of the participants and fuelling the discussion about certain features, but also providing new indications and evidence, thus facilitating an enhanced interpretive process.
Conclusion

Recording methods in archaeological practice provide the means to dematerialise material reality. The ‘tools for culture’ used in this process (Edgeworth 2006: 78-85), although they succeed in flattening the material objects, they also abstract properties essential for understanding the real-world equivalents. For example, photographs abstract time, and drawings perspective. The main problem realised in this research is that our interventions with the archaeological sites depend on the way that we are going to read about the site in a report or a publication (Lucas 2012: 239). In several cases it was evident that the methods employed, such as the Single Context System, dictated the excavation practice, and the site turned into an archive inheriting all the problems that an archive may have. Overall, the main issue is that although the sites are transformed in order to comply with the rules of reading, paradoxically, in the methods we use in this process, we should demonstrate that the site has not undergone any transformation, and still retains its material integrity revealed by means of excavation (Edgeworth 2006: 273-274).

All the recording methods described in the previous sections, with the exception of some aspects of video, transform three-dimensional information and embodied spatial awareness into flat and abstract measurements and destructive denotations (Van Dyke 2006: 372). These visual media are mainly used to support the production of accurate archaeological knowledge, and also to communicate these ideas to the public. However, the system of signs used often makes these mechanisms inaccessible to the inexperienced and untrained receptors. Textual recordings, either in the form of narration or predefined sheets, include a certain level of scientific jargon and conventions that are not universally applied and understood. Additionally, since the recorded information and the subsequent interpretations depend on the individuals, a high level of subjectivity is involved, even in cases where prompt cards and guidelines are provided. Photographs, or the ‘immutable mobiles’, a phrase used by Latour (1990) to describe the qualities of reproduction and mobility, only record a moment in time, while the drawbacks of the medium itself and its use by the operator result in altered views of the captured scenes. On the other hand, technological advancements, which result in the ruination of photographic materiality, lead to the enhancement of archaeological information, providing methods of processing and presentation that add three-dimensionality in the process of knowledge production. Drawings are equally subjective as the way that the evidence is illustrated highly depends on the individual perception. Video, on the other hand, although it cannot be considered an adequate recording method in terms of obtaining consistent and standardised information that can be later used for revisiting certain aspects of an archaeological site, offers an enhanced bodily experience and material presence in a way that cannot be approached through the other recording mechanisms.
All recording mechanisms are subjective means of representation, which alter reality, and provide a distorted reflection of the already distorted past. The emphasis is put more on meaning rather than the process of obtaining meaning, and therefore through a process of reduction the complexity and diversity of the material world is diminished. Based on the facts presented so far, we should think of the people that never had the chance to visit a particular site and embody themselves its three-dimensional qualities in order to create a narrative and structure understandings (Tilley 1994: 27-33), and therefore can only get that feeling through the products of the various recording mechanisms. This becomes evident especially in Makriyalos’ case, which is a site that was destroyed by the infrastructure work, and the only way to be revisited is by studying its out-of-context remains, and the recorded evidence that captured a moment of its physical existence.

Without a doubt, there will inevitably be problems in the records, which are also inherent to each and every representation, and there is a whole range of physiological and perceptual factors that affect the materialisation of our interpretations of the past. The archaeological process transforms and translates the material world, while producing a new material past and present. Although through reductionism we lose the qualities of three-dimensional space, along with other qualities related to the continuity of material remains, we gain other qualities which are not accessible without the use of the established recording methods. Each recording method provides a different angle of view and perspective, delivering information in different codes, while knitting the same piece of evidence in comprehensible ways, offering a more complete observation and explanation. However, by trying to document more properties of the material world, we neither become objective, nor we achieve a retrievable past; the result is probably a two-dimensional ‘present-past’ which is increasingly difficult to decipher (Buchli 1995: 190).

Recent advances in the technologies employed in archaeological fieldwork direct the recording of the evidence towards a three-dimensional approach. Laser scanners, photogrammetry and Reflectance Transformation Imaging are methods which are increasingly applied to archaeological datasets in an attempt to capture more information than conventional recording (see 2.2.b.3). The fact that these methods capture the three-dimensionality of the evidence, it does not mean that the record will retain its original characteristics and that the process of digital reconstruction will provide more coherent understandings of the outputs. Since these techniques have various problematic components as they involve technological constraints and human choices, the emphasis should be put on the process of reconstruction itself as a means of visualising hypotheses and experimenting in a bi-directional way with alternative ideas. However, since we cannot presuppose what recording practices will predominate archaeological practice, and we primarily rely on conventional methods to trace the process of transformation, we should be
fully aware of the filtering, clarification and exaggeration of reality that takes place in the process of transforming a site into an archive. It is not anticipated however that the different facets of such multidimensional processes in either analogue or digital media, could be ever fully identified and that archaeologists’ interventions could become reversible.

In the following section, the main aspects of visual perception will be addressed, while all different parameters that influence the perception, capture and reproduction of three-dimensional realities will be examined. This discussion will be contextualised by using examples from archaeological fieldwork and associated practices.
Chapter 2
Perception, Recording and Reproduction of Three-dimensional Space

Introduction

The perception of space is influenced by various factors that enable the processing and construction of real-world data based on the principles of three-dimensional vision in coordination with the rest of the senses, our situated activities and embodied practices (Thomas 1993; Tilley 1994; Tilley and Bennett 2004, 2008). Objects’ morphology along with other parameters such as depth, light, and the angle of view, enable the construction of information, assisting the comprehension of three-dimensional space. In this chapter, the mechanisms of perception and the sensory systems that coordinate this information through processes relevant to archaeological practice, i.e. capture and reproduction, will be discussed. The first part will introduce some principles of three-dimensional visual perception. The second part will critically examine objects’ morphology as a fundamental element of three-dimensional space, attempting to contextualise this discussion in archaeological datasets. This part is divided in three sections. The first examines the concept of micro and macro morphology, also exploring the factors that influence their comprehension. The second part regards general principles of capturing morphology, while the last part examines the process of reproducing real-world morphology into digital space. This discussion is also applied to the context of archaeological fieldwork and associated practices.

The purpose of this chapter is not to extensively consider theories of perception, but only fundamental aspects that will facilitate the discussion in the context of three-dimensional data. In addition, since the breadth of information in the context of perception is enormous, as it involves all our senses, this chapter will be limited only to the extraction of properties from visual information. This distinction, which to a certain extent is artificial since perception is based on a multimodal interaction with space, helps to narrow down the content of this chapter, while sufficiently covering essential information that will enable the transition to the next chapters which examine and evaluate issues of three-dimensionality for Koutroulou Magoula, based on its archaeology and the computer graphic simulations.

Before starting the discussion on the principles of visual perception, I ought to begin with a description of a very familiar object to highlight the diverse range of variables that comprise
the realm of perception. I am currently using my laptop to write this paragraph. It is black; most surfaces are smooth; it is also made of plastic. These three specifications, derive from three different perceptual systems: vision, touch and hearing. I suppose that more or less readers agree with the characterisation of a laptop, as black, smooth and plastic. However, as I start thoroughly examining this device, it becomes apparent that it is not black, smooth and plastic all over. For example, the way that the white fluorescent light of the room falls on and is reflected off the surface, makes it look brighter or darker; this also changes as I change my point of view. Therefore, the initial black colour, which is a reasonable judgment under standard lighting conditions, actually has numerous variations ranging from light to dark black and from silver to white. The question that emerges from this is ‘What is the real colour of the laptop?’ or ‘Does the laptop have a real colour?’.

Things are relatively the same when considering geometry and texture. My laptop, for example, is rectangular. But is it? Or does it only look rectangular when observed from a particular viewpoint? As I change my position, I realise that the shape of the laptop changes. This of course, does not mean that the laptop is constantly transformed into other shapes, but that my perception of its shape continuously changes according to my viewpoint. Similarly, although vision tells us that the device is smooth, if observed closer, or touched, it becomes apparent that it is not smooth at all. This is often observed for archaeological artefacts as well, which although they look smooth, when microscopically examined, a great surface variation, non-perceptible by the human eye, is detected. When we consider touch and hearing the questions emerging are similar. The way we touch the surface of the laptop, the pressure we exert and also the part of the body we use in this task, highly influence the sense of touch. The same variables apply to the way that the laptop sounds when knocked or rapped.

All the above lead to the conclusion that the initial observations of the laptop’s properties only provided the apparent colour, texture and form. These apparent properties though, are not the real properties, since our senses only provide basic information about its appearance and not the truth of it. This is because our familiarity with the object activates the senses to consider real what appears to be real, without questioning our relation with the object and consequently, where this apparent truth does derive from (Russell 2001: 3-4, 6). I used the laptop as an example, since it is a very familiar object used in everyday practice. These observations however, can be equally applied to any artefact or feature in an archaeological excavation. Imagine for example, a white, smooth, rounded stone from the foundation of Building 1 at Koutroulou Magoula (fig. 37). Although stones look as such, and this particular description helps in distinguishing them from these used for the foundations of the lower phases (see 4.1.a., 4.1.b.), it is obvious that these attributes are not suitable. Is the colour even? Does it change under different lighting conditions and viewpoints? Are the
stones really smooth or they just look smooth and even? Are they rounded or irregular? The responses to these questions show that the characterisation of those stones as white, smooth and rounded is not – in reality – valid. However, the use of such standard vocabulary creates a frame for communication. This means that words used in the description of features are often employed to define an abstract sense of form; for example, we use to say that mud bricks are rectangular, not because they are perfectly rectangular, but because this norm helps in the construction of a common frame of reference that enables understanding and facilitates communication.

Such – very practical – observations regarding the nature of perception often lead to the emergence of questions on the verge of psychophysics, neural processing and even philosophy. It is obvious that it is out of the scope of this research to consider such a diverse range of approaches to discuss archaeological and digital space. The fact that this chapter is limited only to vision, as the mechanism to perceive the real world, and to particular aspects of objects’ morphology as the determinative factors in the discussion of real and virtual space, will enable a more thorough coverage of a very broad thematic. This decision also derives from the fact that archaeology, as it is practiced today, privileges vision, while diminishing the rest of the senses. Although I do not agree with the dominance of vision, since the involvement of other senses as well as embodied practices provide invaluable stimuli which can facilitate new approaches in archaeological interpretation, raising emphasis on how ocularcentrism affects archaeology as a practice (Thomas 1993,
2004:199, 2009; Hamilakis 2002) will help to better identify and critically examine the mechanisms of knowledge production.
2.1. The Principles of Visual Perception: How We See in Three Dimensions?

All the objects in the natural world possess different attributes and along with several other factors get a specific form and function. These attributes and factors, through complex patterns of the senses, permit the construction of three-dimensional models of the world and become ingrained in our consciousness through our perception. As our perceptual abilities and experiences are rarely stimulated by only one sense and our independent sensory systems coordinate to create a perception of the real world, it is not possible to talk about different worlds made of senses (e.g. world of touch), but only about worlds of perception (Gibson 1950: 12; Taylor et al. 1973: 261). However, there are certain elements of the real world that give to each object its unique characteristics and are primarily based on visual perception. For example, the identification of colour is solely based on visual perception; form and shape lie in visual and haptic perception; the same applies to texture, although auditory perception may also facilitate the identification of its properties.

Visual perception is not as simple as it may sound, since the discussions on the various factors that enable the construction of visual images draw from different disciplines, i.e. physiology, physics, psychology, neuroscience, ophthalmology, anatomy, biology, philosophy and computer science, different schools of thought within these disciplines, and consequently, diverse approaches that complicate the understanding of how visual perception works. In addition, it is not only the physical stimuli that construct the visual images, but also the input of the observer based on past experiences (Charest 2009). In other words, three-dimensional space is an amalgamation of visual learning and intuition (Gibson 1950: 10-16). Vision does not only facilitate the construction of images, but also our interaction with the world by composing the information needed to act accordingly. In the following part, a few principles of the physiology of visual perception that will help to discuss crucial variables in the perception, capture and reproduction of colour, texture and form, will be examined.

Ancient philosophers, such as Empedokles (c. 490–430 BCE) and Plato (c. 424-347 BCE), as well as the mathematician, Euclid (c. 325-265 BCE) had suggested that vision is possible due to particles of light, or a kind of fire according to Plato, shooting out of the eyes. This idea was challenged in the 10th century by Al-Haitham (Alhazen), but remained dominant until the 17th century. It was Olaus Roemer, Christiaan Huygens and Isaac Newton, who wrote about the nature of light, and challenged the established idea of how light interacts with vision. They argued that there is sight because of light reaching our eyes, after emitted from a light source and reflected off the features in the environment (Wade 1999: 9-25). This means that we can see a particular object because particles of light bounce on it, and then reach our
eyes, which in turn send this information to be deciphered in the brain, in order to identify its location, movement, form, colour and texture. The initial processing of light patterns takes place at the retina, a light-sensitive tissue at the back of the eye, which is layered with neurons. The photoreceptor cells, which are divided into two main categories, i.e. rod cells and cone cells, are the neurons responsible for converting photons into electrical signals that stimulate a series of biological processes in the brain. Cone shells function in bright light (photopic vision) and are responsible for colour vision, since they contain photopigments that are sensitive to long, middle and short wavelengths of light; in other words, they are sensitive to red, green and blue colour respectively. Rod cells on the other hand, respond to dim light (scotopic vision), while they contain only one type of photopigment, and as a result, they do not mediate colour vision. In contrast to cone shells, rod cells provide low spatial acuity. Lastly, between photopic and scotopic vision, there is the so-called mesopic vision, for which both rods and cones operate (for a thorough coverage of the physical properties of light, its transduction in the retina and the physiology of the eyes see Bruce et al. 2003: 3-24).

Objects in the world are three-dimensional and exist in three-dimensional space. However, the optical image of the object formed upon our retina is only two-dimensional. This means that our visual system is in charge of transforming this flat image which is missing depth, into a three-dimensional representation of the real world. In order to perform this transformation, there is a series of monocular and binocular cues that provide the information needed. Monocular cues are those cues which can be perceived by the operation of only one eye, while binocular cues refer to those which need both eyes in order to be perceived. The main factor related to our ability to see in three dimensions is our binocular vision, i.e. the use of both eyes, which are located at a different position in the head, therefore enabling a slightly different perception of a scene. This retinal disparity results in the so-called stereopsis, which provides the information needed by the brain to calculate the depth of a given scene. Stereopsis is the vital binocular cue that facilitates depth perception; the others are convergence and accommodation (Helmholtz 1856), which however, do not seem to offer much to depth perception (Foley 1980; Logvinenko and Belpolskii 1994). Both convergence and accommodation are processes that eyes use in order to focus a scene on the retina. Convergence is the inward movement of the eyes in order to focus on an object at a close range. Accommodation on the other hand, is the adjustment of the eyes’ refractive power to focus on objects located at various distances.

However, the ability to perceive the relative distance and size of objects does not only depend on binocular cues, which can work only over relatively short distances. In the

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6 According to Gibson (1966, 1979: 147-169), humans cannot understand the world in three-dimensions. They can only infer the three-dimensionality of the real world by perceiving its layout; in other words, how objects are arranged in depth.
following part I will refer to monocular cues, while focusing on the so-called pictorial cues, which help us extract information from two-dimensional images (see for example Smith and Gruber 1958; Smith 1958a, 1958b). The careful examination of the latter is vital, since all photographs produced in archaeological excavations fall under this category.

When movement is involved, motion parallax, a movement-produced cue related to the motion of the observer, facilitates depth perception. To be more specific, objects located at different depths appear to move with different rate; this relies both on the distance between the observer and the object, and the velocity of the eye in relation to the object (Gibson et al. 1959; Rogers and Graham 1979). Motion parallax also leads to the accretion and deletion of objects as we move relative to them. However, static retinal images can also provide information about depth by a series of cues, which provide information about the size and distance of objects. I will examine each one of these by referring to relevant examples from the photographic record of Koutroulou Magoula and Makriyalos.

One of the best-known and easily defined pictorial cues is perspective. Perspective is based on a simple principle; the object that is closer to the eyes appears larger, whereas the further the object, the smaller its retinal image will be. Based on the principles of perspective are the cues of linear and atmospheric perspective, texture gradient, relative size and relative height.

In figure 38 the new railway at the location of Makriyalos’ excavation is depicted. According to the cue of linear perspective (see for example Saunders and Backus 2006), the parallel rails seem to converge as they recede from the observer. In addition, linear perspective causes foreshortening resulting in further distortion and compression of distant elements (Bruce et al. 2003: 187). Cutting (1997: 31) has argued that linear perspective cannot be considered as a cue of depth on its own, since it is part of a system of cues, including texture gradient, relative size and height, as well as occlusion.

Texture gradient, was coined by Gibson (1950: 77-94) to describe the phenomenon that the elements composing a textured surface, although fairly similar, appear in two dimensions as having different appearance due to their variation in both their orientation and distance in relation to the observer. For example, in figure 39 the elements composing the soil at Makriyalos’ excavation appear progressively smaller, while their density increases as they recede into the distance. Texture gradient provides a good impression of depth, as well as relative distance and surface slant. The slant though is possible to be observed only when the retinal image is not vertical to that surface (see for example Epstein 1981; Rosinski and Levini 1976; Eriksson 2008).
Fig. 38 The new railway line at the location of Makriyalos’ excavation. The rails seem to converge as they recede from the observer; this cue of depth is called linear perspective. (Image author’s own).

Fig. 39 Trenches Ø026, Ø027, Ø028. Cluster 5. Makriyalos II (Pappa 2008).
The next cue of depth is relative size. According to the principles of this cue, if there are two objects of a similar shape and size in the field of view, the object that is closer to the observer tends to appear larger, whereas it becomes smaller as it recedes. Even if the absolute size of the objects is unknown, relative size can provide information about the relative depth of the objects, given that they are of the same size. For example, in figure 40, although the two highlighted trenches are of the same size, the one that is further from the observer appears significantly smaller. The same effect is also observed at the row of trees on the left. Relative size is also linked to familiar size. As the word familiar indicates, this depth cue in order to be triggered needs some previous knowledge about an object. It may be its shape and/or size that triggers a memory of that particular object at a specific distance, which in turn enables the determination of the absolute depth of the object (see for example Hochberg and Hochberg 1952; Hochberg and McAlister 1955). To the cue of relative and familiar size, we should also add the law of size constancy (see for example Boring 1964). According to Emmert (Edwards and Boring 1951), an object’s perceived size is proportional to the perceived distance. As a general rule, when objects double their distance from the observer, the size of their retinal image is halved. In other words, the image of an object on the retina gets smaller, when its distance increases. However, our perception of objects’ size remains constant irrespective of their changing size because of distance variation.

Fig. 40 General view of Makriyalos II. Although the highlighted trenches are of the same size, the one that is further from the observer appears smaller. The same effect is observed at the line of trees on the left (Pappa 2008).
Depth perception is also influenced by relative height (see for example Dunn et al. 1965; Epstein 1966), since the depth of an object is identified in relation to other objects existing in our field of view. According to this cue, objects that appear higher in the field of vision are more distant, whereas those that are below the eye level are closer to the observer. This means that when having objects at different heights, the highest of them appears further, while the lowest nearer to the observer.

All cues examined so far, are based on the principles of perspective and most of them operate together for the identification of depth in two-dimensional images. In figure 38 for example, apart from linear perspective, texture gradient is evident at several areas, such as the trees and the pebbles underneath the rails. Also, relative and familiar size are apparent at the electricity poles. The combination of these cues provides a more precise sense of depth, consequently enhancing the three-dimensionality of an otherwise two-dimensional image.

In figure 41, the viewer would observe that the low hills at the back appear out of focus, having lower luminance contrast. In addition, they have lower colour saturation in comparison to the features that stand closer and as a result their colour is shifting towards the blue end of the spectrum. This phenomenon, known as atmospheric perspective (see for example O’Shea et al. 1994), is resulted from light scattering by air molecules and particles comprising the atmosphere; the so-called short wavelength light (blue colour) is scattered most and as a consequence the distant dark objects appear bluish. Also, the contrast gradually decreases as objects become more distant, since light is scattered not in a straight line towards the line of sight, and also, because skylight is scattered into the line of sight. As a result, skylight is superimposed on objects and their contrast is gradually decreased. Therefore, these effects result in differing contrasts between the objects and their background, providing valuable information for the identification of depth in static images.

As mentioned above, light plays a fundamental role in the perception of a visual scene and as such, it can provide a wide range of information regarding the three-dimensionality of static images. This enhancement is achieved by observing two phenomena: i) the variation of light’s intensity on different surfaces, i.e. shading, which provides information about the morphology of three-dimensional objects, and ii) the way that shadows are cast when an object blocks the path of light onto another one, which can also give a good impression of depth based on the direction and the nature of shadows. This last category is not often observable when recording on-site archaeological evidence, since the features to be captured are usually shadowed in attempt to obtain a ‘stain-free’ picture (see 1.4.b.).
Fig. 41 Ditch A, Phase I, Makriyalos. Atmospheric perspective results in a low contrast of the hills at the back as well as a shift towards the blue end of the spectrum (Pappa 2008).
As far as shading is concerned it is primarily based on the fact that light comes from a particular angle and is reflected off surfaces in a particular way. Therefore, the way that light points to objects’ surfaces or is reflected off them because features of their surface obstruct the light falling on them (attached shadows), produces patterns of shading which can give valuable information about three-dimensional surface shapes. Moreover, when the light source faces the surface of an object, the intensity of light reflected off this particular surface will be greater, in comparison to surfaces that face opposite to or slant from the source of light (see for example Ramachandran 1988; Kleffner and Ramachandran 1992). It is clear that the brain uses the variation of light across surfaces to extract information in order to enhance depth perception. However, shading is so much ingrained into the definition of objects’ volume, and consequently, into the mechanisms of perception that it actually passes unnoticed in everyday practices (Arnheim 1974: 315). In addition to this, research has shown that interpretations of depth based on shading should be coupled with other cues such as texture gradient or should also take into account other variables that enhance surface shape perception. For example, surface contours can augment surface shape perception, since they are independent of viewpoints and standard lighting conditions (see for example Knill 1992). Based on Knill’s research, it is evident that the physically occurring contours of the stones depicted in figure 37, provide more coherent information about surface shape than any shading resulted from the way that light is falling on and reflected off their surfaces.

Apart from shading, light produces shadows that provide a cue for objects’ shape, size and spatial relationships, as well as light’s angle and nature (see for example Mamassian et al. 1998). Regarding the latter, it should be noted that direct sunlight gives different shadows in contrast to light coming from a light bulb or any diffuse flame light. In addition, shadows help to identify the time of the day, in a similar way that sundials work. Shadows, which are resulted from light obstructed by an object, are two-dimensional and their length varies, depending on the angle of the light source. As a rule, the further the object that is blocking the light from the surface of projection is, the larger the silhouette of this object will appear. In figure 42 from Koutroulou Magoula, several patterns of shadows can be observed. At the left part of the photograph, one can note the sharp and high-contrast shadows resulted from the shed that covers the trenches excavated in the past. In addition, the way that the shadow is cast from the shed shows a wavy pattern, at least for its edge, which is visible on the surface of projection. In the middle of the scene a shadow of different strength can be observed; the lighter shadow is resulted from one layer of semi-transparent textile used for sun protection at the trench. On the other hand, the darker shadow is the result of two layers of the same material. From the edges of the shadows it is obvious that this object is rectangular, while no more information can be derived for its material or texture. At the right side of the scene, the sharp and high-contrast shadow shows that it is
resulted from an opaque object. Knowing that it is a human figure we can understand that it holds something that is probably rectangular. Although there is no indication about its material, the context of the photograph indicates that it is a drawing pad. Lastly, judging by the direction of the shadow and knowing the site’s North, the time of the day is around 10am.

The next depth cue is the so-called interposition/occlusion (see for example Chapanis and McCleary 1953). Although this phenomenon cannot provide information about relative and absolute distance, it clearly shows ordering in depth, when objects are overlapping. The principle is that when an object lies in front of another, it will occlude the contour of the object behind it; therefore, the objects that are partially covered by others are in the back, while objects with uninterrupted contours are at the front of the rest. For example, in figure 43, in which Koutroulou Magoula and the surroundings are depicted, the tell site is at the front since it is not occluded by any object in the scene. However, it partially occludes the hill in the middle, which in turn occludes the mountain at the back; this means that the mountain is the feature that is located further away from the observer.
Finally, it is blur that clarifies the distance of objects from the focused point (see for example Pentland 1987; Mather 1996). This is based on the fact that both the human eye and cameras have a limited depth of focus, and as a result, features that are closer or further than the focus point appear blurred.

In this section, I briefly examined the most important pictorial sources of information for layout perception. Observing figures 37-43, it becomes apparent that these cues rarely appear in isolation, since they are normally combined to provide more information about the third dimension. In figure 44 for example, where the site of Koutroulou Magoula is depicted, more than one cues provide information about the identification of depth. Apart from perspective, which can be observed throughout the picture, texture gradient can be seen at the harvested crops at the front and the green cultivated area at the middle of the picture; their size decreases, while their density increases as they recede from the viewer. Also, the cue of relative size can be observed at the left part of the image, where the electricity poles, although of the same size, seem to be getting smaller as they become more distant. Moreover, occlusion can be identified at the right part of the image, where part of the hill at the front partially occludes the hill at the back. Lastly, atmospheric perspective is also apparent at the back of the picture, where there is lower luminance contrast and colour saturation.
Fig. 44 More than one cues usually operate together to enhance depth perception. In this general view of Koutroulou Magoula, perspective, atmospheric perspective, relative size, occlusion and texture gradient can be clearly observed (Image author’s own).

Based on the fact that more than one sources of depth perception simultaneously exist in a visual image, an interesting discussion has developed regarding the ‘competition’ among different cues in cases where they do not agree in the interpretation of the depth of the scene. This is because some sources of information provide more reliable signs of depth than others, and as a result, a subconscious ‘competition’ that enables the dominance of the most profound cue takes place (see for example Guibal and Dresp 2002; Jacobs 2002; Hillis et al. 2004). Finally, different depth cues are effective for different distance ranges (Cutting and Vishton 1995). For example, atmospheric perspective cannot work for close distances, in contrast to relative size and occlusion that work in any visible distance. This can be clearly seen in figure 44 as well.
2.2. Morphology: A Multi-dimensional Element of Three-dimensional Space

The purpose of this section is to examine morphology, the fundamental element of the real world that seems to comprise, along with depth examined above, the most important property of three-dimensional space. Physical objects have certain properties which can be summarised with the word morphology. Morphology has been used in several disciplines, such as biology, linguistics and material studies to describe the fact that objects, organisms, or words have a particular structure that make them stand as entities. However, in order to understand the morphology of an object, an organism or a word, we have to methodically examine both the components that comprise morphology as well as any contextual elements that influence how these elements are structured. In the case of a physical object morphology should be considered both at a micro and a macro level. The difference between the two terms is that micromorphology describes the fine-level structure of an object, whereas macromorphology the gross structure. In the first case micromorphology is the colour and texture of an object, while macromorphology is indeed its geometry and overall shape. Yet, we should also take into account the viewing context, i.e. light and relative motion that affect the morphology of an object. Considering these aspects of morphology, this section is structured around three main themes: 1) how morphology is perceived in a three-dimensional world, 2) how morphology is captured in the real world, and 3) how morphology is reproduced in 3D graphics.
2.2.a. Perception of Morphology

As mentioned above, three-dimensional space is a multimodal production, since objects stimulate all the sensory organs of the human body. This information, in order to become readable by the human brain, is initially processed by these organs; in turn, the brain constructs their representation. However, this process is not linear, since sensory systems are triggered differently depending on objects’ properties. For example, a stone wall is primarily perceived by vision. This also applies to the perception of its texture. If however, the texture of the wall is unfamiliar to the observer, the brain might need more information to categorise the object. In the case of a wall, touch would play the additional role. If an object had an unfamiliar smell, taste or even touch might have facilitated its further categorisation and perception. In addition, apart from the coordination of the sensory systems, situated activities and embodied practices, experiences, as well as the emotional and motivational state significantly affect the way that reality is perceived. This section examines the visual perception of objects’ micromorphology and macromorphology, also discussing the contextual parameters that influence their perception.

2.2.a.1. Perception of Micromorphology; Colour and Texture

At the beginning of this chapter, I briefly referred to colour vision mentioning the fact that cone photoreceptors in the retina are responsible for colour vision, since they contain photopigments that are sensitive to long, middle and short wavelengths of light. Here, I should mention a few more aspects that will help to understand what colour is and how is it perceived.

When atoms absorb energy, their electrons produce electromagnetic radiation that travels through space in a wave-like form in different frequencies. These frequencies comprise the so-called electromagnetic spectrum, of which, only a small part is visible to the human eye i.e. 380-750 nanometres. The visible part of the spectrum contains different wavelengths of light perceived as the seven main colours that the brain can distinguish, namely violet, blue, cyan, green, yellow, orange and red. As well, the visible light is comprised by variations of these colours across its whole range. However, the slight variations of the colour from one wavelength to the other cannot be detected by the eye.

We use to say that three colours, red, green, and blue are used in the process of perceiving the world, since the photoreceptors in the retina are sensitive to wavelengths of red (R), green (G) and blue (B) colour. This means that light takes these colour values corresponding to the amount of light absorbed by each photoreceptor. In other words, any colour is defined according to the intensity of each of these three primary colours. For example, by
mixing red and green, yellow colour is generated. When the intensity of these two colours is high, the result is towards bright yellow. Once red or green are reduced, the resulted colour gets closer to green and red accordingly. This means that colour consists of three elements defined by their values which are related to the intensity of the wavelengths of light and their perception by the human eye. In order though to describe colour, apart from defining hue, which is the position of light in the visible spectrum, i.e. RGB values, two more properties are needed; saturation and brightness. These three properties comprise the so-called three psychological dimensions of colour (Kaiser and Boynton 1996: 141-145).

Saturation can be defined as the purity of colour. A highly saturated colour means that its intensity is very high, since it contains a narrow set of wavelengths. In the contrary, a low saturated colour means that it is comprised by a wider range of wavelengths. As a result, its intensity is quite low, while, as the values are reduced to 0, the colour becomes a shade of grey. Lastly, brightness is the relative lightness or darkness of a colour and depends both on the reflectance properties of the coloured surface and the intensity of the light falling on its surface.

As far as texture is concerned, a Google search shows that the word texture is mainly related to how objects in the world feel when touched. This is the so-called tactile texture and is only linked to the tangible feeling of a surface. Tactile texture is particularly applicable to surfaces that present some kind of variation with bumps, dents and ridges. However, another type of texture exists, which is not related to its tactile feedback to the observer. This is the visual texture which relies on how observers perceive the surface of objects based on their variation in colour and intensity of light (see for example Heller 1982; Landy and Graham 2004; cf. the term haptic visuality in the History of Art). Textured surfaces interact with light in particular ways and as a result, produce an enhanced perception of objects’ properties. Even in cases where surfaces are smooth, e.g. glass, objects are not chemically homogenous and, as a consequence, the various particles reflect light differently; this means that the observer understands texture by perceiving changes related to variations in colour (Gibson 1950: 80-82).

It is common knowledge that apart from vision, other forms of perception are also complimentary in the experience of the physical world. As far as texture is concerned, a significant number of papers have reviewed tactile perception (see for example Taylor et al. 1973) also looking at interaction patterns with textured surfaces that make the brain decipher the properties of a given textured surface (see for example Menees and Zigler 1923; Klatzky and Lederman 1987; Lederman and Klatzky 1987). However, the initial information about objects’ texture is extracted from the visual system, which then directs the other perceptual mechanisms to act in order to enhance objects’ surface perception. Schifferstein (2006) for example, conducted an experiment for which the evaluation
concluded that vision is the dominant modality in providing sensory product information and is followed by touch and the other senses. Still, there is considerable research in the field that examines how different modalities influence the perception of particular aspects of texture. For example, surface roughness is more efficiently identified by touch rather than vision (Bergmann Tiest and Kappers 2006). On the other hand, experimental approaches suggest that there is no clear difference between the ways that texture is perceived by different modalities, namely vision and touch (see for example Klatzky et al. 1987; Guest and Spence 2003). Characteristic is Heller’s work (1989) which did not identify any differences on how texture is perceived by sighted and blind observers. In overall, it seems that these approaches have resulted in a tendency to consider vision along with tactility, since the majority of those experiments have shown that these two modalities provide stimuli that allow the brain to encode any information related to the perception of texture (see for example Whitaker et al. 2008; Ernst and Banks 2002; for an overview of cross-modal texture perception see Lederman and Klatzky 2004). In addition, apart from vision and touch, hearing has also been considered a source of information for texture perception (Lederman 1979).

2.2.a.2. Perception of Macromorphology; Shape/Geometry

In the first part of the chapter various sources of information, cues, which enhance the perception of macromorphology were mentioned. In this brief section I will only refer to some additional concepts regarding shape perception (for a thorough overview of 3D shape perception see Pizlo 2008).

Shape constancy is one of the most important parameters to recognise objects’ macromorphology. A common example of shape constancy is when objects are presented to the viewers from one viewpoint and they can visualise how they look from different viewpoints. Equally, when observers see the same object from different viewpoints, they can recognise that it is the same object (see for example Shepard and Cooper 1982; Biederman 2001; also see Rock et al. 1989 for the opposite argument; Edelman and Weinshall 1998 for computational approaches to shape constancy). However, shape constancy might fail to work in some cases, such as when objects are illuminated from different directions (Todd et al. 1996).

According to Todd (2004), several psychophysical investigations have pointed out that observers often get an erroneous image of objects’ shape. For example, texture gradient can provide information of 3D shape only for a certain degree of relief (ibid.: 117). The most influential research regarding surface shape is on contour lines (see Stevens 1986, 1988;
Knill 1992). As it is suggested, contours are projected from surface markings and provide an idea of surface shape independently of light and viewpoint.

Literature on shape perception, which is mainly based on computational analyses and psychophysical investigations, suggests that texture can also provide valuable information regarding objects’ shape (see for example Witkin 1981; Blake and Marinos 1990). Recent research however, has shown that although the latter may be perceptually valid, in reality, it is shape that provides information about surfaces (Li and Pizlo 2006). In addition, the assumption that objects’ symmetry enhances shape perception (see for example Lee and Saunders 2011) has been recently challenged (Phillips et al. 2011).

As is the case with colour and texture, previous knowledge about the environment and the object under examination (or similar objects) facilitates the processing of information about 3D shape in the brain. Especially in cases of unfamiliar objects or shading patterns created by the incident light on objects’ surfaces, brain’s assumption that light is located above their head and slightly to the left influences the interpretation of 3D structures (Gerardin et al. 2010). It seems however that when stronger light cues, such as shadows and shading exist in the scene, the concept of overhead light has a minimum contribution to shape perception (Morgenstern et al. 2011).

2.2.a.3. Context of Perception and Perception in Context

As already mentioned, perception is influenced by several variables, most of which are influenced by light. Light gives substance to objects, while helping the brain encode real-world information and enhancing perception (Tarr et al. 1998). However, the experience of the environment through our eyes is more complex since it is not only limited to the sense of vision but also involves personal capacities such as memories and emotions. Still, when we discuss the context of perception, we primarily refer to the relationships formed between the viewer, the viewing angle and the light. An interesting work by Ashley (2008) at Çatalhöyük, which involved systematic vision testing under different lighting conditions, demonstrated that people have completely diverse responses to the perception of the environments depending on several internal and external dynamics. As he suggested, this calls for a viewer-centred archaeology.

The position of the sun, the clouds in the sky and the haze of the atmosphere make light behave in different ways, and consequently affect the perception of objects illuminated under these changing conditions. What is particularly interesting is that because of the fact that the position of the sun and the earth continuously change, the angle of light also changes constantly, thus affecting the way that objects of the physical world appear both in terms of incident light and cast shadows. This means that differing light would directly
affect and continuously transform the texture, colour and shape of an object. Several aspects of the relationship between light and matter have already been mentioned above. In the next few paragraphs, I will attempt to provide a brief account of this relationship and its effects, discussing the phenomenon of shading and shadows resulted by light.

Colour is a product of light, and thus, it would be expected to be light-dependent and change under different illumination. However, the visual stability needed in the world is served by the so-called colour constancy (see for example Jameson and Hurvich 1989); this means that colours look the same even under changing lighting conditions. Experience has shown that this is true. For instance, a brownish Neolithic figurine made of clay, remains the same when seen under an overcast sky or flame illumination. However, what changes is the wavelength distribution of the light reflected from the figurine and reaching the eyes (Delahunt and Brainard 2004). This means that the colour would look different, since the light would have brought about some change to its brightness and saturation. Nevertheless, colour constancy makes our perception of colour relatively constant with changing illumination. The three main factors that affect colour constancy are chromatic adaptation (Loomis and Berger 1979; Fairchild and Lennie 1992), memory colour (Jin and Shevell 1996) and the effect of objects’ surroundings (Land and McCann 1971; Brainard and Wandell 1986).

Although it is out of the scope of this research to delve into these parameters, I ought to make a few brief remarks that will help to address the phenomenon of colour constancy in the context of an archaeological excavation. Chromatic adaptation is based on the fact that long exposure to a particular chromatic colour decreases eye sensitivity to these wavelengths, which in turn means that the contribution of those wavelengths in the perception of colour is significantly reduced. Memory colour also plays an integral role in colour perception, since previous knowledge about objects’ typical colour enhances the perception of their colour, making them appear more saturated and richer even under lighting conditions that would cause the opposite results. Lastly, the colour of surrounding objects also influences colour constancy, since the variation of objects’ colour help the brain estimate the illumination and make the corrections needed to enhance its perception. Numerous experiments have shown that the phenomenon of colour constancy minimises the effects that the interaction between light and matter has on the perception of colour (see for example Hurlbert 1999). However, if we think about it in the context of an archaeological excavation especially of a Neolithic site, it becomes obvious that the concept of colour constancy cannot be sufficiently applied, since the identification of subtle colour variation plays a significant role in the understanding of the excavated archaeological information.
From several discussions that I had with Makriyalos’ excavator Maria Pappa, it became apparent that the strong sun in the summer months, which also resulted in long periods of draught, highly affected the identification of features. This was mainly because the negative features left behind by the passing of time, could only be identified by the slight colour variations resulted from the deposition of materials of different origin within other contexts. The sun, however, significantly affected the brightness and saturation of the colours making it difficult to distinguish any differences. Another related example derives from postholes, since it is possible to identify them only by distinguishing the slight colour variation within and out of the limits of that hole. Although the overall colour of the soil, e.g. brown, remains the same, there is a significant variation between the brown identified inside and outside the posthole. The difference in colour is resulted by the minerals it consists of, which absorb and reflect light differently. This can be observed in **figure 45** from Koutroulou Magoula, in which the probable postholes are highlighted with white marks. Shading the trench and spraying the features with water to sharpen their contrast was the only means to safely proceed with their excavation.

**Fig. 45** Probable postholes in Trench 04 indicated by white spots. The filling of those holes is of different colour, as well as composition, in comparison to the surface of the trench (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

From the aforementioned examples, it becomes apparent that in archaeological contexts colour is a major factor in the identification and interpretation of the material evidence. However, to my own knowledge, and also considering different field practices, the variation
of colour in relation to changing lighting conditions and the position of the observers is not a parameter that is normally taken into account. The most common consideration related to this matter is the time of the day during which colours look more vivid and brighter when photographed. Similarly, in several cases artefacts in museums displays appear completely discoloured due to wrong choices of light. To my mind comes a clay figurine that was bearing decoration in a colour close to the colour of clay, which however was barely visible because of the lighting conditions in the display.

Lighting conditions, apart from colour, also affect the texture and shape of objects and features. Similarly to colour, the way that light interacts with three-dimensional objects also affects how their texture is perceived. This is because objects’ properties affect light’s behaviour, producing a variation across their surfaces. Different materials and textured surfaces differ in their reflectance and transmittance properties and therefore, light produces diverse effects and patterns which are then used by the brain to decipher the nature of the objects and their spatial layout in the world.

The way that light is absorbed and reflected off textured surfaces, provides a fundamental optical cue for recognising material properties and the nature of textures. Thus, the image we get about the appearance of an object highly depends on the properties of light that impinge on it. For example, sunlight, which is the light that we are particularly interested in the context of archaeological fieldwork, is both direct, coming from the sun, as well as indirect, reflected off other surfaces. This means that illumination comes from different directions and is scattered all around the scene. As a result, different materials and textures behave according to their reflectance properties and produce lighting patterns that potentially help observers understand the objects’ properties regarding texture. For example, in figure 46 the stone foundation of the south wall of Structure 1 at Koutroulou Magoula is depicted under different lighting conditions. As it has been already pointed out in the previous chapter, technical properties of the camera play their role in this depiction; however, this comparison shows how the perception of texture changes based on the type and direction of light. In the picture on the left, where diffuse light illuminates the scene, the surface of the stones appears rougher, since light comes from a low angle due to the shade that covers the area. In the image on the right however, where the scene is illuminated by strong flashlight, stones appear flatter, since light has been diffused uniformly from a higher angle.
Fig. 46 Photograph of the south wall of Structure 1 at Koutroulou Magoula under different lighting conditions. A. Wall lit by indirect light; B. Wall lit by direct flash light and indirect light (Images author’s own).

Experimental approaches and to a large extent computational methods have shown that variations in lighting influence the perception of objects (see for example Chantler 1994; Dong and Chantler 2004). Several works have focused on face recognition (see for example Hill and Bruce 1996; Braje et al. 1998), indicating that light coming from different directions highly affects the identification of facial features. In addition, by studying the textured surfaces and the patterns of light that are produced due to their variation in a micro and macro scale, i.e. shading, researchers have also attempted to derive information regarding the direction and angle of light (see for example Pentland 1982; Koenderink et al. 2003). As a general remark, surface characteristics appear rougher when the illuminant angle decreases, while vertical direct light flattens the three-dimensionality of textures by decreasing the variations of their surface. For this reason, raking light, i.e. illumination of
objects with the light source at an oblique angle, has also been implemented in the study of archaeological artefacts. In archaeological contexts, Zányi et al. (2007b) have made use of Polynomial Texture Mapping to observe how the direction of lighting affects the perception of glass mosaics in Byzantine churches. An earlier work in Medieval settings (Devlin et al. 2003) has also demonstrated that decorated and glazed vessels look different in terms of colour and also shape when illuminated from different directions and different light sources.

Similar to colour constancy, there is roughness constancy, which especially in binocular vision, and when combined with other roughness cues makes objects appear with less variation under different lighting conditions (Ho et al. 2006). As is the case with colour memory, textures are also recognised by previous knowledge since they have characteristic appearance derived from the particular way that they reflect light and present ‘statistical regularities’ that help observers to minimise any uncanny interpretations (Fleming et al. 2003: 351).

Most of the parameters mentioned above apply to the interaction of light with objects’ geometry. The effects produced by differing illumination, such as inter-reflections, occlusion, shadowing and local shading influence the perception of texture and have been repeatedly noted in experimental and computational approaches. Research so far has proven that in most cases the interaction of light and objects can enhance the perception of their macromorphology. For example, it has been suggested that specular reflections provide accurate constraints of 3D shape, since the visual system treats them like textures (Fleming et al. 2004). In addition, a great body of literature deals with the relationship between shading and shape perception. This aspect, as well as the role of shadows, which are both resulted from the interaction of light with surfaces and objects, were also addressed in the context of depth perception in the first section of this chapter (see 2.1).

Before proceeding to the next section, it is worth mentioning a few more examples that show how morphology’s perception is enhanced or obscured by shadows and shading. Ho et al. (2006: 645-646) have suggested that observers make errors regarding surfaces’ roughness because of the contribution of shading and shadows to the objects. On the other hand, Mingolla and Todd (1986), Ramachandran (1988), Johnston and Passmore (1994a; 1994b) and others have concluded that shading highly contributes to the perception of 3D shape by a combination of our knowledge about light sources and the nature of objects, as well as neural processing. Moreover, Berbaum et al. (1983) have emphasised that the spatial disposition of shading and of the light source are fundamental parameters for the perception of surface relief. Research on shape from shading is mainly based on the assumption that observers perceive objects under direct light. However, Langer and Bülthoff (1999) have shown that observers can equally discriminate shapes from shading under
diffuse light, suggesting that the visual system implements different models in order to get the best response under diverse lighting conditions (also see Schofield et al. 2011).

Regarding the latter, Norman et al. (2004) have proven that specular highlights and the motion of a surface in relation to the light source provide additional information for the processing of 3D shape based on shading. Also, several works have employed computational models for automatic shape reconstruction derived from shading (see for example Savarese 2005). As far as shadows are concerned, it is equally suggested that they can be informative about the shape of the objects, and they can also influence the perception of spatial arrangements in a scene (see for example Yonas et al. 1978; Cavanagh and Leclerc 1989; Mamassian et al. 1998). In addition, Iaquinta and Łukianowicz (2006) have suggested that shadow-hiding effects can be used to determine surface texture.

Fig. 47 Aspect of Trench Z1 at Koutroulou Magoula focusing on the unearthed wall. The contours of the stones provide adequate information to derive their shape and form. View from the east (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

It has been clearly demonstrated both in the context of recording methods and depth perception (see discussion on figure 42 in section 2.1) that shadows highly influence the perception of a scene. However, shading has been seen with some mistrust since the various experiments carried out both in psychophysics and computer graphics have demonstrated
the ambiguity of shaded surfaces. For example, O’Shea et al. (2008) have shown that even when shading is omitted, contours are the elements that provide information regarding the orientation of objects’ surface. This also accrues from the familiarity that observers have with those objects. This is demonstrated in figure 47, where even if shading resulted from both diffuse and direct light would have been removed, the contours of the stones, which are independent of viewpoints and lighting variation, would have provided adequate information regarding the objects’ macromorphology.

Finally, I ought to emphasise that light mainly interacts with matter at a microlevel. Although texture and colour are usually considered entities, they are composed of molecules, which in most cases are not visible by the naked eye. This means that light does not interact with an object as a whole, i.e. the entire coloured or textured surface, but indeed, with the molecules that comprise it and selectively reflect and absorb certain wavelengths. Thus, the colour and texture perceived is the result of the interaction at a microlevel. For example, the red colour of a fresco is composed by a red pigment which is made of billions of grains. These grains, when applied on the surface to be painted, interact with each other, as well as light. Therefore, the result we see at a macrolevel, i.e. the entire surface, is actually the outcome of their interaction at a microlevel (Mayer 1991:166).

In the same context, it is also worth noting the effects of the varying position of the viewer on the perception of objects’ morphology, while taking into account that any observed differences do also accrue from the principles of the interaction of light with surfaces and objects. For example, since colour is mediated by light, both in the case of light changing positions and that of the observer changing viewpoints, the result is that the light reflected off objects in the scene reaches the eyes from different angles, and as a result, a non-uniform perception of colour is produced. This was also supported by Ho et al. (2007), who tested how surface roughness is perceived under changing viewpoints. Their results showed that observers made significant errors in the identification of shapes when their viewpoint was changing in relation to the objects’ surfaces. These results were very similar to those from an earlier experiment (Ho et al. 2006) regarding how surface roughness is perceived when the direction of illumination changes. Similarly, research on the relation of viewpoint and shape perception has shown that the brain mentally transforms objects’ orientations to match them with a known orientation of this or of a similar object in order to enhance their perception (see for example Tarr and Pinker 1989; Tarr 1995). In figure 23, Structure 1 at Koutroulou Magoula has been captured from four different viewpoints, at different times of the day. The latter has resulted in the variation in the appearance of colours, since light falls on the objects from different directions. In addition to that, the observer due to the different viewpoints, receives light from different angles, and therefore, although the colour remains prototypically the same (Lyons 1995: 199), the perceived chromaticity changes. This means
that although a different viewpoint cannot result in an entire change of the perceived colour, e.g. brown does not turn into green under normal conditions, certain variations in saturation, brightness and contrast do occur.

2.2.b. Capturing Morphology of Physical Objects

Objects' morphology, a property of the real world that is evidenced in everyday life, should also be documented, as it often comprises the basis for further analysis, decision-making and interpretation. For example, conservation practice requires thorough recording of buildings' morphology in order to get an account of structures' condition and decide their preventive or corrective maintenance. In archaeology, the documentation of features' morphology is equally crucial, since many of these may not survive, or be accessible again. Therefore, different methods have been implemented that facilitate the capture of the various properties. These are discussed below, regarding both micro and macro morphology, also examining the techniques that archaeology has adopted to record the revealed features' properties.

2.2.b.1. Capturing the Micromorphology of Physical Objects; Colour and Texture

Since the perception of colour is based on the absorption and processing by the retina and the brain of different wavelengths, which respond to three primary colour values (red, green and blue), the way to measure those is to find the means to make instruments that mimic the way that the retina works. The definition of colour depends on the principle of trichromacy, i.e. the long, medium and the short wavelengths absorbed by the retina, which are then turned into colours. In 1931, the Commission Internationale de l'Eclairage (CIE), specified the so-called CIE XYZ colour space, according to which a perceived colour is a tristimulus value (X, Y, Z channels), indicating the luminance and chromaticity of a stimulus as it is perceived in a 2-degree (or 10-degree according to later experiments) field around the foveal centre (see for example Giorganni and Madden 2008: 10-18). The XYZ values are converted into the xyz chromaticity coordinates, which have been used to produce the well-known horseshoe-shaped colour space that incorporates in a grid the x and y chromaticity values, which correspond to colour and its saturation. This colour space defines the entire human gamut of visible light and is completely device independent. It is also used as the basis to present the range of colours that can be reproduced by different devices. Based on this colour space, CIE has specified other device independent colour spaces, such as the L*a*b* and L*u*v*, which are considered perceptually uniform, since any change within the colour space will result in an equal perceived change to the observer. In such a way, human vision and particularly the perception of lightness by a standard observer is more closely approximated (Hunt and Pointer 2011: 52-56).
The techniques that measure the colour of light employ red, green and blue filters to calculate the level of light’s absorption after it has been reflected off particular surfaces. This method which is called colorimetry, and was initially based on experimental colour matching approaches, has evolved to more accurate and automated processes involving advanced instruments that measure colour as a tristimulus value, as well as its temperature, spectral power distribution and spectral reflectance (Hunt and Pointer 2011: 99-116).

However, colour’s perception in the real world significantly differs since it heavily relies on perceptual and cognitive factors, as described in the previous sections. The classic example of McCann’s photographs of the colour charts under the sun and in the shade, in which black and white have the same intensity, shows that when colour is only considered as a value, it does not incorporate contextualised information regarding its appearance in the real world.

As far as texture is concerned, reflectometry is the primary method utilised to measure objects’ reflectance properties and consequently derive texture’s properties. Reflectometers have been used as early as the 1940s based on the principle that different materials and geometric forms reflect light differently, therefore allowing the assessment of surface texture (see for example Halling 1954). In order to better describe the reflectance properties of objects’ surfaces several functions have been formed; these depend on the refractive index and the texture of the surface, and account for the interaction of light with both micro and macro morphology, as well as the viewer. The most known of these mathematical models is the Bidirectional Distribution Function (BRDF) (Nicodemus 1965; Nicodemus et al. 1977), which describes how light is reflected when it comes in contact with a surface. On the other hand, some surfaces are more complex and BRDF is not adequate to define the interaction of light with their textural properties. For this reason, Bidirectional Texture Function (BTF) (Dana et al. 1999), which is related to the spatial variations of BRDF due to the complexity of some textured surfaces along with different viewpoints, has been formed. Both BRDF and BTF can be measured by RGB devices, such as cameras, or a combination of reflectometers/gonioreflectometers and spectrometers, which identify light’s intensity in the whole object or particular areas of the object by taking multiple measurements from different directions (see for example Murray-Coleman and Smith 1990; White et al. 1998; Han and Perlin 2003; Lyssi 2009; for mathematical models used in computer graphics for physically accurate simulations see section 2.2.c.1).

However, methods and devices for reflectance measurement, where the viewpoint remains fixed while illumination varies, have also been developed. A characteristic example is that of polynomial texture maps (PTM), also known as part of image capture techniques under the term Reflectance Transformation Imaging (Malzbender et al. 2001). It is worth mentioning though that the original intention of PTM was to produce a graphics shader which could
replace more traditional shaders related to diffuse light (see 2.2.c.1.), as well as geometry building techniques in 3D graphics, such as bump mapping, to replace existing, but not sufficient methods used to reproduce varying texture and self-shadowing (see 2.2.c.2.). Reflectance Transformation Imaging (RTI) uses digital cameras and lights to capture and enhance subtle surface details, and generate detailed surface models of objects (Mudge et al. 2005, 2008; Malzbender et al. 2000, 2001). This method uses a camera in a fixed position, and a series of lights at a known position, either because they are also fixed, or because this information can be derived from the photographs by using shiny spheres during capturing. The photographs are then combined in a software package, enabling the virtual relighting of the objects by calculating the values for each pixel in the photograph under any incident light direction. Users can use a software viewer to virtually move the light across the surface of the captured object. By combining the results of raking light with image processing and computer graphics algorithms (Earl et al. 2010a), details of the objects’ surfaces can be enhanced, providing an augmented perception of colour, texture and form, in a way that would have been impossible without the use of this technique.

2.2.b.2. Capturing the Macromorphology of Physical Objects; Geometry

Apart from capturing objects’ colour and texture, there are more advanced techniques which enable the recording of objects’ form. Non-contact 3D digitisers, known as laser scanners, are devices that capture three-dimensional information of given surfaces, objects and structures, collecting points at a high rate and producing results in real time (Böhler and Marbs: 2002). Laser scanners generally operate on one of three principles: triangulation, time of flight and phase comparison, and generate a ‘point cloud’, which is a collection of three-dimensional (XYZ) co-ordinates that portrays to the viewer an understanding of the spatial distribution of a subject (Böhler et al. 2003: 1). Post-processing, which is sometimes quite time consuming, is needed to turn the point cloud into useful information, most often as a meshed model (Jones, D. 2007: 12). Depending on the quality of the device used and the amount of post-processing, the results can range from accurate to extremely accurate, mainly regarding the acquisition of measurements and the morphology of the scanned objects. For example, the density of the point cloud highly depends both on the amount of scans of the subject-matter, as well as the time spent to register the results with the highest possible accuracy. The replication of texture and colour also depends on several factors, such as the detail that the device can capture, the number of scans obtained, as well as the amount of post-processing. The use of photogrammetry on top of scanned data (see for example Bitelli et al. 2002; Böehler and Marbs 2004; Neubauer et al. 2005, Lambers et al. 2007; Cabrelles et al. 2009; Remondino 2011) can result in complete object modelling, in terms of both geometry and colour characteristics.
Photogrammetry is a technique that relies on photographs, and is used for deriving accurate three dimensional measurements. The simplest application of photogrammetry is to determine the distance between two points that lie on a plane parallel to the photographic image plane by measuring their distance on the image, if the scale of the image is known. More advanced applications of photogrammetry, called stereophotogrammetry (analogue, analytical or digital), involve the estimation of the three-dimensional coordinates of points on an object, which are determined by measurements made in a series of overlapping photographs taken from different positions. The XYZ coordinates of a given point on an object or surface are measured by the method of triangulation, according to which, rays are constructed from the camera location to the point on the object, and where these rays meet the 3D location of the point is determined. In recent years several applications have been developed which link the accuracy of photogrammetry with the detail of object recognition and modelling that computer vision produces (Mundy 1993). These methods produce three-dimensional photorealistic models which correspond to the properties of the real objects, and can also be used to derive accurate measurements (Pollefeys and VanGool 2002; Remondino and El-Hakim 2006).

Image-based photogrammetric modelling is based on conventional photography and therefore, the various constraints described in chapter 1 apply in this case as well. Some of the major parameters that should be taken into account are: the distance between the camera and the object, the focal length of the camera, the angle of view, and the precision of the software used for post-processing (Lo Bruto and Meli 2012).

2.2.b.3. Capturing in Context

In archaeological contexts, no automated ways are applied to measure the colour of the excavated trenches as an individual piece of information. Any attempts are limited only to the subjective description of soil’s perceived colour or its identification in the Munsell Color Chart. In chapter 1, I extensively referred to the objectivity of colour perception and capture through Munsell Color Charts which are used in archaeological excavations and especially in those that employ the Single Context System of recording. Here, I will refer to a few additional issues emerging from the study of Munsell’s colour identification system. Munsell Color Chart was invented in 1900s and was soon adopted by the Department of Agriculture at the United States of America (Munsell 1905, 1912). The principle of this system was based on the fact that colour has three elements; hue, value and chroma. Hue describes the basic wavelength of the colour; value indicates the level of lightness or darkness of an object when seen under daylight; and chroma defines the degree of colour’s saturation. Apart from being a significantly standardised way to describe colour as a value, there are several conditions that should be fulfilled to ensure a somehow accurate identification.
Firstly, the readings should take place under natural light and preferably on a clear and sunny day. The best time is midday, since light is at the right angle causing the minimum disturbance with less shadows and reflections. Most importantly, the soil should not be dry or wet, but moist. In addition, the sun should be over the right shoulder and the Munsell page should be at the right angle. The observers should not wear sunglasses and the pages should be clean and not discoloured in order to avoid misidentification of colours. All these parameters confirm that ‘rarely will the color of the samples be perfectly matched by any color in the chart. The probability of having a perfect matching is less than one in one hundred’ (Munsell Soil Color Charts 1994: 1).

The Munsell system was soon adopted by archaeologists, realising that some standardisation of colour description is needed for the material that they excavate and study (Gerharz et al. 1988). However, in parallel to its adoption, the limitations that this method has, especially because of the individual perception and the conditions under which the examination takes place were realised (Frankel 1980). Apart from the latter, my own experience in archaeological excavations that employ a Munsell System to define colour values has shown that the guidelines mentioned above are rarely followed. The excavation at Koutroulou Magoula is not an exception. In that case, colour identification is a process – I would say semi-automated – which takes place along with the other tasks that supervising archaeologists have. Archaeologists use the Munsell without following any particular guidelines, while in a few cases the colour value is just copied from the previous context sheets, since the soil supposedly has the same properties. As noted previously, only the colour of the soil is defined by Munsell values. The colour of other features is either described in the form of narrative or it is completely omitted, since it is considered a piece of information that is either unnecessary or that it can be captured by photographic techniques.

The problems inherent in Munsell Charts and individuals’ perception have been extensively discussed and debated so far. Photography seems to be the only means available in the hands of archaeologists to capture an approximation of colour. However, the fact that light’s and viewers’ position affect the colours captured by the camera and perceived by the eyes, seems to remain neglected in the realm of archaeological fieldwork. On top of that, the limitations of the camera in capturing colour are coupled with the limitations of the devices that reproduce colour, such as the monitors where those images are seen and the printers through which the images are printed.

In spite of these inherent limitations, fieldwork projects have eagerly adopted several techniques that enable the recording of archaeological information. RTI for example, was quickly adopted by cultural heritage research and conservation studies, as it was realised
that by using simple and relatively low-cost equipment it is possible to extract information which otherwise would have been lost if using conventional photography (Earl et al. 2011; Mudge et al. 2010). Some of the first applications of this technique were on written records, such as epigraphy, while other fields, such as rock art, numismatics and lithics have also benefited from its capabilities. In addition, in some cases RTI has replaced conventional finds photography with encouraging results, in terms of both speed and resolution of surface details (Earl et al. 2008). Moreover, RTI has been used in conservation to detect details and surface anomalies that would have been impossible to identify by the naked eye, as well as to identify the state of the objects prior to their conservation and also the impact of any conservation strategies employed on damaged items (Kotoula in press; Kotoula and Kyranoudi 2013).

It is worth mentioning that although RTI techniques to derive three-dimensional properties are gradually developing (see for example MacDonald 2011; Drew et al. 2012), RTI can at the moment only capture and interactively visualise two-dimensional information. However, the way that this visualisation is implemented, by moving light and surface enhancements, the perception of three-dimensionality is far more accurate and closer to reality than conventional photographic approaches, both in terms of geometric properties and surface details. To overcome this constraint, which is also intensified by the lighting conditions under which capturing takes place, and especially in cases where three-dimensional capturing is considered necessary because of the extreme flatness of the surfaces, RTI has been used along with photogrammetry to enhance surface details (Earl et al. 2010b). However, this technique can only be used for objects and surfaces, as it cannot capture volumes, such as buildings or larger datasets.

Although RTI technologies have not been used in Koutroulou Magoula, the RTI highlight method has been used for artefacts in the excavation at Zominthos, Crete, where I work as a supervising archaeologist (fig. 48). Based on that, it is worth mentioning that the results of RTI are constrained both by technical and personal choices. As far as the technical constraints are concerned, these have been thoroughly addressed in the section about photography (see 1.4.b.). On the other hand, the human factor can greatly affect both the outcome of the capturing process and the interpretation of the results. A few examples will follow to illustrate this point; the amount of images to be captured is determined by the individual and the intended outcome. This means that the RTI builder (CHI 2013), the software used to combine the images, can efficiently produce a result with fewer pictures, although the level of detail and the range of information will be affected by that choice. In addition, the result of this process and the interpretive value of this application depend on the choice to capture the artefact from a particular side or viewpoint, or even to focus only on a specific part. In addition, the selection of particular enhancements affects the results,
as in each case different features and degrees of surface details are enhanced. Also, there are cases, especially when very small objects are involved, where conventional RTI is not adequate to capture the information needed (e.g. use of microscopic or multispectral RTI). As a consequence, the outcome of RTI and the interpretation of the results, apart from the technological constraints, which are also inherent in digital photography, are bound to users’ choices, their knowledge of the software’s capabilities and their ability to develop a workflow that suits the needs of a particular research project.

![Fig. 48](image)

**Fig. 48** Reflectance Transformation Imaging on a seal made of steatite from Zominthos, Crete. A. Normal maps; B. Coefficient A5; C. Specular Enhancement; D. Luminance Unsharp Masking; E. Coefficient A3 (Images author’s own).

There are several examples in archaeological recording, including Koutroulou Magoula, which have shown that the advances in the field of photogrammetry and computer vision can produce highly accurate information from a series of images by using low-cost or free web-based software. Three-dimensional photogrammetric techniques in archaeological projects have been extensively used in excavation recording, employing different theoretical and methodological approaches to capture finished contexts, intermediate excavation stages and completely revealed features (see for example Doneus *et al.* 2011; Lo Bruto and Meli 2012; Dellepiane *et al.* 2012; Forte *et al.* 2012: 366-370). Similar techniques have also been used for modelling artefacts (Kersten and Lindstaedt 2012) as well as profile estimation for digitised sherds and vessel reconstruction by fragment matching (Willis 2011: 323-352). In the case of Koutroulou Magoula, the resulted 3D model of Building 1 (**fig. 49**) was produced in the software *Agisoft Photoscan* (Agisoft 2013) by combining 120...
photographs taken without prior planning or an established protocol regarding photographing and post-processing. The outcome was commended by the members of the project, since the perception of three-dimensionality was enhanced in comparison to conventional photographs.

Fig. 49 Photogrammetric 3D model of Building 1 at Koutroulou Magoula, Phthiotida, Greece. A. Point cloud; B. Geometry; C. Textured model (images author’s own).
However, since the photogrammetric model relies on conventional photography, technical factors, such as the quality of the lenses, lighting conditions etc. play a major role in the final result. On the other hand, individual choices also form the outcome. The number of photographs taken, as well as the different viewpoints and angles of view, are essential factors which are only determined by personal choices. As the site may not be revisited, and the artefact or structure not accessed again, it is crucial to make the right decisions from the beginning of each project. Moreover, post-processing, e.g. editing the photographs, correcting brightness, contrast and white balance, eliminating unnecessary information in the frame etc., is a necessary and often time consuming step to help the software analyse the images and produce a better model. The outcome is determined by the software itself, however not only the amount of time that it can take to produce the result, but also its quality and the level of detail, depends on the careful workflow that has been employed.

Apart from photogrammetry, which can be employed in archaeological research projects with a relatively low cost, field projects have often implemented laser scanners which provide a very high level of detail and accuracy, mainly regarding the geometry of the subject-matter, but in several cases of its colour and texture. Laser scanners have been used for different scales of datasets, i.e. landscapes (Lasaponara et al. 2011), buildings, artefacts (Esquivel et al. 2007) and human remains (Kuzminsky and Gardiner 2012), while the high-resolution 3D models have often been combined with photogrammetry (see for example Lerma et al. 2010) to produce surface models and eliminate the practical issues that laser scanners pose (Remondino and Campana 2007: 41). Also, there are a few cases where laser scanners have been used to capture contexts in archaeological excavations (Doneus and Neubauer 2005). Finally, laser scanned data have been used as a basis for formal analyses, such as the analysis of buildings’ structural integrity (Miles et al. 2013a).

The results from numerous case studies have clearly shown that especially for large scale datasets the outcomes justify both the cost and the technical and practical issues involved, since at the moment there is no other method which can approximate laser scanner’s level of detail (cf. Miles et al. 2013b on the use of computed tomography for scanning artefacts). The geometry of smaller sites, buildings and objects can be captured with a resolution of a nanometre, while colour and texture can also be recorded with high accuracy. However, comparative studies, such as this at Catalhöyük (Forte et al. 2012), have demonstrated that photogrammetric techniques can produce equally accurate models, while significantly reducing the costs and the technical expertise needed. In the case of Koutroulou Magoula, a Konica Minolta Vivid 9i laser scanner was used during the 2010 field season to capture the most important and better-preserved figurines, ranging from 2 to 8 centimetres, which were found since the beginning of the excavation in 2001. Mainly because of time constraints, the amount of scans and post-processing for each figurine was limited (fig. 50). The results
showed that the laser scanner was incapable of capturing the whole breadth of information, especially regarding the texture and colour of the objects, while the resulted geometry was in several cases problematic. This was mainly because of the small size of the figurines, in conjunction with the detail that the 3D digitiser was able to capture. The far from expected result was due to several technical constraints, as well as personal choices dictated by the available time. It is certain that if better resources were available the information recorded would be much more substantial, and fairly adequate in the context of this discussion (for a study of a Neolithic figurine based on 3D scanning see Kaimaris et al. 2011).

In this section, I referred to three of the methods widely used in the field of archaeological documentation that capture buildings’ and objects’ geometry, colour and texture with greater level of detail and accuracy in comparison to conventional recording methods. It is beyond doubt that these techniques are more sufficient in recording the three-dimensionality of the evidence and making the sites more easily retrievable for future research and interpretation. Also, this three-dimensionality can provide more information to produce a digital reconstruction of a site. For example, the details depicted in conventional hand-made drawings cannot be compared to the fidelity of a texture derived from RTI or geometry from photogrammetry. This means that by using this enhanced information,
digital reconstructions can become detailed and accurate representations of the past. However, as it is argued in this thesis, when computer graphic simulations in archaeology are only seen as products, i.e. images, which attempt to replicate reality and produce pristine images of the past, they can neither augment the process of knowledge production nor improve the understandings about the spatial characteristics of the past. A detailed depiction of three-dimensionality can provide more stimuli about the past (see 5.2.b.2., 6.2.a.); however, the emphasis should be put on the different stages of the process of digital reconstruction, which, if problematised and approached as black boxes that require careful dismantling, can significantly augment understandings. Therefore, it is believed that the advanced computational methods that capture details of colour or texture are not a panacea that will give three-dimensional information about the past. It is the process of questioning how these records are formed and how they are implemented in digital reconstructions that can significantly improve the understandings about present and past practices.

2.2.c. Reproduction of Morphology in Computer Graphics

In the last two sections, I provided an overview of how morphology is perceived and captured both in the real-world and in the context of an archaeological excavation. In the last part of this chapter, I will attempt to address issues related to the reproduction of morphology in computer graphics. This is an integral part of this thesis since the processes and outcomes of the computer graphic simulation of Koutrouloou Magoula examined in chapters 5 and 6 are to a great extent based on how morphology is perceived and captured, as well as on the capabilities of the software used and its flexibility to transform through a graphical interface the real world into digital space.

2.2.c.1 Reproduction of Micromorphology in Computer Graphics; Colour and Texture

The nature of colour and texture is very complex and therefore digital technologies have attempted to provide various means to reproduce their actual properties. For example, in order to define colour as a value in a standardised way, there are several colour models which are based on the principle that a set of primary colours can result in the whole range of visible colours. To achieve that, colour models use a three-dimensional coordinate system and a colour space, where colour is defined as a point which corresponds to three values in the xyz axes. One of the most common colour models is RGB, which is primarily used in computer graphics and is based on the principles of human colour vision. According to this additive model, by combining the three primary colours of light (Red, Green, Blue), the secondary colours are produced. The RGB colour model is extensively used in display devices, although it is device-dependent; this means that each device that employs this
model reproduces colour values differently, since the technology used for the display of
colour elements varies (MacDonald 1999: 24-25). In contrast to the RGB colour model which
is additive, the CMYK colour model primarily used in printers is subtractive. In other words,
Cyan, Magenta and Yellow in order to be produced, subtract colour from white. In CMYK, the
last letter stands for Key; this is actually black colour, and is used on its own to achieve
better results, instead of subtracting cyan, magenta and yellow to produce it. This colour
model is also device-dependent.

As mentioned previously, the range (gamut) of colours that devices can reproduce
significantly varies based on the technologies employed, differences in manufacturing
process as well as the ageing of the materials. This means that an image taken with an SLR
camera is displayed differently in a computer monitor and is simulated differently in a
printer. Although the colours depicted in that image exist in the visible spectrum, the
limitations of devices’ colour gamut result in some of them not to be reproducible either on
a display or a printer. For this reason, colour management is required in order to ensure
that colours render accurately (see for example Emmel and Hersch 2000). Colour calibration
as well as gamma correction are necessary steps so as to convert colour values into
reproducible values, therefore conserving the appearance of an image in different devices.
In order for the colours to be calibrated, devices’ abilities to reproduce colour (colour
gamut) should be specified. For this reason a colour space with a known reference and scale
should be used to encode the degree of colour reproduction in a profile that will allow their
consistent reproduction in different devices. This means that once a device has been
calibrated either by a software or a hardware, a new colour profile is created and becomes
associated with the device.

Gamma encoding/correction is equally important and accounts for a balance between our
eyes’ light sensitivity and of the device in use. As it has been discussed in the previous
sections, humans perceive light and colour in specific ways having a particular response in
certain intensities. However, monitor displays do not follow the same principles. For
example, when a double amount of photons hits a camera, the sensor receives double the
signal. On the other hand, when a double amount of photons hits our retina, we perceive
this amount as being slightly brighter. In such a way our visual system protects itself and
enables it to function in a wider range of brightness. However, devices may allocate on the
one hand more power to areas that humans cannot visually distinguish (highlights), whereas
on the other, much less power to areas that are important to maintain a good visual acuity
( shadows). Therefore, gamma encoding, i.e. increasing or decreasing the bits allocated to
highlights and shadows, is required to ensure that a monitor or a captured scene is
calibrated according to how human vision perceives light and colour (Hunt 2004: 48-54).
In this context, High Dynamic Range Imaging (HDRI) should also be mentioned, since it is a method that allows a greater range between the maximum and the minimum light intensities of an image or a video. Older – non-HDR – devices cannot efficiently display the whole range of intensities, usually resulting in limited contrast. Dynamic range is of great concern especially in cases where high contrast is observed. In archaeological fieldwork for example, where the majority of photographs are taken at an open space, there are cases that part of an image is lit by direct sunlight, while the rest is shadowed. However, most cameras are unable to register that contrast and as a result the image fails to represent the range of intensities existing in the real scene. Similar is the case of the presentation of artefacts and excavated contexts in computer monitors, where limited contrast as well as their inability to accurately display black colour does not allow complete appreciation of the colour ranges involved (for HDRI see for example Reinhard et al. 2006; for a theoretical background and examples of HDRI in archaeological fieldwork see Wheatley 2011; for HDRI in byzantine art see Zányi et al. 2007a).

As far as excavation projects are concerned, they usually fail to record images that capture a greater level of detail because of the pressure exerted, as well as the equipment used and the limited expertise of the person in charge. In several cases, only a couple of images of the excavated features are taken, and these are without any changes in the aperture, shutter speed and consequently exposure, settings that could result in a photograph with a higher level of detail. My own experience has shown that the production of HDR images is rarely attempted in such contexts, since the only rule that is followed is that direct light should be behind the camera and any over-exposed scenes should be properly shadowed to minimise sun’s bleaching effect. To my own knowledge, in none of the excavations in a Greek context photos of varying exposure have been used to produce HDR images (Debevec and Malik 2008). In figure 51a from Koutroulou Magoula, you can observe the loss of detail because of the limited range in contrast. Conversely, figure 51b has been enhanced in HDR Shop (HDR 2012) in order to provide a wider range of textures and colours. Although this is a post-processing effect based on one image, it is clear that a greater range between the areas with lower and higher light intensity can result in more variation in depicted characteristics that might be of benefit to archaeological recording and interpretation.
This section was primarily concerned with the visual perception of colour as one-dimensional entity, i.e. a value. Colour values seem to considerably change when light is modified or when the viewpoint of the observer is altered. Simulations of a stone modelled based on the evidence from Koutroulou Magoula make this apparent. In figure 52, where a stone is rendered in different times of the day, it becomes clear that although the colour of that stone is towards the white spectrum, variations of light during the day significantly affect its perception. For example, between 52C and 52F, the colour varies from light white to grey/black. Similarly, in figure 53, where a close-up rendering of the same stone is depicted, it is observed that even in the microstructure of this object, clear variations of colour exist. The not chemically homogenous composition of the stone, make the particles that it consists of to reflect off light in different ways and therefore to produce local colour variations. The perception of colour is also defined by the position of the viewer. Figure 54 presents the same stone illuminated by a stable physically accurate light (photometric light) rendered by six different cameras. The different viewpoints at different angles and distances from the stone, show slight variations in the object’s colour, as well as texture, confirming what has been argued in the course of this thesis about the variables affecting perception’s main elements.
Fig. 52 Rendering of a stone. A. No sunlight/daylight; B. Daylight/sunlight at 9am; C. Daylight/sunlight at 11am; D. Daylight/sunlight at 1pm; E. Daylight/sunlight at 3pm; F. Daylight/sunlight at 5pm (Images author’s own).
Fig. 53 Close-up rendering of a stone at different times of the day. A. 10am; B. 12pm; C. 2pm; D. 4pm; E. 5pm (Images authors’ own).
Fig. 54 Rendering of a stone from different viewpoints with a stable photometric light (Images author’s own).
Although there are a series of reliable technologies that can be used to measure and capture those changing colour values, it seems that especially in archaeological contexts this cannot be applied due to several constraints posed by the fieldwork’s nature and established practices. However, colour as a chromatic value is not sufficient on its own to provide enough information for a three-dimensional world. That is the point where another crucial element of the world, texture, can provide context to colour and enhance the visual perception of space.

As mentioned in the previous section, Bidirectional Reflection Distribution Function (BRDF) and Bidirectional Texture Function (BTF) have been developed to characterise surfaces’ reflectance and help to better define objects’ textural properties when they are seen from various angles. BRDF is a mathematical model that is used in computer graphics for the production of photorealistic and physically accurate images, since it defines the interactions between light and objects’ properties, i.e. the amount of light incident from one direction emitted to another direction. Similar to BRDF is Bidirectional Transmitted Distribution Function (BTDF), which describes the same relationship between light and matter but for the opposite side of the surface. This mainly applies to transparent objects which allow light to pass through them. BRDF and BTDF could be seen under the more general model of Bidirectional Scattering Distribution Function (BSDF), a term which actually encompasses the functions of both BRDF and BTDF, i.e. how light is reflected off and transmitted to objects’ surfaces. Lastly, there is a more advanced mathematical formula that describes the phenomenon of sub-surface scattering. In other words, when light enters a translucent material, it scatters around, and finally, leaves the surface at a different location. This is called Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF) (Jensen et al. 2001), and the main difference with BRDF is that the latter assumes that light enters and leaves at the same point (fig. 55). Characteristic example of a translucent material that requires BSSRDF rather than BRDF for physically accurate modelling is marble (fig. 56).

![Explanation of BRDF, BTDF, BSDF, BTF, BSSRDF mathematical models](Image author’s own)
These functions of geometry and texture can be both captured and simulated. The latter is possible via the graphical interface of a 3D graphics software (see 5.1.). The simulation however of physically accurate models requires the implementation of a physically accurate rendering engine. A renderer in 3D graphics is a computer program or a set of programs that combines all details in the modelled scene (geometry, textures, illumination etc.) in order to compose the final output, which may be a digital still image or an animation. The way that this output is constructed through complex rendering equations is dictated by the parameters chosen both within the software package and the rendering engine itself. Unless otherwise stated, for all models presented in the thesis, Mental Ray renderer (Nvidia 2013a), a standard across industries for physically accurate simulations, has been employed.

Although rendering engines play a definitive role in the production of three-dimensional models, one of the basic parameters in the reproduction of texture in computer graphics is the so-called texture mapping, a method which adds details to the modelled scene. After
creating the geometry for the scene, the modeller has to choose the desirable materials, including colour, which correspond to real-world equivalents. Materials can be also enhanced by applying a map. A map is a bitmap that is applied to the surface of an object and is wrapped around either to change its appearance or to modify its surface based on the intensity of pixels in the map (see 2.2.c.2.). However, in order for the textures to be correctly applied, the modeller has to do some texture mapping (Catmull 1975), a process similar to gift-wrapping. This means that in order to accurately apply the desirable textures the person in charge should define how and where the textures will be applied. For example, how a stone texture will wrap around the geometry so as not to become distorted due to the irregular shape of the object? Texture maps can be further refined in image-editing packages, e.g. by adding hand-drawn details, which will then be applied to the objects in the scene. Examples of texture mapping can be seen in figures 52 and 53. In those images it can also be observed that variations in light result in different perceptions of the textured surface. For example, in figure 52, the stone in C which is rendered with the sun almost vertical to its surface, seems like being entirely smooth in contrast to the stone in E where the low angle of light enhances the perception of its texture. The latter is the reason why in figure 53, significant variations are observed especially in areas where texture is less rough and dents less apparent. Variations in texture can also be observed in figure 54; greater distances from the object, as well as low angles of observation have as a result a smoother appearance of the stone.

The addition of materials and texture maps are not the only steps needed to be taken towards the production of a three-dimensional scene. In the rendering process, another mathematical algorithm, a shader, also intervenes to result in a certain output according to its input parameters. Shaders are primarily used to produce lighting and shadow effects by determining the intensity, colour and distribution of illumination across a surface. In addition, they can also be used to create special effects, and therefore, can be applied not only to the geometry of the scene, but also to the lights and cameras involved. Lastly, based on the material type used, there is a wide range of shaders that can be applied, which allow different material maps and properties. However, it should be noted that in cases were physically accurate renderers are used, modellers do not have to select a shader that accounts for the interaction of light with objects’ materials and textures, since this is regulated by the rendering engine. Shaders are divided in three categories depending on the aspects of the scene that they affect with their algorithms; vertices, pixels and geometry. Vertex and Pixel shaders mainly affect micromorphology, whereas geometry shaders affect macromorphology. Based on the capabilities of these three types of shaders, software packages have developed a series of integrated shaders that affect objects’ appearance by defining highlights and reflections as well as special effects for cameras and illumination. For example, in figure 57, the same stone has been rendered with four different shaders.
Although the application of most of these shaders render the stone a non-physically accurate object, it gives an indication of how these mathematical algorithms affect the interaction of light with matter. For example, ‘phong shader’ smoothes the edges between faces and produces highlights for regular or shiny surfaces. On the other hand, ‘blinn’ makes objects’ highlights appear rounder, whereas ‘Oren-Nayar-Blinn’ smoothes the highlights and gives to materials a matte effect (for more details on the use of shaders in the rendering pipeline see Akenine-Möller et al. 2008: 11-28; Shirley and Marschner 2010: 161-179).

Fig. 57 Close-up view of a stone lighted by a photometric light of 14 candelas and rendered with various shaders. A. Anisotropic; B. Blinn; C. Oren-Nayar-Blinn; D. Phong (Images author’s own).
2.2.c.2 Reproduction of Macromorphology in Computer Graphics; Geometry

Computer graphics software packages support a wide range of tools to produce three-dimensional geometry. The most common way is by creating basic geometric shapes and by applying various modifying tools to give the desired final form. For example, in order to create a stone, a basic shape to start would be a rectangle or a cube. Apart from dimensions, all these objects have additional parameters that should be defined in the creation process. Objects consist of segments, i.e. polygons, which indicate the amount of detail that they can carry. Therefore, the addition of segments increases objects’ complexity, thus affecting hardware performance. On the other hand, more segments would facilitate the modifiers chosen to alter the original geometry, since more detail in objects’ geometry means more detailed modifications. For example, a box with two segments in length, width and height can be bent less efficiently in comparison to an object with more segments. Apart from creating geometry by modifying ready-made geometric shapes, flexible lines, usually called splines, can also be employed to produce outlines of objects in two dimensions and then be edited to define their volume and other three-dimensional properties. Before proceeding to the examination of other techniques for creating geometry, it is deemed necessary to refer to normals, another property that is integral in objects’ morphology. Normals are vectors perpendicular to the surface of an object, and although they are not rendered or may not be directly visible, they are an essential factor in geometry production, since they define the way that the surface of an object is facing, and consequently how geometry is shaded, smoothed and illuminated.

The needs of gaming and technical industries have forced developers to find efficient texturing algorithms in order to mimic the appearance of real textures without affecting computational power. As mentioned above, 3D graphics make use of texture mapping in order to assign textures to objects and make them look more realistic. However, there are some texture mapping techniques that can also work to produce or fake geometry. In the next part, I am going to refer to three methods, bump mapping, normal mapping and displacement mapping (fig. 58), evaluate their fidelity and discuss about their impact on the perceived three-dimensional scene. As the name of the first method suggests, bump maps allow adding a certain amount of bumpiness to objects. Although the application of bump mapping makes even flat surfaces get some three-dimensionality, objects’ geometry is not affected, since the only parameter that is changing is the reflection of light as if the geometry dictated by the bump map would have actually existed (Blinn 1978). A bump map is a greyscale image that tells the renderer to redirect the light according to the image’s values by altering objects’ normals; areas of light tones in the image become high points on the objects’ surface, whereas areas of dark tones become low points accordingly. The benefit of bump maps is the easiness of their production, even by hand, and that they can
be efficiently handled by the renderers. The main disadvantage is that greyscale images are of low resolution and as a consequence, the details of the resulted model are limited, especially around its edges.

Fig. 58 Wall in Z1 Trench. A. Diffuse map; B. Bump map 50%; C. Bump map 100%; D. Displacement map 5%; E. Displacement map 5% and Bump map 100%; F. Normal map 100%. On the right side are the corresponding maps (Images author’s own).
A similar technique to bump mapping is normal mapping, which was developed in an attempt to enhance 3D models’ appearance without adding geometric information and increasing their complexity (Cignoni et al. 1998; Cohen et al. 1998). The base of this method is as well an image, not in greyscale, but in RGB colours, containing three times more information in comparison to the previous technique. The colours in the image are used by the renderers to define the direction that surface normals point to; and because normals have been already calculated within the image, renderers can more efficiently handle their processing. The latter is the main reason why normal mapping has been adopted by game industries, where real-time rendering is required. However, similarly to bump mapping, normal maps do not alter geometry and therefore objects’ edges appear relatively flat. It is also worth mentioning parallax mapping (Kaneko et al. 2001), an improvement of bump and normal mapping, which uses the information of a greyscale height map, in order to get a height value at the current pixel and work out which pixel the viewer/camera would be looking at. In such a way, parallax mapping creates a depth illusion in relation to the camera, which is not reduced as the camera moves closer to it, as is the case with normal mapping.

In contrast to the previous techniques of texture mapping which create an illusion of extra geometry and depth, the last method, displacement mapping (Cook 1984), as its name describes, displaces objects’ geometry in order to produce the desirable level of detail. A displacement map is a greyscale image that works the same way as the greyscale bump maps. Although this is the only method that adds view-independent detail, since it is not only shadowing but modifying geometry, displacement mapping highly affects processing power and memory usage. As a technique that requires more computational resources than the other texture mapping methods, it cannot be often afforded in real-time rendering applications (see 5.1.c.). For this reason, it is usually implemented along with bump and normal mapping; the latter are used for the fine detail, whereas displacement maps give the initial larger form. The major disadvantage of displacement mapping is that apart from adding to the complexity of the scene, the level of detail depends on the geometry of the models, i.e. a detailed mesh produces a high level displacement, whereas meshes with low resolution result in less texture/geometry detail.
Conclusion

At the beginning of this chapter I expressed several concerns regarding the colour, texture and form of everyday objects experienced under varying conditions. In the course of this discussion, I tried to show that each object, although an entity, consists of several components which mould its appearance. Contrary to what is commonly believed, an object is not three-dimensional only because its form occupies 3 axes (xyz). Both its micromorphology, i.e. colour and texture, as well as macromorphology, i.e. geometry, are essential interrelated components that comprise its three-dimensional properties. The understanding of these properties is fundamental in any attempt to understand the real world, as well as the relationships and interactions between people and objects. However, the perception of these properties is a complicated process since it is influenced by the viewing context, which is regulated by both nature and neural processing. This means that the same object is uniquely perceived by each person even if viewing conditions remain constant, while each variation in the viewing context results in numerous versions of the same object. From this accrues that there is not a single real object, since the real is only in the eyes of the beholder.

By discussing some of the extensive literature that exists in the field of perception, and using examples from archaeological fieldwork, it was demonstrated that the constraints of perceiving objects’ reality, pose certain theoretical, practical and methodological issues for the way that fieldwork is practiced. The available means to effectively capture the three-dimensionality of the archaeological evidence either are limited or involve technologies that are not widely spread in the discipline and/or require skills, training, time and money. However, even if all resources needed to capture the three-dimensionality of archaeology were available, the recording of this information would be complicated, since a single object consists of an infinite number of three-dimensionalities depending on its internal elements and external factors. Obviously, it is not suggested that it is futile to record archaeological evidence since only one of their numerous facets will be captured each time. Rather, it is crucial to raise archaeologists’ awareness that since there are several factors related to objects themselves, humans’ perceptual mechanisms and the conditions under which the process of perception takes place, perceiving the three-dimensional character of archaeological features is quite complex. Therefore, what is futile in this context is not the process of recording per se, but the overemphasis to an objective and unbiased archaeological record.

Similar concerns, but of a different nature, are also evident in the process of transforming the three-dimensionality of the evidence to the distinct three-dimensionality of computer graphics. There are several modelling and processing tools and methodological approaches
that provide the means to transform the real into the digital world. The complexities of the real world however, make it difficult to simulate the interaction between micro and macro morphology as well as the viewing context. Therefore, what seems more important from archaeologists' perspective is not to reproduce reality, but to explore how the process of 3D modelling, could augment the understanding of the archaeology of a given site. The realisation that archaeological computation and particularly 3D graphics are increasingly considered an implicit part of archaeology rather than a separate discipline makes the problematising of the modelling process a timely and meaningful pursuit.

In the next two chapters, aspects of the Greek Neolithic, as well as the archaeology of Koutroulou Magoula will be examined. In particular, the next chapter about the spatialities of the Greek Neolithic will primarily focus on domestic spaces, also discussing the heuristic use of ethnography, experimental archaeology and visualisation in an attempt to contextualise the case study, as well as to highlight the varying sources of information in the process of knowledge production.
Chapter 3
Spatialities of the Greek Neolithic:
Organisation, Domestic Spaces and Living:
Archaeological, Ethnographic and Experimental Approaches

Introduction

The Neolithic period encompasses four millennia of transformations and transitions across the whole western world, during which hunters and gatherers gradually adopted new modes of production and survival. These communities, which occupied fertile lowlands, marginal rural areas and insular regions formed settlements, developed their own social and economic arenas, and ensured their survival and growth. The material culture suggests that they were also in contact with each other, constructing a dynamic network and giving specific meanings to their locales, encapsulating memories as well as personal, social and cultural values.

The purpose of this chapter is neither to duplicate information that has been presented in numerous text books, articles, conference proceedings and in more synthetic approaches regarding settlements, architecture and domestic spaces of the Greek Neolithic, nor to present data from Neolithic sites and an exhaustive bibliographic list of the relevant research completed to date. As this chapter is intended to cover a well-trodden field, I will attempt by drawing on completed research and the related literature to present my own understanding of three-dimensional evidence in the Greek Neolithic, in terms of architecture and the sense of space. I will first refer to the basic characteristics of tell settlements in order to contextualise the case study. Then, I will examine issues related to the architecture of Neolithic structures and the use of space, using evidence from archaeological sites. In this context, I will discuss the importance of ethnographic and experimental approaches referring to some characteristic examples that provide new insights into Neolithic materiality. Finally, I will examine the ‘tradition of (re)construction’ in the Greek Neolithic as evidenced in physical (re)constructions, (re)construction drawings and 3D visualisations. Further discussion on patterns, organisation and some theoretical considerations of Greek Neolithic tells and flat-extended settlements can be found in Appendix I.
3.1. Tell Settlements in the Greek Neolithic

Greek Neolithic settlements are almost synonymous with tell sites. Although there are about 1000 identified sites spread across the whole country, including the Peloponnese and the islands, the excavation of Sesklo and Dimini (fig. 59, 60) by Tsountas (1908) has led to the uneven geographic distribution of research projects and a limited interest in regions out of the Thessalian Plain (Kotsakis 2009). However, research in Northern Greece during the last two decades, with Makriyalos (Pappa 2008) being a prominent example, proved that another type of settlement existed, which was morphologically, functionally and also ideologically different from tells (also see Appendix I).

Tells’ internal organisation is indicative of the intensive use of space. In several cases, the structures were built in direct contact with each other (fig. 61), while a small amount of open space was left to facilitate tasks that could not be carried out in the interior, as well as communal activities (see for example Mottier 1981; Hauptmann 1981; Milojčić 1983 for related evidence from Otzaki Magoula). Storage of goods, food preparation, consumption and habitation were taking place in the interior of rectilinear mud brick houses, often with stone foundations consisting of one or two rooms. In the Late Neolithic period, ‘central buildings’ may have played a different role in the organisation and management of the community. In Nea Nikomedeia for example (Rodden and Wardle 1996), the central building has been interpreted as a shrine (fig. 62), while in Ayia Sofia it was connected with a tumulus preserving evidence of rituals (Milojčić 1976). The role of these central buildings is also strengthened by a new type of multi-space structure called megaro during the Late Neolithic period (fig. 63). Because of its resemblance to the megaroid structures that emerged in the Bronze Age, the same term is used for Neolithic structures, and has connotations for a more complex social and hierarchical organisation, as was the case in later periods; this cannot be sufficiently supported for the Neolithic. However, as they were structurally unique they might have had a special function, but not necessarily a symbolic one (Kotsakis 2004: 64).

The various constructions were surrounded by enclosures (fig. 64) which divided the different parts of the settlements and retained the soil of the slopes. Walls made of adobe and/or stones, such as these in Sesklo and Dimini, have been characterised by Tsountas, the first excavator of these sites (Tsountas 1908), as fortification constructions. Chourmouziadis, who excavated Dimini in the 1970s, rejected this role, pointing out that they were internal boundaries constructed to organise different areas in the settlement (Chourmouziadis 1979). In addition, ditches might have already defined settlements’ boundaries from the Early Neolithic. These constructions have often been interpreted as defensive (Runnels et al. 2009), although the most profound arguments link them to the planning and organisation of the
settlements; not only did they have a practical function by limiting the intrusion of wild animals and the escape of domesticated livestock (Grammenos 1996: 43), but also a symbolic role by distinguishing binary opposites: inside vs. outside, built space vs. nature, occupation vs. production etc. (Kotsakis 1996: 52, 1999: 68, 2004: 64; Andreou et al. 1996: 543).

Ditches, walls and other communal constructions were not only delineating space, but they were also visual, aural and olfactory barriers for the people that were not allowed to come into the settlement area (Bailey 2000: 47), or they moderated access to particular zones. These constructions were both limiting physical access and access to the social arena, thus embodying the knowledge and the ideologies of these communities. In order for somebody to get into the inhabited area, he/she might have had to pass through several structures, which acted as barriers, therefore constructing a physical and symbolic rite of passage, after which he/she was accepted in the built space and the settlement’s social realm (Gheorghiu 2008:171, 2009b: 353-354).

Fig. 59 Sesklo A and B - The Neolithic ‘acropolis’ and the ‘flat’ settlement. Different sections and trenches are shown (after Theocharis 1973).
Fig. 60 Dimini – Neolithic structural components and features (Souvatzi 2008).

Fig. 61 Intensive use of space in Sesklo’s houses outside of A’ region (Akropolis) (Theocharis 1973).
Fig. 62 Early Neolithic building levels at Nea Nikomedeia (after Rodden 1964, redrawn from Pyke and Yiouni 1996).

Fig. 63 Neolithic Megaron at Visviki tell (Velestino) (after Benecke 1942).
Fig. 64 Tentative construction of Neolithic Dimini by Manolis Korres. External and internal enclosures are presented (Theocharis 1973).
3.2. Constructing a Neolithic Dwelling

3.2.a. Architecture, Materials and Meaning of Neolithic Houses

Although the Greek Neolithic is relatively uniform regarding settlement patterns and types, the architectural evidence, i.e. house forms, construction techniques and materials, show a clear diversity even within the same settlement, reflecting different engagements with the landscape, both physical and social, as well as social relationships and organisation. The intended use of an environment and the activities involved shape architecture (Kent 1990: 2; Rapoport 1990: 11). Architecture, which does not only provide shelter or a borderline between private and social space, but also constitutes private and social life, influences the behaviour of its users, while reflecting and also forming social relationships, and supporting the construction of identities. However, architecture on its own is not adequate to infer any kind of social or other behaviour. There are complex spatial and temporal activity systems, which are actively generated, developed and transformed by its users, and link the built environment with people and their cosmos (Rapoport 1990). The problem though lies in the fact that many spatial and temporal components of these systems cannot be traced in the archaeological evidence.

Architecture, and consequently the use of space, is influenced according to Sanders (1990: 44-46) by seven factors: climate, topography, materials, technology and skills, economic resources, function and cultural conventions. The first two are naturally fixed; the last two are culturally derived, whilst the rest are flexible. To these factors we should also add the usually excluded body, as architectural order is 'violated' by human movement and in turn, architecture 'violates' the human body by moulding new relationships, compelling each other to adapt (Tschumi 1996: 117-138). In archaeology, Hamilakis has also pointed out the exclusion of corporeality in archaeological reasoning, discussing the impact of the human body on the environment and vice versa, examining the notion of embodiment and the sensory experiences developed through the interaction of the human body with its context (Hamilakis 2002a, 2002b). The relationship of the human body with architecture not only affects its form and function, but it has a great impact on the capabilities of its users to experience space through kinaesthesia and the sensory system.

Architecture, which encompasses social and political meaning, as well as world views, is combined into a spatial and temporal system to form a locus of shared experience (Kovacik 1999: 165); a settlement. Settlements are dynamic sociocultural landscapes, which materialise people's ideologies at a large scale (Herbich and Dietler 2009: 12). At a smaller scale, it is houses that reflect the beliefs of a particular society and of the individuals who are part of it.
However, houses not only distinguish the internal/private and the external/public space but also have a wider meaning, which links the private to the social realm of the settlement (Wilk 1990: 40). For example, in the case of abandoned Neolithic dwellings, houses become mnemonic devices (Bourdieu 1977) that interconnect social, spatial, temporal and material elements (Bailey 1990: 28; also see Appendix I). Houses’ material aspect is equally important since it not only reflects daily life and skills, but also cultural concepts and social processes through which the inhabitants express and shape their identities and create a series of symmetries and asymmetries.

Fig. 65 Tentative construction of a building with two storeys from Promachona/Topolnica (Koukouli-Chryssanthaki et al. 2007).
The archaeological evidence to date has provided concrete data about the materials used for the construction of the Neolithic dwellings, the plan of the houses, the foundations and their internal organisation. To be more specific, most buildings are square or rectangular, and sometimes have an upper storey (e.g. Tsangli - Wace and Thompson 1912; Otzaki Magoula - Mottier 1981; Hauptmann 1981; Milojčić 1983) (fig. 65, 66), while there are cases, e.g. Makriyalos (Pappa 2008), where apsidal or circular and elliptical buildings have been preserved. The latter is mainly evidenced in flat-extended settlements (see Appendix I). The materials used depended on the available resources; therefore, in lowlands where stones were scarce the main material was mud, which was dried under the sun to produce mud bricks (e.g. Argissa - Milojčić et al. 1962) (fig. 67, 68, 69). On the contrary, in regions where it was easier to find stones, the foundation of the buildings and part of the wall was made of stones, while

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the rest of the superstructure was made of mud bricks (fig. 70, 71, 72), pisé or wattle-and-
daub (e.g. Sesklo and Dimini, Lerna - Caskey 1957, 1958; Tsaggli - Wace and Thompson 1912; Gediki - Theocharis 1967 etc.). However, it has been argued that the choice for particular materials, was not only a matter of availability, but also accrued from Neolithic dwellers' attitude towards different approaches to built space, either on an aesthetic or symbolic basis. Different types and sizes of wood were used for timber frames (fig. 73), while walls and roofs were made by small tree trunks, among which smaller branches and twigs were woven, often covered by clay and mud (wattle-and-daub), a technique mainly associated with pit houses (e.g. Argissa; Nea Nikomedeia – Pyke and Yiouni 1996 etc.) (fig. 74). From impressions found on the various materials, mainly mud bricks, it is clear that reeds, straws and other fragile materials were used to make mud bricks more durable, while the use of textiles and animal leather has also been suggested. The structures, either made of mud bricks, posts or with stone foundations, were laid either directly on the ground (e.g. Otzaki Magoula, Sesklo, Nea Makri – Pantelidou-Gofa 1991; Lerna, Achilleion II - Gimbutas et al. 1989) or were set in trenches (e.g. Nea Nikomedeia) (fig. 75). Posts were also set on or within the stone foundations of wattle-and-daub and pisé structures.8

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Fig. 67 Decorated part of a mud coating from the superstructure of Building H at Kleitos I (Papadimitriou and Tsirtsoni 2010).

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8 See Perlés 2001: 181-3 for a summary of architectural material remains from the Early Neolithic.
Fig. 68 Construction of a wall made of mud bricks (Perlès 2001).

Fig. 69 Abandoned structure made of mud bricks at Neo Monastiri, Phthiotida, close to Koutroulou Magoula (image author’s own).
Fig. 70 Tentative construction of the Neolithic House T from Tsangli with stone foundation and superstructure made of mud bricks (Wace and Thompson 1912).

Fig. 71 Abandoned structure with a stone foundation and superstructure made of mud bricks at Neo Monastiri, Phthiotida, close to Koutroulou Magoula (image author’s own).
Fig. 72 Reconstructed Neolithic house at Volos. It is made of mud bricks coated with mud and has a stone foundation. It has a slightly gabled roof made of reeds and straws (image author’s own).

Fig. 73 Tentative drawing of the timber frame of Building 6 IV at Nea Makri (Pantelidou-Gofa 1991).
Fig. 74 The elements of a wattle-and-daub wall (Perlés 2001).

Fig. 75 Foundation trench for Wall E – Phase 1, Structure 3: F10/D, F20/C at Servia, Kozani (Ridley et al. 2000).
Although there is a clear idea about buildings’ plans and the materials of their superstructures, the evidence rarely provides indications of doors and windows or any other openings that could have facilitated entry, light distribution and air circulation. In addition, the identification of roofs and their materials is quite ambiguous, as there are no preserved superstructures of the Greek Neolithic. Ethnographic parallels indicate that roofs were often gabled or flat, and frequently conical in the case of circular structures, and were made of tree trunks, covered with reeds and straws (fig. 76). Although the use of mud has been suggested, Skafida’s ethnographic study in Thessaly (Skafida 1994) has shown that the builders were not using mud or clay as the roof became quite heavy, especially with rain, and its conservation became difficult. As far as their internal organisation is concerned, they might have had a central row of posts in cases where the superstructure was heavy, while any internal partitions would have been supported by posts. The fragile materials used for the construction of these buildings make the problem of erosion apparent, especially in conjunction with rainwater or high levels of humidity. The gabled roof, the frequent maintenance, the coverage of surfaces with mud, as well as the open space between the houses might have counteracted this issue, whilst the construction of a stone platform often covered with stone jambs might have been an additional choice (Skafida 1994: 181).

Fig. 76 Abandoned house at Neo Monastiri, Phthiotida, close to Koutroulou Magoula. Its gabled roof is made of reeds and straws, supported by thicker wooden elements (image author’s own).
As far as the interior of the structures is concerned, the evidence suggests the existence of distinctive activity areas, such as platforms, hearths, pits for cooking or storage etc. (e.g. Sesklo – Kotsakis 2006b) made of stone and clay (fig. 77). Hearths (fig. 78) were especially common inside the houses, but their position and nature varied even within a single site (Perlès 2001: 192). Domestic activities were assisted by portable artefacts as well, such as quern stones, grinders, palettes, obsidian and flint blades, axes, adzes, chisels, as well as spindle whorls, loom-weights and spools, and of course, pottery. The distribution of these artefacts in and around domestic spaces indicates areas of human activity, while after the analysis and study of these remains, human activities and use of space are interpreted and related to the form of habitation. For example, in Koutroulou Magoula, among the various finds unearthed, stone tools, animal bones and carbonised wood suggest that activities related to food processing and consumption were taking place both inside and outside the habitats. This involved both the open areas and areas where access was limited to the inhabitants of particular buildings (e.g. yard) (see 4.1.c., 4.3.).

Fig. 77 Tentative construction of House 11-12 at Sesklo. Storage vessels, as well as areas for cooking and processing are shown (Theocharis 1973).
Outside the buildings there were activity areas related to domestic and social practices associated with hearths and ovens, excavated pits, floors, basins etc. As far as pits are concerned, the identification of their use is quite ambiguous, as they might have been used as clay digging pits for the construction of the houses, for storage of food and water, for fire, or for rubbish, all of which are to a certain extent equally supported by the archaeological evidence. These activity areas were located in yards (e.g. Sesklo A – Kotsakis 2006b), shared spaces between buildings, or in larger spaces left free of buildings. This indicates some form of communal activities, such as food sharing or gardening (Chapman 1990: 38; Andreou and Kotsakis 1994: 23), not just for survival, but for the materialisation of the identity of the households (Halstead 1989: 74; especially for areas used for gardening see Mlekuž 2010: 197-201) and the reinforcement of domestic strategies of surplus production (Halstead 2004).

These areas were differentiated by terraces, walls and ditches, for practical and/or symbolic reasons (Perlés 2001: 175), while boundary walls and ditches (e.g. Souphli Magoula – Biesantz 1959; Achilleion, also see Souvatzi 2008: 175-178; Pappa 2008: 48-53) were constructed around the communities to delineate space, define village and non-village spaces, limit access or even for defence (Runnels et al. 2009).
In both tell sites and flat-extended settlements, buildings were acting as territorial markers, either by their gradual formation, or their slow dilapidation and sudden destruction. In all cases, these intentional acts and their perceptible results in the landscape were functioning as a memorial both of people’s predecessors, as well as of public and private events, forcing the Neolithic inhabitants to position themselves in relation to the rest of the community (Bailey 2005a: 96). The increasing materialisation of Neolithic life, with the dwellings themselves as individual objects, the various internal and external features and the artefacts used in everyday tasks, provided an arena with multiple levels, where individual and collective memories were constructed and managed (Hodder 2005: 131).

3.2.b. Neolithic House Models: Evidence of Architecture or Heuristic Sources?

Miniature representations of buildings, known as house models, can potentially be heuristic sources for the discussion of architecture, as they provide indicative information regarding the vital elements of Neolithic dwellings, which most often are not preserved in the record. In the Greek Neolithic, house models were produced during the middle Neolithic period with an emphasis to the representation of the exterior, and in the late Neolithic period, mainly depicting buildings’ interiors (Bailey 2005b:170-171). House models, especially of the middle Neolithic period, indicate slightly gabled roofs with an opening in the middle for the adequate ventilation of the interior, especially when a hearth was in use (fig. 79, 80). The exterior of these buildings is often decorated, while other architectural parts, such as roof beams, are also depicted via paint, reliefs and incisions. The colours used on these miniatures for the decoration of their surfaces have led to the assumption that Neolithic houses were also painted (fig. 80, 81). However, it is probable that the various patterns depicted could represent animal fur or organic materials. Features of the interiors, such as ovens, benches and hearths, are also present in these models.

House models have been often used in archaeological reasoning in order to overcome the various constraints posed by the inadequate preservation of the material. However, direct analogies should always be treated with caution, since the assumption that the people of the Neolithic were producing exact replicas of their dwellings, which can be used by archaeologists to fill in the gaps of any assemblage, may be misleading. In the same way, it cannot be adequately supported that human and human-like figurines are portraits of Neolithic people. For example, the house model from Chaironia (fig. 79) indicates that houses – or this particular house – had a small opening, which could be used both as a window and a door, as there is no other opening to facilitate these needs. Ethnographic evidence indicates that an opening at the roof often facilitates air ventilation and light diffusion, as well as the escape of smoke from the hearth. On the other hand, a house model unearthed at Koutroulou Magoula (fig. 81), which preserves coloured bands, bears four openings, one at each side, also having a hearth in the middle. It is not clear which of these openings represent doorways...
and windows; however, it seems to be suggested that more than one opening existed in the superstructure of the buildings. Yet, the evidence from the site so far has not provided a definitive answer to this matter.

Based on the above, how reliable would it be to reconstruct the Neolithic houses from Chaironia and Koutrouloú Magoula in the same way as these house models? Can they be used as a basis to simulate dwellings in other settlements? Are these depictions of houses in these particular settlements, or abstract and schematic depictions of the house as a concept? Were all the houses built on the same principles or do they represent particular buildings? These questions cannot be satisfactorily answered based on the available evidence, and therefore, cautious interpretations should be made before using house models to inform the simulation of Neolithic dwellings.

![House model from Chaironia](image)

**Fig. 79** House model from Chaironia. It has a window and a gabled roof which bears an opening to facilitate air ventilation (Theocharis 1973).
**Fig. 80** House model from Mirini Karditsas (Middle Neolithic 5800-5400/5300). The roof has an opening and the exterior is decorated with coloured patterns (Papadimitriou and Tsirtsoni 2010).

**Fig. 81** House model from Building 1 at Koutroulou Magoula (Middle Neolithic 5800-5400/5300). It has four openings at its sides and a hearth in the middle. It also preserves coloured bands (Koutroulou Magoula Archaeology and Archaeological Ethnography Project; processed by the author).
3.3. Ethnographic Research in the Process of Reconstruction

Although there is a great number of Neolithic assemblages that provide evidence for the plan, the materials used and the internal organisation of these structures, there is no indication for the process of construction, including the amount of people, time and skills needed, as well as the durability of the structures. These are very important issues in the discussion of the relationship that the Neolithic inhabitants were forming with and within the built space, as well as the construction of ideology and culture. Both ethnography and experimental archaeology are useful heuristic sources in the course of such research and analysis; however, such approaches should not be imposed on archaeological datasets to compensate for missing data. Although the parallels used are usually chosen so as to bear resemblance to the past (for related criticism see Binford 1968; Hawkes 1954; Laming 1959; Leroi-Gourhan 1964; Smith 1955; Stanislawski 1973), apart from similarities, they have great differences, since they have their own culture and history. For this reason, the so-called analogies should be used as broader comparative sources and generators of hypotheses, while trying to be as detached as possible, and avoiding judgements and interpretations based on modern analogical reasoning.

There are several concepts in archaeological theory which have been supported by such generalisations under the principle of uniformitarianism. For example, formation theory developed from the 1960s onwards, used several archaeological and ethnoarchaeological studies, mainly from the American Southwest, to discuss about the processes that take place when a settlement is abandoned. However these studies gave birth to a series of natural and cultural laws to describe these processes (Schiffer 1972; 1975, 1976, 1987; Schiffer and Rathje 1973), which in turn were used to prove the cross-cultural generality of these processes around the world. However, recent works in the Mediterranean about abandonment and post-abandonment behaviour (see for example Creighton and Segui 1998; Papadopoulos 2013) have proven that especially for cultural factors, i.e. human intervention, law-like generalisations or the concept of universality are ‘mundane and trivial’ (Tilley 1996: 1).

The impetuous use of ethnographic parallels to talk about the past without considering the distinctive spatiotemporal contexts (see for example Groube 1977: 69-90), and especially the constant use of Melanesia (see for example Spriggs 2008), have been criticised by several scholars in the field. Melanesia has been uncritically used to illuminate Neolithic Europe without taking into consideration that colonialism and the interaction with the west have transformed these societies. The problems emerging from such analogies are multidimensional, as the new Neolithic (or other period) that is produced is affected even by the ethnographers themselves, who introduce to these societies new elements, or subtract

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9 For a discussion on ethnoarchaeology/ethnography and the methods see: Donnan and Clewlow 1974; Stiles 1977; Kramer 1979; David and Kramer 2001; Cunningham 2009. For a discussion on archaeological ethnography and the methods see: Hamilakis and Anagnostopoulos 2009.
others. This brief reference to some of the issues pertaining to ethnographic analogy aims at drawing readers' attention to the fact that, although analogical thinking can help to solve many issues emerging from the fragmented evidence, it can also produce a distorted version of the past reflecting ‘a turbulent ethno-history from some other part of the world’ (Groube 1977: 87).

Ethnographic observations can potentially provide useful information that cannot be derived from the archaeological evidence. For example, the evidence that Skafida has gathered from Thessaly (1994) indicates that a house of 50 sq.m., could take up to a month to be completed. The building would involve a few experts for the construction of the mud bricks, in collaboration with other people from the family, relatives and neighbours, including women and children. In addition, the maintenance of the surfaces 1-2 times per year, and the renewal of the soil of the floor at regular intervals were essential, in order for the house to last up to 100-150 years. This time span is not in accordance with research carried out in Thessaly and Corfu, which indicated that a Neolithic house’s life cycle could not be more than 50 years (Halstead 1984; Sordinas 1978). However, a house’s life cycle is significantly less if not maintained, or if essential structural components, such as the stone platform which prevents erosion, are not used.

It is also interesting that during the erection of a house, rituals might have taken place, such as animal sacrifice, feasting and foundation offerings (e.g. Platia Magoula Zarkou - Gallis 1985). Therefore, it seems that the construction and maintenance of a house was not a private event, but involved other members of the community acting in an arena where the individual met the collective, and social relationships were formed, maintained and transformed. These events, in which a large segment of the community took part, although ephemeral, were becoming fixed in the memory of the participants. In the first case, the construction of a house or any other structure signalled the beginning of something new, having a ritual significance by strengthening the cohesion of the society and the social memory. In the second case, the deconstruction of a building, especially through fire (Bankoff and Winter 1979; Stevanović 1997, 2000a; Metoki-Chondroyanni 2009), was a traumatic and simultaneously fascinating event, which was a compulsory stage to start something new; the old however was becoming eternal in the memory of the participants and was transformed to an ancestor itself (Gheorghiu 2011: 65-66). However, events of abandonment might not have been only realised by the deconstruction of buildings. The evidence from different places and periods (Hodder 1994: 75) show that alternative approaches, such as superpositioning of the houses, making house models or leaving artefacts at the abandoned structures, would have definitely marked these events in memory (Hodder 2005: 131).

Ethnographic correlates can also provide useful information regarding the population of such settlements. It is estimated that a typical Neolithic site might have had about 300 inhabitants,
based on a minimum amount of roofed space for each individual (Kotsakis 2004: 60). From the latter it is assumed that at least 30 dwellings should have existed to accommodate that number, considering that large groups were occupying each house (Halstead 1999b: 77). Size and population estimates in the Neolithic are controversial issues, and the opinions significantly vary. Based on the distribution of finds in a series of sites, it can be estimated that settlements occupied an area from 1-4 hectares. However, even if the number of buildings in a given phase is known, population cannot be securely estimated, since the contemporaneity of the structures is usually uncertain. Several figures have been suggested regarding a settlement’s population in the Neolithic period; the relationship between site size and population has been favoured over other methodologies, although the results cannot be considered accurate (see for example Naroll 1962: 588; Angel 1972: 95; Renfrew 1972: 236-244; Halstead 1981; Jacobsen 1981: 113). Therefore, according to estimations, calculated on the basis of the relation between site size and population, a figure of 100-400 people is plausible.
3.4. Experimental Archaeology: Simulating the past in the Present

Experimental archaeology is similar to ethnography since they both identify common characteristics for the assemblages under examination, therefore enhancing the understanding of distant datasets and the interpretive process in the present. In contrast though to ethnography, experimental archaeology employs techniques, methods and analyses to perform repeatable experiments in a controlled environment. Experimental archaeology does not only attempt to replicate artefacts and structures, but also to simulate procedures and test processes and functions (Reynolds 1999). Therefore, it provides archaeologists the only possible and reliable way - with the exception of computer graphic simulations - to test their hypotheses, validate their methodological assumptions and generate heuristic analogies (see for example Coles 1979; Carrell 1992; Reynolds 1999; Mathieu 2002; Outram 2008; for a collection of papers on experimental archaeology on a case study basis see Stone and Planel 1999). Similar to the controversies that have emerged in the field of ethnography, are the debates regarding the nature and importance of experimental archaeology. Although it is out of the scope of this research to discuss the various arguments, a few which have been derived from the different approaches and objectives through the years will be mentioned.

Saraydar and Shimada (1973) approached experimental archaeology as a source of mathematical formulas to simulate and explain the functions of the past. This means that experimental approaches were merely seen as scientific experiments whose results could have a cross-cultural generality, without, however, taking into account human behaviour and other cultural factors. Similar to this was Ascher’s view (1961) that experimental testing can also reveal patterns of past behaviour. Therefore, one of the main criticisms is that experimental archaeology is not an objective scientific process, but actually the people involved have their own subjective cultural and temporal input. This means that cultural behaviour or patterns cannot be inferred from such approaches on the basis of uniformitarianism, since each experiment takes place in a distant spatiotemporal context and under controlled conditions. Building on this, the criticism was also based on the evaluation of the processes and the results; since each experiment validates only one possibility, there are several other possibilities, which cannot be tested, but could also be valid. To overcome such difficulties, Coles (1973) published a series of guidelines attempting to define the minimum requirements for experimental approaches in order to ensure that the results are credible and valid.

Experimental archaeology has been dominated by the (re)construction of artefacts and testing of their use. In this case however, I will only mention experimental approaches that attempted to simulate the construction and lifecycle of buildings, also discussing the information that can be derived from them for the Greek Neolithic. I will not refer to any open-air museums or centres of ancient technology, such as the Butser Ancient Farm in the UK (Reynolds 1995;
Two of the most recent experimental approaches are those by Dennis (2008) for Beidha in Southern Jordan and Gheorghiu (2008) for tell settlements of the Lower Danube area. They are both remarkable, since they set different research agendas, they used different approaches and the outcomes were also distinct. Dennis for example, who based the (re)constructions on the evidence gathered from the excavation and analysis of the datasets at Beidha, wanted to test the various theories regarding the construction methods and techniques employed in Pre-Pottery Neolithic period of the region, as well to provide a visual aid for the visitors, since the site was previously neglected. It is noteworthy that in an attempt to answer questions regarding buildings’ lifecycle, i.e. construction, maintenance, destruction, Dennis provided a thoroughly illustrated and well-documented record of all processes involved, including the acquisition of materials, the cost of labour, the design of the roofs, the durability of different choices for plasters and mortars, the accumulation of deposits etc. This information was also used to assess issues related to technological developments, social organisation and the impact of the environment. In addition, careful monitoring of the structures suggested that the fire which destroyed the buildings might have been intentional and not accidental. Lastly, it is important that the constructed buildings were not only used for scientific experiments, but also as visual displays and educational centres to promote the archaeology of Beidha.

Although Dennis’ case study is in a distant spatial, temporal and cultural context, essential information of heuristic value can be derived regarding the construction methods, the labour involved and the durability of these structures. It is important for example that substantial erosion of the roof was noticed within one year of the construction, while within two - three years the rain left bare the reeds and the timbers that were once coated with mud. In addition, the plaster which coated the foundation and the superstructure cracked within 12 months. Similar to these results are those derived from Gheorghiu’s work in Vadastra village (2008: 173-174) which indicated that wattle-and-daub structures could not last for more than 5 years if they were not maintained, resulting in the rapid dissolution of the clay and mechanical fracture due to anthropogenic and animal factors. Lastly, the research indicated that these structures might have had different use through the year; during winter months they might have been used for habitation and in the summer months for storage.

Gheorghiu’s work is quite different in comparison to Dennis’ as he implements a mixture of experimental and experiential approaches to discuss about the landscape of the Lower Danube Area in the 5th millennium BCE. It cannot be considered as pure experimental archaeology, but an experimental approach by evocation. Gheorghiu mainly stresses the
attention to the fact that embodied evocation and sensorial experience can potentially work as an instrument of understanding space. Therefore, the experimental and experiential performances were designed to study more the individual and social experiences, rather than construction methods, buildings' lifecycles and construction techniques. In this context, Gheorghiu and his team created a series of embodied experiences of space, which unfortunately were not successfully conveyed on paper, as he also argues (2009a). These included the evocation of water and palisades by the use of textiles, as well as the construction of a suspended bridge across the river valley and the perimeter ditch to create a rite of passage from the exterior to the interior of the palisade. Besides, part of a settlement in Vadastra village was constructed, including a wattle-and-daub house, which was also set on fire (Gheorghiu 2011).

Based on the above examples, it becomes apparent that such approaches can benefit archaeological inference. While experimental approaches are essential to discuss technical factors regarding settlements and structures (e.g. materials, methods of construction, maintenance etc.), such observations can be rarely used to raise issues regarding Neolithic world views. Gheorghiu’s work manages to do both, also giving a particular emphasis to the latter; a neglected aspect in archaeological interpretation, which however is the decisive factor in the formation of uniformity and variability in architecture, domestic spaces and practice. Such approaches are extremely valuable in the understanding of social organisation and the sense of living in the Neolithic (or in any other period), since conventional approaches are rarely sufficient to move beyond the boundaries of material culture.

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10 Shaffer (1993) has also worked on experimental firing of wattle-and-daub structures using thermoremanent magnetism to talk about intentional burning, either to make a building collapse or to harden the materials for their incorporation into new constructions.
3.5. The Tradition of (Re)construction: Physical/Experimental Constructions, Illustrations and Computer Graphic Simulations

The tradition of (re)construction is a very wide topic that could be a research project on its own. This part of the chapter intents to focus and critically discuss (re)constructed scenes of the Greek Neolithic – although limited, either as physical constructions and illustrations or as computer graphic simulations.

3.5.a. Physical/Experimental Constructions

Noticeable examples in Neolithic archaeology are the reconstructed houses at Çatalhöyük, in Turkey (Stevanović 1999; also see 6.2.b.), as well as Volos (fig. 72) and Dispilio in Greece (Chourmouziadi 2002: 331-348). These are hypothetical physical constructions of typical dwellings at Çatalhöyük, the Thessalian plain and the lake site at Dispilio accordingly, based on the evidence from those regions. They have been constructed to observe the conditions that might have existed in the interior of these buildings, and as educational resources for the public, giving a taste of life in such an environment. In all of them compromises had to be made both for their durability and easier access for the visitors. Regarding the houses at Volos, they are both built on the same principle, with stone foundations and superstructures made of mud bricks and coated with mud for additional protection. The roofs are slightly gabled, making use of reeds, straws and mud, and are supported in the interior by thick posts. Although attempts were made to mimic the conditions that might have existed in a typical Neolithic dwelling in Thessaly, these constructions significantly depart from the concept of experimental archaeology, as in order to protect the buildings from vandalism, make them more durable in adverse weather conditions and avoid maintenance costs, materials, such as glass, plastic and metal have been employed. In addition, the windows are extremely small, making the interior darker than it might have appeared. As long as visitors are able to enter, walk, browse and touch the buildings, they get an excellent perception of their three-dimensional properties to a greater extent than it would be possible via a photograph, an illustration or in situ remains. These structures provide an excellent source for the public to familiarise themselves with the Neolithic architecture of this region, and manage to provide a decent overall impression about certain aspects of Neolithic life. However, these physical constructions hardly depart from the stereotypical images of the Greek Neolithic that have been produced in illustrations since the 1970s.
Apart from the physical constructions, there is the tradition of (re)construction drawings with the purpose of translating the two-dimensional and often abstract evidence into comprehensible information, both for the public and the academic community. In Greek Neolithic contexts, (re)construction drawings are constantly produced for final publications, while such attempts are rarely seen as part of the recording process and prior to the end of an excavation. The drawings can be divided into two distinctive categories, which have different purpose and target groups. Paradoxically, only the first category is evidenced in academic books and journals, while the second, which often takes the form of comics, can be found in the so-called ‘educational books’ for young children to adolescents: 1) (re)construction drawings that depict architectural or other features to show an approximation of the initial state of the archaeological evidence, without including any reference to the people that were making use of these constructions, 2) (re)construction drawings which attempt to integrate sociocultural aspects and the human agent into the archaeology of a site. The former category significantly outweighs the latter.

Most (re)construction drawings presented in this chapter (fig. 64, 65, 68, 70, 73, 74, 77, 78, 82, 83), which derive from traditional publications of case studies, old and new, as well as some syntheses of Greek Neolithic data, are in black and white format. They either depict close-ups of particular architectural features and construction techniques (fig. 68, 73, 74, 78), or (re)constructions of houses based on the evidence from particular sites (fig. 65, 70, 77). However, in both cases only one version of the archaeology is presented, implying a certain degree of certainty and scientific integrity. Only one of these figures (fig. 64) presents a wider view of a Neolithic settlement, Dimini, with an emphasis on the actual settlement, while positioning it in the wider landscape of the region. This tentative construction, which is the only one of the 8 illustrations of the chapter which is in colour, is derived from a popularised guidebook mainly targeted to a younger audience, and also appears in the history book for students in the third year of primary school (Maistrellis et al. 2010: 105).

Dimini is one of the most popular Neolithic sites in Greece, and is the ideal case for such (re)constructions. A similar, but perspective illustration of the site which presents the old interpretation of the walls as defensive due to the bow depicted, illustrates the history book for students at the first class of high school (Koutsoulakos et al. 2010: 10), also incorporating a few human figures. Also, the section about the Greek Neolithic includes an illustration of everyday life (ibid.: 9) making use of gender and other stereotypes, as these have been discussed by Moser (1998, 2001). On the other hand, the architect Manolis Korres (Theocharis

\[^{11}\text{For a brief history of archaeological representation from renaissance painting and antiquarian illustrations to museum displays, film and television see Moser 2009: 1050-1071.}\]
1980: 92-93), along with a detailed (re)construction drawing of the site, has reservedly incorporated a few human figures involved in everyday activities, which however serve as a guide to human scale, rather than as an attempt to present sociocultural aspects of Neolithic life. Lastly, a few illustrations of the Neolithic Dimini are presented at the website of the Foundation of the Hellenic World (http://www.fhw.gr/chronos/01/en/vpoints/start.html), which depict interior and exterior views of houses attempting to demonstrate the range of everyday activities in the settlement and also give a sense of living in these environments. They are all in colour and include human figures in an attempt to incorporate information regarding everyday life and use of space. Judging from their pictorial style, as well as the reductionism and the conventions employed, it seems that these illustrations are targeted to younger audiences. This is also apparent in the captions that accompany most of them. For the illustration of House 25 (fig. 82) the visitor reads: ‘Their height [refers to the height of stone enclosures], as well as their thickness (0.6-1.40 metres) suggest they were used for drying fruits, for carrying out various tasks and for relaxation as well!’.

Fig. 82 Reconstruction drawing of House 25 at Dimini (Foundation of the Hellenic World - http://www.fhw.gr/chronos/01/en/vpoints/vp8.html).

Overall, it should be pointed out that both categories provide a sense of three-dimensionality, since all these depictions try to incorporate as much of the evidence as possible. They achieve that either by including scales and human figures or by attempting to mimic the textures and
colours of the depicted archaeological evidence. The drawings targeted to a specialised audience (first category) are limited to the depiction of information deriving from the evidence, keeping speculations to a minimum. On other hand, the illustrations of the second category, which mainly appeal to a wider audience, attempt to incorporate details that provide a better sense of these environments, even though they did not accrue from the excavated evidence. Although this is not negative by definition, artistic license in several cases distorts the actual dimensions and the relationships between architecture, objects and figures, therefore presenting an informative, but somehow misleading reflection of the past.

3.5.c. Computer Graphic Simulations

As far as three-dimensional computer graphic simulations are concerned, there is an extensive body of literature that discusses the underlying issues; I do not intend to duplicate or fuel any of these debates here. On the one hand, proponents of this practice argue that 3D graphics provide communication and experimentation opportunities that might be difficult to achieve by using conventional capturing and visualisation techniques (see for example Barceló 2000; Hermon and Fabian 2002; Kensek et al. 2004; Earl 2006). On the other hand, dissentient voices often argue, especially in relation to photorealism and high-fidelity 3D visualisations (for photorealistic/high-fidelity 3D graphic visualisation see Chalmers 2002; Sundstedt et al. 2004; for non-photorealistic rendering see Roussou and Drettakis 2003; Frankland 2012; also see 5.3.b., 6.1.c., 6.2.c.), that the high visual stimulus that these images provide, especially due to their ingrained realism, deceive viewers that what they see is a precise image of the past, also conveying ideas and meanings that rarely derive from the archaeological evidence (see for example Miller and Richards 1995; James 1997; Moser 1998; Kantner 2000; Eiteljorg 2000; Gillings 2005; Pujol-Tost 2011).

In a Greek context the only known Neolithic 3D graphic visualisations are for Neolithic Dimini, produced by the Foundation of the Hellenic World (http://www.fhw.gr/chronos/01/wrl/index _en.html) and a computer graphic simulation of the exterior of a house from Makriyalos for the needs of a temporary exhibition for its finds. Dimini’s representation employed VRML programming language to provide visitors the chance to move through the site and get an overall idea about the organisation of the settlement. Today this presentation seems rather obsolete, since the technology employed did not give the chance to depict in a realistic way any of the architectural components of the site or to include any individuals and some action to these rather static and isolated constructions. Outside the Greek context there are several computer graphic simulations of the Neolithic that are worth mentioning. For example, Morgan (2009) has created an interactive virtual world for Çatalhöyük in Second Life, providing a less static approach to the constructions of the past, involving avatars and the creation of artefacts by the (virtual) visitors. A very different approach for the same site is the work undertaken by Cox (2010: 123-128) on the ‘Level V Shrine of the Hunters’ in an attempt
to create a 3D visualisation to virtually contextualise the four mural paintings unearthed (fig. 83). This photorealistic computer graphic simulation, has considered the evidence by Mellart’s excavation, as well as the discussions by Hodder’s team. It has also incorporated information that was not preserved, probably following the paradigm of the (re)constructed house to produce a complete image of an interior space, as well as to create a sense of living in that space. However, the inhabitants are missing (see 6.3.d.).

**Fig. 83** Computer Graphic Simulation of the ‘Level 5 Shrine of the Hunters’ at Çatalhöyük (Cox 2010).

Computer graphic simulations manage to successfully evoke a sense of three-dimensionality by using photorealistic techniques to depict light, colour and texture. Taking as an example Cox’s simulation of the Shrine of the Hunters, the rendering of the building can be easily compared to an imaginary photograph. One can be easily immersed into that world, since the depiction of the various elements is so realistic, that the only frame of reference for this image is the real world. On the other hand, it could be argued that since these images are presented in two-dimensional formats (e.g. computer screen, printed etc.), they lose some of their initial power to mimic reality. Probably the solution to this would be the adoption of virtual and augmented reality technologies (see for example Chrysanthi et al. 2013, also 6.2.b.) that could provide more immersive and interactive environments through which users would experience a higher level of realism and could broaden the dialogue between archaeological reality and virtual content.
Conclusion

Apart from the structural and other features that make Neolithic houses distinctive, which were briefly reviewed in the previous sections, and have been extensively covered in the related literature, the most important question that ethnographic, experimental, experiential and computer graphic simulation approaches should address is what buildings meant to the Neolithic observer. What did it feel like living in these houses and using the various areas for practicing everyday activities? Was it dark and smoky or bright and clear? Was sufficient illumination coming to the interior during the day, or were hearths constantly in use? Was it warm and dry or cold and humid? What were the acoustic properties of the buildings? What were the soundscapes of Neolithic life, and how were people structuring their lives and engaging with their surroundings based on the auditory information (Mills 2005)? What did the buildings smell like? How much time did people spend indoors, and how was space organised so as to facilitate socialisation? In order to answer, or at least efficiently approach such issues and study the human use and experience of space, a combination of methodological approaches is needed. However, most approaches are not sufficient to approach concepts such as the sense of living, not only because of their inherent limitations but also due to the inappropriate interpretive models used, which are based on different spatial, temporal and cultural contexts. Therefore, apart from archaeological research and ethnographic observation, experimental and experiential approaches, if used judiciously, can provide insights into these vague concepts, and help understand the materiality of built environments. Still, the question is how can these multisensory experiential embodiments be successfully transferred into two-dimensional and three-dimensional formats?

In this chapter, I tried to make apparent that several sources of visual and textual information form our knowledge about the Greek Neolithic, and especially about areas of habitation and domestic spaces, which are of main interest in this thesis. It is not only the scientific literature, but also ethnographic and experimental approaches, as well as traditional and modern visualisations which have their own input in knowledge production by attempting simulations of the past. All this evidence and the sources of information can produce, significantly enhance and/or alter understandings about certain aspects of the Neolithic, which are often not limited to material culture, but also encompass the intangible elements of the evidence related to senses, experience and perception. The information about Neolithic domestic spaces that has been presented in this chapter, also supplemented in Appendix I, and which will be incorporated into the computer graphic simulations of Koutroulou Magoula, was mainly produced by consulting the related literature. However, this information, which in most cases is the result of excavation or other type of fieldwork, has been already moulded by several variables, as these described in the previous chapters. Also, my own package of
knowledge and experiences has influenced the understanding and presentation of this material.

In the next chapter, the archaeology of Koutroulou Magoula will be presented; a knowledge that was produced by reading field notes, discussing with team members, consulting my and others' acquired knowledge, and also participating in the excavation for the last three years.
Chapter 4
Koutroulou Magoula: The Archaeological Evidence

Introduction

Koutroulou Magoula in Thessaly is a tell site revealed in 2001 by the Greek Archaeological Service (fig. 84, 85). In 2009 a team from the University of Southampton participated in the excavation, and since 2010 the excavation has been carried out as a collaboration between the University of Southampton and the Greek Archaeological Service (the Ephorate of Palaeoanthropology and Speleology of Southern Greece and the 14th Ephorate of Prehistoric and Classical Antiquities). In contrast to Makriyalos, which is a site that cannot be physically revisited, Koutroulou Magoula is an excavation in progress, and the exceptional level of preservation for such a site facilitates the computer graphic simulation of the various domestic features. However, as like any other archaeological dataset, Koutroulou Magoula has certain problematic aspects accruing from both the numbers of archaeologists who worked in this excavation, using different methods of recording and documentation, as well as the constant reuse of space from the Neolithic period to date. However, the cooperation with a diverse range of archaeologists, with different backgrounds and stimuli, comprises a valuable resource for the process of reconstructing the archaeology of the site.

Regarding the excavation of the evidence, only 0.3 out of 4 hectares have been explored in Koutroulou Magoula so far. The synthesis of information presented in this chapter is solely based on the field notes from 2001 to date, drawings and the photographic archive, as well as on excavation reports since 2009. At the moment, only one publication exists for the archaeology of the site concerning the results of the first field seasons (Kyparissi-Apostolika 2006), as well as a brief overview of the whole project (Hamilakis et al. 2012). The results of the first geomagnetic prospection have also been published (Tsokas et al. 2009). In addition, there are a few unpublished reports with preliminary results on pottery (Katsarou and Kaznesi 2011), soil micromorphology (Karkanas 2012) and the new magnetometer survey (Cole 2012). The understanding of the evidence was enhanced by my personal observations and the discussions with the directors and other team members over the last three years of fieldwork. These constitute a crucial element for the enhancement of the 3D modelling process since in most cases, computer graphic simulations are undertaken by specialists who do not have a clear picture about the material of an archaeological site, and the visualisations they produce rely exclusively on the interpretations of the directors.
Fig. 84 A. Koutroulou Magoula from the south; B. Koutroulou Magoula from the north (Images author’s own).
Fig. 85 Terrain model of Koutroulou Magoula including the excavated trenches, as well as the positive and negative anomalies identified by the geophysical survey (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
Koutroulou Magoula is located in Central Greece at the north of Phthiotida prefecture, 2 km NE of Neo Monastiri Village. The tell, situated 130.19 metres above sea level, covers a region of 4 hectares and is cultivated all year long. Cultivation disturbs the archaeological contexts and constrains the expansion of the excavation (fig. 85). Agricultural activity has already destroyed a large part of the fill at the west part of the tell when a rural road was opened. As the land has not yet been expropriated, and still belongs to its five owners, the expansion of the project largely depends on their kindness.

Both the survey conducted prior to the excavation and the removal of surface layers proved that there is a long history of activity in the region. Not only during Neolithic times, but also in historic periods, people passed by or even settled at the tell, as indicated by the large amount of pottery ranging from Neolithic to Byzantine times. Similar to this case is the neighbouring tell Komeno Tzami, where a survey indicated different cultural phases (Dimaki 1994: 92-93). After a decade of excavation in Koutroulou Magoula, at least four successive layers of Middle Neolithic habitation have been revealed (5800/5600-5400/5300 BCE). Moreover, finds within these layers indicate activities in the Bronze Age, the Late Byzantine period, as well as the modern era. Characteristic examples are the Mycenaean tholos tomb that was revealed in 2011-12 seasons (KM Report 2011: 22-25, 2012: 37-49), the inhumation of a young woman dating in 1040-1220 CE (KM Report 2011: 12-14) (fig. 86), as well as the coin of the 12th century CE (KM Report 2010: 29).

Fig. 86 Digitised plan of Buildings 1 and 2 and of all other features unearthed at the tell (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
Below, discussion will be particularly focused on Building 1 and the area outside of it, which will be the main element of the reconstruction process. Additional information about the rest of the structures and the various finds will be presented to give an overall idea about the settlement and complete the picture of Building 1.
4.1. Building 1, Earlier Phases of Habitation and Distribution of Finds

4.1.a. Building 1

Building 1, which was unearthed during the first excavation seasons, roughly occupies an area of 6.2 X 6.4 metres (interior 4.3 X 5.3 m.), as parts of the walls still lie outside the trenches and under the baulks (fig. 86, 87). This structure had a stone foundation, made of well-sorted limestone ranging from 2-7 cm. width. The first course of stones is positioned horizontally, whereas the rest of the wall, with a maximum width of 44 cm, was composed in the ‘herringbone’ coursing style bonded with clay (fig. 87, 88). Both the inner and outer rows are made in the same style, while the foundation was most likely not covered with any mud brick tiles in contrast to Building 2 (see 4.2). The maximum preserved height of the elaborate stone foundation is 30 cm, however the two earlier phases that lie below this structure provide further information regarding this matter. Evidence for stone foundations also exists in Early Neolithic settlements, such as in Lerna, Nea Makri, Halai, Achilleion 1B, Gediki and Sesklo (Perlès 2001: 181-183).

Fig. 87 Plan of Building 1 and of the earlier phases. Clay features on the floor are compacted mud bricks fallen from the superstructure (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
At the south side of the structure a large opening of approximately 211 cm is formed, whereas at the east side, 3.5 metres from the northeast corner, there is a smaller opening, which is not possible to be measured as it continues under the baulk. At a close distance from the west wall, it seems that another structure existed, which may have been partially destroyed by agricultural activity. These remains are possibly related to or are part of the wall revealed in Trench Z1 in the 2011 and 2012 seasons (KM Report 2011: 26-29, 2012: 17-23; see 5.2.b.2.). It is also worth noting that the walls revealed in Trench Z1 have been truncated or overbuilt by Building 1. Remains of another rectilinear structure were found on top of Building 1, which, however, were recorded and removed in order to allow the excavation of lower deposits (KM Field Notes 2001: 22-67).

The cobbled floor is made of small and medium size stones, of the same material as the foundation. However, at the western part of the house, the floor is constructed 20 cm higher than the rest. It may be an indication that this building was divided in at least two parts, in the same way as Building 2, which used different sizes of stones, to make this distinction apparent. The fact that stone tools were found on soil rather than on cobbles (KM Field Notes 2001: 149) is an indication that the floor was covered by a layer of soil, which was replaced at regular intervals for cleaning purposes. This was also confirmed by the geologist of the project. The cobbled floor is often interrupted by circular areas filled with soil, which were
most probably constructed purposefully. Some of these areas were investigated for burials under the floor, a known custom during the Neolithic (e.g. Prodromos in Karditsa, Nea Makri, Soufli Magoula, Kefalovryso in Trikala etc.); however, the results were discouraging. It is probable that these circular features cut into the floor were used as storage pits, or facilitated the positioning of posts to support the superstructure and the roof of the building. There is at least one clear indication of a posthole near the west wall of the building, as a hole filled with stones and traces of burnt wood was revealed (KM Field Notes 2001: 106). Near that posthole, pithoi sherds were positioned in a circular arrangement, while in the middle, signs of fire were evident (ibid.: 121). Thus, it is possible that this was a rudimentary hearth. In contrast to Building 2, which belongs to a later phase of habitation, there is no channel between the cobbled floor and the stone foundation, indicating that the foundation or the rest of the interior was not covered by a thick layer of mud or mud brick tiles; this does not however disprove the idea of walls coated with mud or clay.

Although, there are no areas that seem designated for sleeping, it is quite probable that this was also taking place inside, either on the floor or on mud brick structures which have not been preserved. Similarly, internal partitions to separate areas of sleeping, working and storage might have existed.

As far as the superstructure is concerned, it was most likely made of mud bricks, as indicated by the great quantity of mud bricks revealed, many of which bear impressions. During the excavation, a thick layer of compacted clay was exposed, which might be the result of the collapsed roof and walls, or it could be related to the collapse of a later phase of habitation. Several tiles were found trapped in these lumps of clay, which, according to Kyparissi (pers. comm.), comprised structural components of the roofing. Debate is still open regarding the use of these tiles, as their weight might have affected the stability of the building.

4.1.b. Earlier Phases of Habitation

Below Building 1 (phase 3), and following the same orientation, two earlier habitation phases are evident (fig. 89). These three successive layers of habitation comprise a vivid example of tells’ formation processes, and are often linked to the construction of senses of place, memory and identity (see Appendix I). Although only parts of their walls have been revealed, it is probable that these structures are much larger than those of the later phase. They have stone foundations, which in Building 1B (phase 2) are preserved up to 1 m., providing a significant indication about the height of the foundation of the rest of the structures. There is a chance that both of them preserve narrow openings in their east walls. The east wall of Building 1B also seems to be partially built over the east wall of Building 1C (phase 1), whereas both 1B and 1C east walls run under the baulk and continue to the so-called Open
Area (fig. 90; see 4.3.). In addition, it is notable that although the coursing style is the same, i.e. ‘herringbone’, the stones used were of different origin in comparison to Buildings 1 and 2. This can be observed on the size and cuts of the stones, as they form rough edges rather than smooth surfaces, which is the case in the rest of the buildings. As far as their superstructure is concerned, the amount of mud bricks recovered shows that these structures largely employed the same style of construction.

Fig. 89 Two consecutive phases of habitation under Building 1, following the direction of the later building (image author’s own).

Fig. 90 Phase 2 and 3 of Building 1 at the so-called ‘Open Area’ under the central baulk that divides trenches Θ and H (image author’s own).
4.1.c. Finds and Distribution

In Building 1, there is a clear distinction of finds (fig. 91) revealed in the interior of the building and the area outside of it. Most of the finds, especially animal bones, beads, spools, as well as some figurines, were unearthed from the unbuilt area outside the east wall of the structure. On the other hand, worked bones, quern stones, as well as stone tools and several figurines were found in the interior (Kyparissi 2006: 609). Obsidian blades and flakes, as well as cherts, were found both inside and outside the structure.

![Finds unearthed from Building 1](image)

**Fig. 91** Finds unearthed from Building 1: A. Ceramic vessel; B. Spindle whorls; C. Obsidian blades; D. Beads and pendants made of various materials; E. Bone tools; F. Figurines (Koutroulou Magoula Archaeology and Archaeological Ethnography Project; processed by the author).

Ceramic finds show a great stylistic variation and a wide range of sizes and uses. Apart from coarse monochrome sherds, such as pithoi and bowls, which were found both inside and outside, there is a great quantity of fine painted pottery and a few examples of incised and impressed decoration. Regarding animal bones, the vast majority was found outside Building 1. Although the systematic examination has not been completed yet, about 70% belong to goats and sheep, while pigs and cattle of different ages, as well as remains of game, such as deer and boar, are also present (*ibid.*: 610).
Building 1, as well as Building 2 (see below), seems to be relatively empty. Although it could be easy to relate this emptiness to different uses of space (inside vs. outside), the evidence does not facilitate such a distinction. It is probable that as part of the house’s ‘death’ and prior to its abandonment the household stuff was wiped away, while the rest of the features were also dismantled. Could this be a reason why the majority of small finds is located outside the structure, or hearths and other features cannot be safely identified in the building? Could the relative emptiness of Koutroulou’s buildings and the absence of structures be related to such processes?

4.2. Building 2

Building 2 (fig. 92, 93), which was unearthed during the 2006-2010 seasons, roughly occupies a region of 7X7 metres, as part of the structure is buried under the baulks. The foundation of the building was made of rectangular, well sorted slabs of unworked limestone, and the first course was aligned horizontally. The rest of the wall was composed in the ‘herringbone’ coursing style bonded with clay. It is interesting that this coursing is only noted at the outer row, which may indicate that the interior side of the walls was covered with mud or clay (KM Report 2009: 11). In addition, the foundation of the south wall of the structure is composed of different stones and the ‘herringbone’ coursing style is in reverse order (KM Report 2010: 8). Another feature of the foundation walls is that the north and west walls are more robust than the east wall (fig. 92). This may suggest that these walls were not designed to support much weight, perhaps indicating where any openings existed. Lastly, the south wall of the building was deliberately removed, as the southern part of the floor foundation remained undamaged (ibid.: 20) (fig. 93).

Between the foundation and the cobbled floor a small channel was built (fig. 92) to facilitate the construction of a thick layer of mud or mud brick tiles, as also indicated across its west wall, where compacted mud brick tiles have been preserved. The cobbled floor preserves three courses of stones, which most likely comprise a unitary deposit, instead of successive floor surfaces (KM Report 2009: 8). Although there are no partitions or buttresses, as in the case of Sesklo and Tsangli Magoula, a separation of space may be indicated. Part of the floor is constructed at a higher level with smaller cobbles, whereas the rest is made by larger cobbles 7cm lower than the rest (ibid.). Three pits which may be postholes, or used for storage with diameter ranging from 50-80 cm. and depth from 10-38 cm. were also cut into the floor. Lastly, at the northwest corner of the building, an oven-like circular structure has been revealed. However, no burnt material was identified in the interior, but only several wheel-made and glazed sherds. This evidence, as well as the fact that part of this feature is built on
the stone foundation of the Building, indicate a non-Neolithic chronology (KM Field Notes 2006: 23-24/05) (fig. 94).

As far as the superstructure is concerned, lumps of fired and baked mud brick were unearthed, which also contained traces of fibre and negatives of materials. Also, the observation of the stratigraphy at the south side of baulk that divides Building 1 and 2 indicates the fallen mud brick superstructure, suggesting that this house had a height of about 3 metres. The relative cleanliness of the interior, as well as the fact that no mud bricks were found outside the structure, may indicate that the internal destruction of the building was deliberate, similar to the intentional removal of the south wall (KM Report 2010: 20).

Fig. 92 Building 2 from northwest. It has pits dug in the floor which is made of layers of stones and compacted clay (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
Fig. 93 Building 2 from south. Missing south wall (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

Fig. 94 Building 2. Oven-like structure at the northwest corner (image author's own).
4.3. Open Areas

The unbuilt spaces revealed near the various structures are conventionally named ‘Open Areas’. There is an area of significant size that occupies roughly 25 m² to the south of Building 1 (fig. 95). These two areas are divided by a baulk covering part of the east walls of 1B and 1C phases, which continue under the baulk and are clearly visible at the north part of the Open Area. According to the quantity, density and diversity of finds, it is anticipated that the inhabitants were making use of this space for performing various tasks. However, it is difficult to draw conclusions regarding their nature, and it is not yet possible to identify if particular buildings or the whole community had access to this area. It is, however, important that the soil micromorphologist of the project (Karkanas 2012) identified large quantities of animal dung, which suggest constant presence of animals, most probably because of an animal pen built there. This may be also related to the remains of postholes found which indicate some kind of fencing.

Fig. 95 The so-called ‘Open-Area’ in trenches Ø1 and Ø2. Photogrammetry model (image author’s own).

The upper layers of this area, excavated in the 2004 and 2005 seasons (KM Field Notes 2004, 2005a, 2005b), apart from being related to Buildings 1 and 2, may also be associated with other structures which have not yet been revealed. Among the finds a large quantity of coarse monochrome pottery that belongs to storage vessels with traces of firing both inside and outside were uncovered. In addition, several cherts, obsidian blades, flakes and cores, and also quern stones and bone tools were revealed. Furthermore, the discovery of eight
postholes, with a diameter ranging from 15-35 cm (KM Field Notes 2005a: 236-240, 309-312), a possible clay floor as well as two potential structures identified by an accumulation of stones (ibid.: 251-254) prove that this area was extensively used for activities related to the preparation and consumption of food, whereas the postholes indicate that another perishable structure was built to facilitate these activities.

At a lower level, a cobbled floor consisting of four layers of cobbles was unearthed (KM Field Notes 2005a: 345-348; 2006a: 14/06, 20/06, 23/06, 17-18/07). The finds are similar to these of the upper levels also suggesting that several domestic activities were taking place at this open area. A similar distribution of finds, though in larger quantity, were recovered from the lower levels, namely 1.5m – 2.5m from the surface of the tell (KM Field Notes 2008; 2009). The latter, in conjunction with the great quantity of animal remains unearthed (KM Field Notes 2009: 19, 30, 60) in addition to shells, indicate that food preparation and consumption as well as other activities were taking place. The great quantities of carbonised wood and burnt vessels found point to the use of fire in these tasks, which is also amplified by a few stones with traces of fire roughly forming a circle.

Fig. 96 Hearth/Oven installation unearthed in Trench Ø5 (2012) (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).

Open areas used for food processing, preparation and possibly consumption have also been revealed outside the rest of the structures. For example, in all field seasons there have been
clear indications of activities involving fire, such as the hearth/oven installation revealed in 2012 to the west of Building 2 (KM Report 2012: 34; fig. 96). Close to this area, several quern-stone fragments were unearthed in 2011 (KM Report 2011: 6, 19-20; fig. 97), suggesting that this spot was used for processing food or other materials. A possible hearth was also revealed near-by. These are all indications that areas outside of the structures were used for activities related to food that might have involved the members of a household or larger segments of the community. This is common in the Greek Neolithic and the Neolithic of the Balkans, since open areas in between the various constructions (Andreou and Kotsakis 1994: 20) may have been used for common activities not only related to food production and consumption, but also herding and gardening.

Fig. 97 Concentration of quern stones revealed in Trench Θ4 (2011) (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
Conclusion

The Middle Neolithic site of Koutroulou Magoula is only one of the new settlements that were built in Thessaly during that period, when the general circumstances seem to have fostered the construction of self-sufficient hamlets or settlements. In the case of Koutroulou, autonomy is not only observed in the large quantity of ceramic finds, but also in the stone tools and animal bones which prove that the inhabitants were exploiting natural resources, and were also producing the objects used in their everyday activities. The increased standard of living is also reflected by the fact that raw materials, such as obsidian, were imported from Melos, which is an indication that they had developed relationships and trade with the Aegean.

The most important aspect of people's lives was their dwellings, and Koutroulou Magoula preserves one of the most characteristic examples of tells' formation processes. Houses were built independently of each other and had one or more rooms, probably divided either by partitions or by levelling and raising of specific areas, as well as using different structural components, such as cobbles of different sizes. The elaborate construction of their houses is apparent; intricate stone foundations preserved up to 1 m deep, stones of different colour and texture in different phases, superstructures made of mud bricks, wooden constructions to support the roof, pits for storage etc., which can all still be seen in several abandoned houses and storage rooms spread across Neo Monastiri village, a few kilometres away from the site (fig. 69, 71, 76, 98, 99).

Fig. 98 Abandoned storehouse constructed with a stone foundation and a superstructure with mud bricks at Neo Monastiri, Phthiotida, close to Koutroulou Magoula (image author's own).
Fig. 99 The interior of an abandoned storehouse at Neo Monastiri, Phthiotida, close to Koutroulou Magoula (images author’s own).

Among the dwellings there were also open areas, which were used for large scale activities, including food preparation and possibly consumption and animal breeding. It is probable that neighbouring dwellings made use of hearths and ovens situated in spaces for common use in between the houses. The existence of open areas is not a new feature, and has been evidenced in several cases, such as in Achilleio (Gimbutas et al. 1989) and Makriyalos (Pappa 2008). However, in the case of Koutroulou, we are not yet in the position to know if these areas where also used to cultivate crops, or whether this was only taking place at a certain distance from the inhabited areas, or even out of the settlement’s boundaries.

Although to date only six Neolithic structures have been partially or completely exposed, a geophysical survey carried out in 2004 (Tsokas et al. 2009) showed resistive structures, which
are likely to reflect architectural remains occupying a region of at least 90 X 35 metres. A new magnetometer survey carried out in 2012 (Cole 2012) identified a series of structural remains in the eastern and southern areas of the current excavation trenches. Also, at the east of the tell, negative magnetic anomalies indicated the existence of terracing walls and surrounding ditches (fig. 84). The latter were identified by two test trenches in the 2012 season (KM Report 2012: 13-16), indicating that the tell was surrounded by at least two ditches. Also, several of the identified features seem to extend beyond the topographical limits of the tell and onto the flat area to the south, possibly suggesting an extended settlement.

As Kyparissi argues (2006: 612), in order to construct such elaborate buildings, you have to be self-reliant with an increased standard of living. The inhabitants of Koutroulou managed to organise a prosperous settlement, make use of the available resources and also import others from near-by regions and the Aegean. Further investigations will reveal the extent of this occupation as well as the subsistence strategies and living standards of the inhabitants in comparison to other Neolithic sites known from neighbouring regions.

The following chapter will be based on all aspects of perceiving, capturing and reproducing the morphology of the real world examined in the first part of the thesis, to address issues related to the modelling process within a computer graphics software. In this context, the capabilities of the software used and its flexibility to transform through a graphical interface the real world into digital space will be discussed. As well, the decision-making process and the computer graphic simulations produced will be examined.
Chapter 5
Visualising Koutroulou Magoula in Three Dimensions: Understanding the Process of 3D Modelling, Rendering and Decision-Making and their Impact on Knowledge Production

Introduction

This chapter focuses on aspects of 3D modelling, rendering and decision-making in order to understand the process of constructing computer graphic visualisations about various features from Koutroulou Magoula. The chapter is divided into two sections; the first discusses aspects of 3D modelling, examining the tools which condition users to interact in a particular way with graphics software in order to get an enhanced perception of three-dimensionality through their two-dimensional interfaces. Then, based on conventional recordings from Koutroulou Magoula, a 3D visualisation of a stone wall unearthed in Trench Z1 in the 2011 field season is attempted in order to investigate the aspects of reality that the process of modelling augments. The modelling of Trench Z1, a pilot small scale 3D study, which is an introduction to the second part of the chapter, attempts to examine from a practical point of view the overarching theoretical considerations already discussed in this thesis, and also to study how/if 3D modelling in a computer software could potentially provide a better understanding of materiality. In the second part of the chapter, all the available material from Koutroulou Magoula, as well as archaeological, ethnographic and experimental correlates presented so far, are combined in order to produce computer graphic simulations of Building 1 and of the whole settlement.
5.1. Interactive Graphical Interfaces: Converting Two Dimensions into Three

5.1.a. An Introduction to Graphical Interfaces

3D graphics software packages do not prompt designers to work to an analogue of the real world, since the whole process is driven from the need to imitate. This is mainly because the dominant approach in computer graphics is to mimic the appearance of real-world objects and create photoreal virtual surrogates, rather than to assign to them properties of the real world. For example, in a scene illuminated by sunlight, the light coming from the sun is imitated by a non-physically accurate light, which resembles the sun's colour and intensity. This is a common approach in films and television graphics, in which the whole modelling process is dictated by the expected visual product. In such cases the primary concern is the appearance of the end product rather than a physically valid image. However, there are cases, such as in architectural design, where physical fidelity is fundamental in order to identify the functional role of light and the interactions between people and architecture.

In the last years, there is a clear emphasis on physical realism. In other words, the designed scene attempts to simulate in a physically accurate manner the interactions among light, geometry, colour and texture in order to produce not just a replica of the world, but an instance of this world at a particular moment in time. Although the process of 3D modelling is mainly dictated by the need to imitate the real world, user interfaces, i.e. the medium between the user and the software algorithms (human-computer interaction), have been designed so as to enable modellers to provide the input needed by the machine in the most friendly and familiar way, following tasks and processes that they are used to in the real world.

Research in the field of human-computer interaction has shown that the design of user-friendly graphical interfaces improves productivity (see for example Cope and Uliano 1995; Baca and Cassidy 1999) and reduces the costs involved in training, assistance and rectification of problematic components (see for example Karat 1997; Pressman 2005). What is crucial in the process of designing such an interface in order to become user-friendly and facilitate the interaction between human and computer, is to take into account all these characteristics of human nature that make people perceive and comprehend the real-world (Galitz 2002: 65-72). These characteristics, which have been thoroughly discussed in chapter 2, should be incorporated in the design of both the ways that commands are sent to the machine and the means through which the
results become available to the user. In such a way the system becomes an extension of the real world.

Although it is not the purpose of this chapter to examine different aspects of graphical interfaces, it should be pointed out that one of the main reasons why they have taken precedence over textual interfaces, is because their visual organisation with symbols and familiar images makes the process of understanding come naturally, since human perception is primarily based on the capabilities of vision (see Oviatt and Cohen 2000 for multimodal graphical interfaces). However, learning the various properties, unknown symbols and complicated interactions requires some training. In addition, since users have individual styles of understanding, the use of text to input information is sometimes considered more suitable. This is especially true in cases where the words used in commands refer to things of the real-world, while the images do not have a direct relation to known information. Yet, what is more crucial in the design of an interface is not the type of interaction with it (Whiteside et al. 1985), but the easy and effective use of it by humans (Shackel 1991: 24).

The most important element of a 3D graphics software interface is to successfully convey the sense of three-dimensionality. At the heart of the process of 3D computer graphic simulation lies the fact that, contrary to conventional ways of 3D visualisation (e.g. axonometric drawings) which depict a given scene or an object only from one viewpoint, graphical interfaces, although seemingly two-dimensional, provide the chance to manipulate the objects in three-dimensions, by moving, rotating and transforming them on three axes. As a result, the modeller gets an augmented perception of the three-dimensional character of the scene both during the process of modelling and for the finished model. In such a way the resulted scene, even if displayed in a two-dimensional medium, e.g. computer monitor, is a product of a three-dimensional process of construction and understanding.

Given the need to work to an analogue of the real world, stereoscopic displays and headsets that enable three-dimensional vision have been invented (cf. Malin 2007 for the invention of stereoscope). They are nowadays quite common in the film and gaming industries. However, since their input is limited only to three-dimensional vision and not to any other physical interaction with space, design industry has developed a series of technologies that enable the generation of 3D form via human movement. In such a way, the artist/designer comes closer to the traditional pen and paper sketching by freely moving his/her hands to produce art and design (LaViola and Keefe 2011: 20-24). There are also cases in 3D design where modellers can feel the shapes created (Geomagic 2013), while other motion tracking technologies, such as
Microsoft's Kinect (Zhang 2012) turns the whole human body into a controller, thus enabling full and free movement. These technologies by combining 2D and 3D inputs move computer graphic interfaces and the process of 3D modelling to another level as they enable physical interaction with space and free movement, thus bringing the virtual environments closer to the real world.

5.1.b. Autodesk's 3ds Max Graphical Interface

The software Autodesk 3ds Max (Autodesk 2013a) will be used to discuss interface elements that were designed to bridge the gap between the flatness of a computer monitor and three-dimensional space, and facilitate an enhanced perception of three-dimensionality. This software, which is a standard for many film industries, video game developers, as well as architectural and engineering visualisation studios, has been employed for the 3D models presented in this thesis.

Autodesk's 3ds Max interface has been designed so as to make the transition from a 3D to a 2D environment and vice versa as smooth as possible. Its interface is dominated by the viewports, i.e. the windows through which users interact with their models into a 3D world via different viewpoints (fig. 100). Navigation in the viewports can be performed by several different ways: 1) viewcube; 2) steering wheel; 3) mouse. In real life, the viewcube would allow users to know their current orientation within the four cardinal points, as well as to change at any time the orientation of the object/scene they are looking at and, consequently, their viewpoint, e.g. vertical view, top left corner view, down right corner view etc. Similarly, the viewcube in 3ds Max shows the current orientation of the viewport, but also allows basic interactions by changing the active views. In addition to that, the software includes a steering wheel, which enables additional navigation options, such as zooming, panning and orbiting. However, once modellers become used to the interface and the various tools and buttons, the easiest way to control the various features is by using a mouse with a scroll wheel and keyboard shortcuts. For all models presented in this thesis, the navigation was performed by a mouse and a keyboard, while the viewcube was used to reorient the model when it was twisted around to an extraordinary angle. These actions, although performed on a two-dimensional medium, mainly a computer screen, provide a sense of three-dimensionality, since they allow the creation, processing and movement on three axes. Therefore, a flat computer monitor is turned into a device with depth providing all properties required in three-dimensional space.
Fig. 100 Autodesk’s 3ds Max Design 2012 Interface (Image author’s own).
Another useful feature in the software’s interface is the visual feedback that it can provide regarding the final output of the scene. The lowest level of feedback is the preview of shadows and lights in viewports (shaded viewport) (fig. 101). This utility helps the modeller to understand various properties of the model in real-time and adjust the settings accordingly. In such a way, the modeller works closer to the real world, since the process of 3D modelling is accompanied by effects that take place in reality. However, this feature only enables the simulation of direct illumination, which although is the main concern when lighting is previewed, there are cases where indirect illumination can enhance perception and understandings. For example, the examination of Greek Neolithic dwellings has showed that interior light was mainly the result of indirect illumination that entered from doors, windows and roof openings. For this reason preview of Global Illumination (direct and indirect light) would be an asset in the perception of three-dimensional space during the process of reconstruction. Yet, ambient occlusion which approximates how light radiates can also be previewed in the viewports and gives an idea of how Global Illumination would work by generating darker areas where light does not reach. However, the display of lights and shadows in the viewports is not always accurate and the feature is used more as a convenient way for the modellers to preview without any computationally intensive calculations the effects that their models will result in. This can be clearly seen in figure 101, where screen captures and a rendered result of a preliminary 3D model of a Neolithic stone foundation are compared.

The next level of visual feedback is the ActiveShade (Autodesk 2013b) which produces a preview rendering when materials and/or illumination changes in the scene. In contrast to the shaded viewport, the ActiveShade uses the default Scanline renderer (Autodesk 2013c), which is not physically accurate, to calculate direct and indirect light as well as the interreflections that occur in the scene and the corresponding changes of the various materials. Apart from the fact that ActiveShade does not by default employ a physically accurate renderer, its accuracy in comparison to production rendering is further diminished by the fact that extreme detail in materials is automatically reduced to enable real-time updating. In addition, atmospheric and rendering effects cannot be rendered, while there are limitations regarding the size of the preview window.

On the other hand, ActiveShade also supports iRay renderer (Nvidia 2013b). The latter, is a physically accurate renderer developed in the last versions of 3dsMax. As it is shown in figures 101E and 101F the results in the production rendering mode and the ActiveShade preview are almost identical. However, there are some issues that make its use problematic. The most important is that ActiveShade with iRay does not update
automatically to show changes in daylight settings, e.g. time of the day, or camera settings (e.g. field of view). Similarly, changes in materials’ parameters cannot be previewed. In order to preview these changes, ActiveShade has to be switched off and then re-enabled. This means that previewing the most important changes in a scene requires a process similar to production rendering (pressing a button and waiting), and therefore, iRay ActiveShade is at the moment of little use. In overall however, it is a feature that allows the appreciation of the three-dimensional character of the scene as the modelling proceeds and is considerably closer to reality than the shaded viewport. This is an asset for the modeller, since she/he can get an immediate understanding of materiality and the various interactions in the scene, and can consequently refine the modelling to come closer to the desirable outcome.

![Interactive light and shadows in the viewport at 2pm. A. No shadows; B. Hard shadows; C. Hard shadows and ambient occlusion; D. Soft shadows; E. Rendered image - Iray renderer; F. ActiveShade - Iray renderer (Images author’s own).](image-url)
Fig. 102 Architectural and Design Material: Stone. Preview in Material Editor. A. Bump 1/10; B. Bump 3/10; C. Bump 6/10; D. Bump 10/10; E. Bump 1/10 and Anisotropy 10/10; F. Bump 1/10 and Glossiness 1/1; G. Custom made stone object loaded in the material preview slot. Bump 1/10; H. Rendered sphere. Bump 1/10; I. Rendered sphere surrounded by purple objects. Bump 1/10 (Images author’s own).
The last level that comes closer to the final production of the scene is the sample slot in the material editor, which uses the same renderer that is used in the final output to produce a preview of the material on an object. Changing materials’ properties before assigning them to objects in the scene is particularly useful, since slight changes in the settings, such as reflection properties, can be previewed and amended accordingly (fig. 102). This also gives an approximation of how these changes will proportionally affect the objects in the scene, providing a sense, though limited, of three-dimensionality. However, the preview utility cannot reflect the rendered result, especially in cases where the final output depends on complex calculations of illumination, changing viewpoints and interactions between materials. In figure 102H, where the rendered object is a sphere illuminated by sun and daylight the result is rather consistent. However, in figure 102I, where many objects and different lights have been put in the scene, the output is quite different from the previewed material in the sample slot. The sample slot also provides the functionality to upload a custom-made object to be used for previewing materials instead of the predefined; sphere, cylinder and box. In such a way, previewing can be done for the type of object that a particular material was designed for, thus bringing the user closer to the rendered output (fig. 102G).

5.1.c. Static and Real-time Rendering in the Process of Reconstruction

From the discussion presented above, especially in relation to the ActiveShade mode, where changes in light, textures and geometry can be quite accurately previewed in a viewport, the question that emerges is if and to what extent static or real-time renderings, or animations are required as outputs in the process of reconstruction. Static renderings can simulate all possible modelling choices and produce high fidelity graphics, providing that the hardware supports them, and that the amount of time required can be afforded by the modeller. However, static rendering is rather problematic, since the output is constrained in a two-dimensional static environment, i.e. an image. The latter can be overcome in real-time rendering, primarily used in computer games, which has been developed to allow users’ real-time interaction with a virtual environment. Nevertheless, real-time rendering is computationally intensive, and thus, real-world effects that depend on distance, viewpoint, direction of light etc. are not usually simulated in real time as they are all ‘baked’ in the scene. This means that aspects of materials, geometry and light are recorded as an image, and are then applied on the objects of the scene to accelerate the rendering process. Therefore, it could be argued that real-time rendering is to an extent static, since it cannot effectively incorporate view-dependent effects. However, recent advances into graphics chips allow selective rendering of components, e.g. shadows, reflections etc., based not only on pre-captured but also to live-generated results. Lastly, animations, which
are a sequence of static renderings (frames) in a rate of about 12 frames per second, can efficiently incorporate any level of physical accuracy (subject to resources). However, such animations are essentially films, and therefore, no interaction between the users/viewers and the sequence of images can be performed.

It seems that for a reconstruction process that aims to enhance understanding and interpretation, a rendering either in the form of static or animated images, or in real-time may not be required, unless the result is also intended for dissemination purposes. This is primarily because the modelling of structures and artefacts in a 3D digital environment provides a certain sense of space and three-dimensionality, while preliminary renderings in the viewport enhance the information regarding elements of the real world. However, as it will become evident in the second part of this chapter, as well as in chapter 6, where the models of Koutroulou Magoula are evaluated and refined, photorealistic images that bear a high level of resemblance to the real world, can more efficiently evoke senses and augment understandings about Neolithic space. This is particularly true for the audience of the resulted images, even if it is highly specialised, since it does not participate in the process of modelling and therefore its perception of a digital environment primarily depends on the output. However, this is in contrast to the modeller, who can get this augmented sense of space and materiality during the whole process of reconstruction, without relying on the prosthetics that rendering provides.
5.2. The 3D Modelling Process of a Computer Graphic Simulation

The 3D modelling of a computer graphic simulation is rather complicated, since principles and standards that condition the real world cannot be simulated in the software’s 3D environments. The experimentation with texture maps in figure 58 makes this apparent, since all different maps were applied on a box with certain dimensions. Although the resulted model resembled to a great extent one of the Neolithic walls unearthed in Koutroulou Magoula, the decision-making process regarding the visualisation cannot be related to the process that Neolithic builders would have followed in the past. This is not negative by definition, but in order to enhance the understanding of three-dimensional space and augment archaeological interpretations decisions should be driven by questions related to archaeological aspects and be related to some of the properties of the real world. This is a demanding route, since 3D software packages are not designed for that, and available hardware cannot always cope with such decisions. To give an example, in the aforementioned case of constructing a wall, such a decision would mean to construct individual stones and position them manually. In such a way, the questions raised during the process of reconstruction would not be how to make the wall look more realistic but actually how stones should be positioned in order to make the stone foundation stable and strong enough to withhold the weight of the superstructure. I would agree to a potential criticism that such 3D software products normally used to produce photorealistic scenes are not designed to simulate physics, and therefore any pursuit to answer those questions and/or perform structural analysis seems impossible. However, even advanced structural analysis software solutions are not designed to simulate and test structures that are made of materials like irregular stones, clay bonding and mud bricks. Therefore, since structural analysis cannot be easily performed in such datasets, other solutions should come forward to overcome issues of understanding and interpretation.

5.2.a. The London Charter: Problems and Perspectives

The London Charter, a meeting of 3D visualisation specialists held in London in 2006 established a series of principles to ensure the best practice regarding different aspects of the computer-based visualisation of cultural heritage content (The London Charter 2009). A process of reconstruction should start in the field and be completed in the lab – to the latter I would argue that a reconstruction is a never-ending process – by a person who has the skills and knowledge to assess and incorporate in the
decision-making all the available data. All sources should be identified, assessed and correlated, while a tree of hypotheses and sub-hypotheses should be created prior to any 3D visualisation (Pletinckx 2007: 6-24). This information along with comments, decisions and interpretive processes comprise the paradata (Baker 2012: 163-176) of the project, which allow a clearer interpretation management and understanding of the relationships between primary data and the outcome. Moreover, the updating process becomes easier when new sources come to light.

It is true that The London Charter and its elaboration by various scholars (Hermon 2012: 13-22; Niccolucci 2012: 23-36; Pletincxk 2012: 203-242) provided the archetype, serving as a tool to enhance the knowledge about cultural heritage and enrich communication to the academic community and the public. However, these elaborations have primarily focused on the principles of documentation of 3D visualisation processes, neglecting the complicated issues that emerge from the modelling process itself and the often neglected perceptual, physiological and technical factors that are inherent to the archaeological process. According to §§ 4.5 and 4.6 of the London Charter (2009: 8-9):

A complete list of research sources used and their provenance should be disseminated. Documentation of the evaluative, analytical, deductive, interpretative and creative decisions made in the course of computer-based visualisation should be disseminated in such a way that the relationship between research sources, implicit knowledge, explicit reasoning, and visualisation-based outcomes can be understood.

Although the London Charter suggests the documentation of a visualisation’s project paradata, i.e. the information about the processes that humans use for understanding and interpreting particular data, this thesis has already demonstrated that rigorous documentation in terms of a list, direct relationships and links that connect sources and outcomes is not possible. Such documentation would only assert an ostensibly solid method, and consequently testify archaeologists’ epistemic authority (see 5.2.b.1.), without any further contribution to the understanding of knowledge production.

For example, in the case of Building 1, I should have documented in a list all research sources and how these feed into the visualisations produced. Building 1 was visualised based on archaeological evidence from the site, archaeological parallels, i.e. other sites, Neolithic house models etc., and ethnographic correlates from the region. This is a piece of information that can be documented, even in a list. However, how would I have documented the various informal discussions, the ways that archaeologists
produced the records that I used, the means through which other sites have been excavated and published and the consequences of bad practices and the diverse ways of perceiving archaeological information? Documenting only the direct sources (archaeological, ethnographic etc.), would give a wrong impression about the process of visualisation, suggesting that the result is solely based on the primary sources of information.

The downside of the guidelines provided by the London Charter is that they are based on the principle of a linear process of visualisation with clear connections between data and 3D models. However, this thesis makes apparent that tracing roots, tracks and connections in knowledge production is utterly problematic, especially since various perceptual, physiological and technical factors, as well as their connections and outcomes can be rarely identified in the course of 3D visualisation. As a result, attempting to answer the question asking where the knowledge depicted in 3D visualisations comes from by documenting research sources in the form of lists and direct relations is quite dubious. That is also the reason why an appendix with this kind of information has not been provided, contrary to the normal practice in 3D visualisation projects. This of course does not mean that documenting the sources is futile. Documenting the evidence is a necessary step that will provide the basis for the process of reconstruction. However, the emphasis should not be put on linking the primary sources with 3D models, since there are different elements that act in the transformation of real into digital spaces and blur the connections between the various aspects of the process. Nevertheless, it is important to consider the diverse range of sources in the context of the process; in other words, to identify how and to what extent the sources feed into the process of 3D visualisation. Ultimately, it is the understanding of the process of reconstruction itself that will provide an enhanced perception about both the sources and their translation into digital spaces.

London Charter has also laid emphasis on datasets of historical archaeology, disregarding the intricate issues that should be addressed in datasets of prehistory. For example, when studying prehistoric material, the only available sources are the excavated evidence and their recordings, while in the absence of literature and iconography, potential correlates are only structures of the same period, which are also problematic. Moreover, ethnographic comparators with similar characteristics can be used as heuristic sources. Thus, assessing the sources becomes more difficult, finding relevant correlates is a very demanding and often unreliable task, while hypotheses are rather complex to be constructed, since the alternatives that should be considered are numerous, and often, these of higher and lower probability cannot be distinguished. Therefore, the argument that comes forward is that in order to adequately understand
and interpret a given dataset, especially of prehistory, the documentation of sources, correlates and hypotheses is not enough.

5.2.b. Modelling Trench Z1

The principal consideration in this thesis is that it is the modelling/reconstruction process which can help to solve, or at least, better interpret and understand aspects of past reality. Therefore, the purpose of this section is to examine another aspect of the process, which is modelling within 3D graphics software, and investigate how modelling choices and decisions related to the archaeology of a site can enhance the understanding of particular features.

One of the main issues that this pilot 3D visualisation as well as great part of this thesis is trying to cope with is the fact that computer graphic simulations take place after the excavation, and all recordings are taken without having in mind that they might be used in different, less conventional ways. Trench Z1 is such a case, since, when a colleague and I were supervising its excavation, taking levels and drawing features, we did not know that its visualisation would be attempted as part of my thesis. Therefore, all recordings that are used in this process are the result of conventional practices, similar to those described in chapter 1. The approach that is going to be followed is rather simple. I have attempted to visualise from scratch the final 2011 state of Trench Z1 based on the available records (field notes; context sheets; photographs; drawings; and the final report). On the one hand, I discuss aspects of three-dimensional space which remain obscure through these records, while on the other hand, the level of detail that a three-dimensional visualisation should incorporate in order to enhance archaeological understandings is examined. To discuss the latter I started from the maximum level of abstraction, gradually moving to greater detail.

Trench Z1 was excavated for four consecutive weeks and was overseen by two archaeologists; a colleague with long experience in British fieldwork and myself. The context sheets were filled in by both of us, as well as the students under training from the University of Southampton. Sketches and drawings were mainly made by us, while students were also making sketches of finished contexts under our supervision. The notebook, which is an extended version of the context sheets since it includes the same information in descriptive narrative, was kept only by the supervising archaeologists. Lastly, photographs of the completed contexts were taken either by the field director or a fellow archaeologist working on the site for the production of a theatre/archaeology on-site performance.
5.2.b.1. Issues of Authority and Hierarchical Divisions

Before proceeding to the examination of Trench Z1, I deem it necessary to briefly discuss the role of authority and hierarchical divisions as they emerge from the previous paragraph. Archaeologists are authoritative agents who use a series of materialising strategies to produce authoritative accounts of the past. It is both the methods used during fieldwork, as well as archaeologists’ epistemic authority (Hardwig 1985; Kruglanski 1989; Raviv et al. 2003) that build a chaff around the translations of the past. Authority is gained, established and maintained through university degrees, publications, titles and roles. More university degrees and more expertise in a subject simultaneously means a greater level of authority. Also, the higher the role in a project, the higher the authority that the person carries. Thus, among archaeologists there is always a clear hierarchical division closely linked to the authority they exert.

The excavation at Koutroulou Magoula is not a different case, even though it has been attempted to lay emphasis on a mutual collaboration among team members. Starting from the two directors who are by definition at the top of the hierarchy, the rest of the team comes in the following (unofficial) order: field director, supervising archaeologists/specialists, students, workmen. Although there are cases where this hierarchy is shattered, when for example the director digs or the field director fills in context sheets, the hierarchical division that also bears a certain level of authority is apparent.

Knowledge is produced by all team members according to their role in the project. Students, however, only produce particular types of information (e.g. catalogues, sketch drawings etc.), which are then checked by supervising archaeologists and the field director, and amended accordingly. The work of staff members is also checked by other staff members and most often by the directors of the project. For example, in the first stages of my work, when I had to critique others’ field practice, I also had to ‘repress’ my texts, since ‘field notes are difficult to be written...younger generations easily denounce them’ and ‘the project is still at an early stage. We should not give to the public a wrong impression about our work’. Both these criticisms are reasonable, since my work came to spoil hierarchical divisions, authority and their products. On the one hand, as a younger archaeologist, I should not have critiqued the work of more experienced people, while on the other, a potential criticism by the public or fellow archaeologists would have harmed the archaeologists’ epistemic authority.

\[12\] For a definition and the different categories of authority see Pruitt 2011: 14-24.
As it is out of the scope of this work to examine in depth the role of authority in the production of archaeological knowledge (Pruitt 2011) since it is only a single element within the complex processes that lead to a 3D visualisation, I used the previous example to demonstrate by and large the impact that authority and hierarchical divisions have on archaeological practice and materialising practices, such as 3D visualisations. Knowing how archaeology functions in a Greek context, I would say that such encounters are expected and welcomed. My experience in field projects has shown that such conflicts often give birth to productive discussions, dynamic collaborations and vibrant exchange of ideas, thus adding another facet to the distinctions raised among team members. Authority is so much ingrained in academic practice that any attempt to set it aside might have had unexpected results for the way that archaeology is practiced and perceived by the public today. However, it is not authority per se that poses significant limitations to our work, but archaeologists’ abuse of authority to impose their egos and infuse a sense of objectivity to their work.

5.2.b.2. The Evidence from Trench Z1

The records available for this trench provide uneven information for its three-dimensional visualisation. Although I supervised the trench in 2011 and I also had constant presence in the 2012 field season, revisiting these a year later for this pilot study, they seemed inadequate to me, since more information would be needed for certain areas. To be more specific, the field report (2011) gives an extensive account of the features unearthed, divided by contexts, including information that is also present in the context sheets. Dimensions, textures, colours as well as finds are all documented. Still, the descriptions of colours and textures are not enough without being seen in parallel to photographs and Munsell values. As it is a common practice however, Munsell values only exist for the soil and not for any of the objects or other features unearthed (see 2.2.b.3.). This means that there is not a colour value for the stones of the wall or its bonding material and therefore their visualisation should be based on the colour derived from the photographs. The same applies to the texture of the features, which has not been recorded in field notes or contexts sheets.

Regarding the photographic record, there are only four images that present the final state of Z1 (fig. 103); one is almost vertical, providing an overall view of the trench and information about the top surface of features, while the rest were taken from an angle that provides some additional information about the sides of the various features. The problem however is that there is not any consistency between the photographs taken. For example, there is a clear north side view of the E-W wall, but not for the N-S wall, since there is only one image of its top surface with a slight indication about the
stones at its east side. Similarly, there is no information for the stones at its west side. Unfortunately, this is a visual piece of evidence that cannot be retrieved from any of the other records, since even drawings have only depicted the top of the N-S wall and the north side of the E-W wall (fig. 104). In addition, photographs pose another problem in comparison to the actual records; the depiction of colours and textures is problematic, since each image, because of the varying viewpoint and the overall lighting in the scene, presents this information differently; this becomes clear in the area of mud bricks at the northwest section of the trench in figures 103A and 103D.

Fig. 103 Four photographs of Trench Z1 that present its 2011 final state. A. Vertical view of the trench – the four main areas of interest are highlighted; green - mud bricks, blue - concentration of stones (from the masonry?), beige - wall, pink - pebbled floor(?); B. The north side of the E-W wall from the north; C. The N-S and E-W walls from the east; D. The north section of the trench from the south (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
The field report (2011: 26-29) provides information for the various features and their arrangement in space. It presents a detailed account regarding their size and building techniques, the colours and textures of the soil in the different areas, while it gives some interpretations for certain elements of the trench, e.g. the concentration of mud bricks at the northwest corner, the stones at the west of the N-S wall and the area at the northeast of the E-W wall with the small sub-rounded stones (fig. 103A).

Fig. 104 Drawing of the wall in Trench Z1. Top: North facing section of the east-west wall; Bottom: Plan view of the north-south, east-west walls (Koutroulou Magoula Archaeology and Archaeological Ethnography Project).
A comparison between the drawings, photographs and the information presented in the context sheets and the field notes provide an accurate estimation about the various features, and especially of the four areas that seem of vital importance in the understanding of the trench. However, is this information sufficient to proceed with a three-dimensional visualisation? Most of the times, the answers to such questions are negative. However, since archaeological data and their recordings are by their nature problematic, the aim should be to find sufficient ways to visualise the evidence in 3D in order to provide some additional understandings than these derived from two-dimensional records.

5.2.b.3. Experimenting with Alternative Ways of Modelling

In the case of Trench Z1, the first attempt was made by creating simple volumes with random colours that represent the location and approximate dimensions of these four areas. In figure 105 it is evident that the replacement of the actual features with volumes can only provide a very abstract indication of the original evidence. It is only the volume in beige colour that refers to a linear feature, which, judging by the dimensions and the context, could possibly be a wall. However, it is apparent that the modelling of volumes to stand as the archaeological features under question is not adequate on its own to enhance the understanding of Z1’s content. This means that more information should be added.

Fig. 105 The four main features of trench Z1 have been replaced by single volumes (Images author’s own).
It is assumed that the wall unearthed is the most important piece of evidence in this trench since it might belong to the stone foundation of a Neolithic house. Therefore, the 3D visualisation process will be mainly focused on this area to highlight how alternative modelling processes can affect perception and understanding. The first attempt with the coloured volumes showed that based on their form, it was only the wall that could be potentially recognised. The next attempt incorporated additional details by applying bump and displacement maps. The main issue with this approach is that in order to create texture maps based on the actual photographs of the features, the images should be of high resolution, also capturing all the sides of the feature under examination. However, in the case of Trench Z1, neither high resolution images nor adequate captures of all sides of the wall have been taken. The result showed (fig. 106) that the application of texture maps as a 3D visualisation technique is rather problematic. This is not only because the three-dimensionality that they construct is an illusion that does not encompass important aspects of reality. It is mainly because in many cases, where the primary data are of not sufficient quantity and quality so as to allow their proper processing and application, the result, although three-dimensional, is of lower value in comparison to the actual image that was used to create the maps. As well, it is not only the result itself, but the process of creating and applying maps that does not provide the means to further understand the three-dimensional character of the evidence. It is understandable however, that the pace and pressure of most excavations, and especially in cases where 3D visualisation is not within the scope of the project, does not always allow the formation of a visual record that could later be used in a computer graphic simulation.

Fig. 106 The wall in trench Z1 modelled by using bump and displacement maps derived from figure 103A. Left: Bump map 3/10; Right: Bump map 1/10 and Displacement map 0.05/10 (Images author’s own).
Realising that the process of understanding cannot be enhanced by using rather abstract means to build reality, the next attempts were focused on the addition of more detail in the construction of the wall to observe if, and to what extent, an object is better understood when digital objects come closer to reality. The first attempt was made by creating individual pieces of geometry that were positioned to resemble the ‘herringbone’ style of the stone foundation. These were rectangles (boxes in 3dsMax) in a random colour which were made to roughly resemble the size and arrangement of stones as this shown in the photographic record (fig. 103A-C). Also, a modified box was positioned below the stones to mimic the bonding material and the earth. Initially, the stones were rendered with a random green colour and were then compared with a rendering in a white/light grey colour. Then, more detailed textures were applied to the objects in order to examine the level of detail that influences perception. Comparing these three different results of the modelling process (fig. 107), it becomes obvious that general principles of perception, also apply to the process of understanding through 3D modelling. For example, the fact that boxes in white/light grey colour seem more familiar than these in green colour has its origin in the theory of colour constancy (see 2.2.a.3.). This means that since we are familiar with stones being in such a range of colours, it is reasonable that the construction of the wall with such properties would be more easily understood. On the other hand, the use of plain rectangles to create the stones seems problematic, since the building material for this type of buildings is more irregular. It is assumed however that when textures are added to such geometric primitives or contextual detail is also present in the reconstruction, then objects become more comprehensible.

The role of light, shadows and shading as this has been highlighted in other sections of this thesis (see 2.1.; 2.2.a.3.) is fundamental. For example, in figure 108, where the same wall as in figure 107C is depicted, it becomes apparent that the inclusion of physically accurate light and shadows, which result in an interplay between colour, texture and form, enhance the understanding of the object, even though the shape chosen for the stones is not representative of these used in a Neolithic structure. In addition, experiencing the scene from different viewpoints enables an overall appreciation of the modelled object, enhancing the understanding of the interrelation of micro and macro morphology. Modelling the wall with regular geometry instead of more asymmetrical forms has several benefits, especially in terms of the computational resources needed. Moreover, this approach might also be suitable if the main aim of the modelling process is to understand and show in a simple way how stones were arranged in order to make the foundation stable. However, it is worth looking at the level of detail needed for more complicated research questions.
Fig. 107 The wall in Trench Z1 constructed with three different methods: A. Stones as boxes in green colour. Non-physically accurate light and textures; B. Stones as boxes in white colour. Non-physically accurate light and textures; C. Stones as boxes rendered with physically accurate textures. Non-physically accurate light (images author's own).
Fig. 108 The wall in Trench Z1 constructed with stones as boxes, and rendered with physically accurate textures and light at 12pm, 21st September 2013 (images author’s own).
Since the main problem that was realised with the previous attempt was the unfamiliarity with the regularity of the stones, the wall was modelled by constructing stones which more closely resemble the irregularity of those used in the stone foundations of this coursing style preserved in the settlement (fig. 109). Physically accurate light and shadows were also used since their inclusion in the previous model showed that perception of individual components is significantly enhanced. Boxes with bevelled edges (chamfer boxes in 3ds Max) were used as the basic geometry of the stones, on which several modifiers have been applied to make them look rather irregular.

While the initial intention was not to mimic the arrangement of stones as shown in the available images, but actually to follow my own understanding of a Neolithic stone foundation, similarly to the way it was done in the previous example, the irregular shape of stones worked differently. Although the stones produced are not exact replicas of the actual stones, neither regarding their shape and size, nor their texture, it seems that the level of familiarity they provide to real-world objects direct the process of 3D modelling towards the replication of reality. The opposite however, could be equally argued; it is reality itself that calls for a more detailed representation in order to be adequately understood. Probably the truth is somewhere in between the two statements, indicating that in the process of 3D modelling everything is interrelated, with choices affecting perception and perception being affected by choices.

Comparing the last two modelling attempts, the conclusion is that modelling choices significantly influence both the outcome of the process and the perception of the modelled scene, as well as the understanding of the corresponding archaeology by the modeller. The last example also showed that when the components of three-dimensionality come together, i.e. colour, texture, form and context, the perception and understanding of a scene, regardless of their faithfulness to reality, is significantly enhanced. These four different attempts made apparent that extremely abstract modelling cannot be helpful in the comprehension of reality; although it seems simpler and easier to employ than more complex modelling, it does not seem to facilitate a further understanding of the three-dimensionality of the real or the digital world. Finally, similarly to the principle of constancy in perception, the way that a scene is perceived highly depends on triggering familiar aspects of the real world. As it was noted, this familiarity is also increased by the friendliness and usability of graphical interfaces.
Fig. 109 The wall in Trench Z1 constructed with stones as boxes on which several modifiers have been applied to produce irregular geometry, and rendered with physically accurate textures and light at 12pm, 21st September 2013 (images author’s own).
Although visualisation across the disciplines and especially in archaeology is often seen only as a way to record and passively communicate results, it is suggested that the process of producing these visualisations, regardless of their style, not only enhances the engagement with the subject-matter but also helps to explore and coordinate understandings. The process of 3D modelling, whether it is based on the construction of complex objects or follows a simpler route, even when involving some level of abstraction, has an inherent advantage. That is why 3D modelling has also been employed in a wide range of working and learning activities, such as product design (see for example Alcaide-Marzal et al. 2013); in such cases, the process of modelling in three dimensions provides flexibility in comparison to two-dimensional approaches, also fostering creativity and experimentation.

5.2.c. Drawing and 3D Modelling: A Comparison

Modelling in three-dimensions, similar to sketching and drawing, can significantly enhance engagement and understanding as well as analyses and testing of forms and functions. The process of sketching and drawing has been repeatedly praised across various disciplines, especially regarding its pedagogical role in young children’s learning (see for example Anning 1997, 1999, 2008; Hope 2008). Although nowadays drawing is considered a tool for thinking that provides the field in which ideas are explored and settled down, this was not always the case, especially in the early and mid-21st century. Drawing was seen – and in some cases is still seen – as a means to represent real or imaginary objects, as well as to solely externalise and communicate thoughts (Anning 1997: 226). In this description, drawings’ powerful ability to instigate thinking, generate, develop and clarify ideas, and produce knowledge and meaning are neglected.

The importance of drawing in the development of creative responses and the stimulation of ideas has also been supported for science students (Silano 1950; Ainsworth et al. 2011; Tytler and Hubber 2011). Especially in some disciplines, such as architecture, drawing is so integral in the process of design that it is somehow considered more important than the process of building itself (Edwards 2008). The same applies to graphic design (Schenk 1991), where drawing has been additionally seen as a means to impose ideas and support managerial tasks. However, it is not only the process of drawing per se that enables thinking and understanding, but also the means through which drawing is performed, i.e. pen, pencil, crayons, stencils etc. (Hope 2008: 123). For example, tracing around an object and feeling its shape is more important in the development of understandings than drawing a shape and merely
observing it. Although the latter derives from observations in primary schools, it could be related to a certain extent to the use of various devices in 3D modelling.

The use of a mouse is not probably the most effective way to produce three-dimensional objects in terms of its haptic input, since it does not work to an analogue of a real process of modelling, building or drawing, and it does not have haptic feedback. Also, a mouse does not provide the most convenient way to navigate in 3D space. The limitations of this and similar devices in user interaction with virtual space, led to the development of motion tracking and gesture recognition technologies, enabling 3D modelling and navigation in 3D space by body movement, also providing feedback that makes users feel the objects that are being modelled (LaViola and Keefe 2011; Geomagic 2013). Such emerging technologies, which have been equally applied to art, design and science move 3D modelling forward, however, by implementing methods inspired by the natural way of drawing/modelling.

The question that surely emerges from this very brief reference to conventional drawing as a means to construct understandings is why is 3D modelling superior to drawing?, especially given that the latter is a long established practice in archaeology and, in contrast to 3D modelling, also uses bodily movement and tactility to be materialised. The answer has been already given in the first chapters, and actually inheres in the question itself. 3D modelling is based on the principles of three-dimensionality, while drawing is missing it, since conventions are discipline-specific and can rarely efficiently communicate the properties of the real world. Cognition and perception do rely on the processing of three-dimensional information, and therefore the manipulation of modelling tools and the modelling itself in a 3D environment actively advance the construction of spatial understandings. Software interfaces become arenas where ideas are stimulated, and alternative understandings accrue from modelling and rendering choices. It is believed that attempting to understand the materialities and spatialities of archaeological information while modelling the evidence can potentially provide alternative forms of experimentation and understanding. In the next section, 3D modelling, decision-making and simulation of an extensive dataset from Koutroulou Magoula is going to be discussed in order to understand their role in constructing new interpretations and spatial understandings.
5.3. Visualising Building 1 and the Settlement

In the second half of this chapter I will particularly focus on the visualisation of one of the better preserved structures unearthed at Koutroulou Magoula, Building 1, as well as on the overall visualisation of the site based on the results of the excavation so far and the geomagnetic prospection undertaken in the 2012 field season. Related archaeological information has been already presented in chapters 3 and 4, and therefore, only essential aspects and additional information will be given here. For both cases, I will address the decision-making process, including modelling and rendering choices. In the next chapter I will canvass the impact of these processes and their results on the directors, team members and students, also discussing their influence on my own understanding of the site.

5.3.a. Visualising Building 1

For the visualisation of Building 1, all field notes, drawings and photographs as well as the preliminary publication of its archaeology (Kyparissi-Apostolika 2006) were studied. Ethnographic comparators from Neo Monastiri village were also valuable to get an overall idea about the initial structure of the building. All processes and decisions were recorded in a blog (http://koutrouloumagoula3dvisualisation.blogspot.co.uk) accessible only by the members of the team, who were asked to contribute with comments and suggestions about the process and the products of reconstruction. In such a way the modelling process could be informed by other scholars with extensive knowledge in Neolithic datasets, and therefore, multivocal, three-dimensional understandings could be formed. However, since no responses were left online, summaries of the processes and the visual products were presented in an online survey, which addressed issues related to knowledge production, senses of place and three-dimensionality, as well as the modelling process. The structure of the survey as well as the participants’ responses are presented and analysed in the next chapter.

As it is evident from the details presented in chapter 4, there are several ambiguities in this dataset accruing both from the preservation of the material as well as the recording processes employed (also see chapter 1). The uncertainties should be addressed prior to any 3D modelling since they are also part of the decision-making process regarding the amount and style of the models as well as the level of detail that should be incorporated. This dataset has certain issues that require further investigation: 1) which was the original height of the stone foundation and the mud brick superstructure? 2) Were there any other openings in the building, i.e. doors,
windows, opening at the roof, apart from the large opening preserved in the south wall? 3) How was the roof constructed and supported? 4) Were there any hearths, storage pits and/or other features facilitating everyday activities? 5) Was it used as a house, and what kind of activities were taking place inside? 6) Were there any structures outside the building and in relation to it?

Similar to the wall in Trench Z1, it was decided to construct both the stone foundation and the superstructure of the building as individual objects, following to some extent a process of building a physical analogue of the structure (fig. 110). Although this is an expensive decision in terms of computational resources and time, it provides an enhanced perception of the actual archaeology during the modelling process. A common approach in computer graphics in order to minimise the impact of the scene's complexity, unless they are intended for structural analysis, would be to limit the modelling to only the visible components. In our case, this would mean that parts of the stone foundation not visible from either inside or outside, as well as the individual mud bricks of the superstructure which were normally covered with a layer of clay would not be modelled. This would have significantly minimised the complexity of the scene, however, emphasising the computational aspect rather than the archaeological significance of the process.

Since the level of preservation of the building’s walls does not allow a clear idea about their original height, their modelling is only an approximation. Based on indications from other sites of the period, as well as on the consulted ethnographic comparators, the stone foundation probably had an initial height of about 40-50cm. The stones were positioned in the ‘herringbone’ coursing style, while earth and smaller stones were used as the bonding material. However, the evidence from the earlier phases (see 4.1.b.) indicates that stone foundations could be much higher, perhaps exceeding 1m. Therefore, another possibility is a stone foundation at 90-100cm (fig. 110). Regarding the superstructure, there is no indication from the building itself about its original height, but evidence from the stratigraphy of Building 2 (see 4.2.) has shown that 3 metres could be possible. The only opening that exists in the building at its south wall might have been its main entrance. There is no other evidence suggesting that there were other openings either at the ground level or anywhere in the superstructure, or the roof of the building. However, it seems reasonable that if a hearth existed in the interior, as the field notes document, an opening at the roof should have facilitated the diffusion of the fumes. A lighting analysis could help to identify if the amount of natural light that entered the room could be considered sufficient for an interior space, which was possibly used for some household activities, other than sleeping.

13 There are cases where the fumes are diffused through the gaps between the reeds of the roof. This however presupposes that the roof is not plastered or covered by any other means.
As far as the roof is concerned, since there are no particular indications about its form and structure, Neolithic house models, as well as archaeological and ethnographic parallels (see chapter 3) suggest that this could be flat or slightly gabled, gabled, or saddled (fig. 111, 112, 113), covered with reeds and/or straws and possibly a thin layer of clay for waterproofing, as suggested by the impressions found in several Neolithic sites in both Thessaly and Northern Greece, as well as the Balkans. Neolithic house models also indicate that they might have been decorated with coloured patterns or covered with animal skins (fig. 114A). Coloured patterns have been also suggested by ethnographic parallels for the walls of the buildings (fig. 115). Roofs
were supported either by beams within the mud brick superstructure and/or one or more beams in the interior (fig. 113, 116). The suggestion that the roofing was also made of tiles (fig. 114B, 120A), might indicate that more beams were required to support it, simultaneously limiting the available space in the interior.

The circular areas on the floor that seem not to be covered by stones could have been used for positioning the beams that supported the roof, while they could also have facilitated the semi-subterranean storage of vessels (fig. 117). At the east of the entrance, a probable hearth has been also unearthed indicating that it might have been used for providing adequate light, warmth and also fuel for cooking (fig. 118).

**Fig. 111** Non-photorealistic renderings showing alternative structural models for the roof with and without an opening. A. Slightly gabled roof; B. Saddled roof; C. Gabled roof (images author’s own).
Fig. 112 Photorealistic renderings of the interior of Building 1 showing alternative structural models for the roof. A. Slightly-gabled roof; B. Gabled roof; C. Saddled roof (images author's own).
Fig. 113 Photorealistic view of the interior of Building 1. The roof has been constructed by using wooden beams on top of which there are straws covered by a thin layer of mud. An opening at the roof facilitates the diffusion of the fumes from the hearth. The roof is supported by a central post (image author’s own).

Fig. 114 Experimental non-photorealistic renderings of Building 1. A. The roof covered with animal skins; B. The roof covered with tiles, similar to these found at the interior of the building (images author’s own).
Fig. 115 Experimental photorealistic renderings at night time with light coming from the hearth. Red-coloured patterns are depicted on the walls based on the evidence from archaeological and ethnographic material (images author’s own).
Fig. 116 Non-Photorealistic renderings of structural models showing alternative ways for supporting the roof. A. Slightly gabled roof with a central post and the rest positioned within the superstructure; B. Slightly gabled roof with three posts in the interior of the building and no posts within the superstructure; C. Gabled roof with four posts close to the four corners of the building and no posts within the superstructure; D. Gabled roof with all posts within the superstructure of the building (images author’s own).
Fig. 117 There are certain areas on the floor which are not covered by pebbles. If this is not due to the destruction of the floor during the habitation period or after the abandonment, these areas might have been used for positioning posts to support the roof or for the semi-subterranean storage of ceramic vessels (image author’s own).

Fig. 118 The hearth at the interior of Building 1. A. Photorealistic rendering of the interior at night time (image author’s own); B. The hearth as it was discovered in the 2002 field season (Koutroulou Magoula Archaeology and Archaeological Ethnography Project); C. The hearth as it survives today (image author’s own).
The fact that most of the small objects were found outside, in conjunction with the study of material which still is at preliminary stages, does not allow the safe inclusion of such finds in the interior of Building 1. Incorporating some very common objects and those that ethnographic parallels and archaeological correlates indicate that might have been used in everyday activities, although extremely hypothetical, facilitates a better understanding of a sense of living in such spaces. Otherwise, the models’ visual impact is limited to the appreciation of the site as a container of architectural components without any indication of life and living. I have often found myself in a similar situation, trying to decide if the addition of abstract and ambivalent evidence is ethical or not. The safest route is obviously that which protects the modeller from criticism, especially that of scholars who are quite sceptical regarding the use of three-dimensional modelling as a means to present, simulate and analyse the past. On the other hand, it is suggested that the past cannot be presented, simulated and analysed if essential elements of past life are missing. The only way to overcome this dilemma is to face such three-dimensional productions as working hypotheses that provide the chance to experiment and test ideas in ways that would be impossible by any other means.

Taking into account the latter, it was decided to incorporate some small finds, similar to these found in and close to Building 1, as well as in the other areas that the excavation takes place. Also, as a source of inspiration, finds from the experimental Neolithic buildings constructed in Greece and abroad, as well as from the ethnographic parallels of those regions were consulted (see chapters 3 and 4). Some of these finds were a figurine (actual figurine found in Building 1 and laser scanned in the 2010 field season), a sling and sling pellets, quern stones, a straw basket, various seeds, animal skins, firewood and wooden sticks, ceramic vessels and some dried herbs (fig. 119).

Lastly, it has been lately suggested by the geomorphologist of the project that great quantities of animal dung at the south of Building 1 most probably indicated the existence of a permanent structure/area for keeping domestic animals (fig. 120). The large number of animal bones at this area might also support this case.
Fig. 119 Photorealistic views of the interior of Building 1 showing small finds and objects made of perishable materials (images author’s own).
Fig. 120 Non-photorealistic views of Building 1 with a fence for animals built at its southwest. A. Building 1 with an alternative roof with tiles. At the outside there is a fence to keep domestic animals, as well as a paved area and a hearth possibly used for some communal activities, such as cooking and gathering; B. Close-up view of the fence with other houses and vegetation at the background; C. Communal areas between houses (images author’s own).
Based on the facts presented above and in chapter 4, it becomes evident that a single visual output cannot be constructed. Therefore, more than 30 structural models which reflect different hypotheses were modelled:

- Two stone foundations, 50cm and 100cm, and corresponding mud brick superstructures;
- Three roofs; slightly gabled, gabled and saddled, with variations regarding a potential opening;
- Roof covered with mud, ceramic tiles or animal skins;
- Roof supported by beams positioned on the ground and/or within the superstructure of the building;
- Interior with/without hearth, storage pits, objects and small finds;
- Walls covered with mud with/without coloured patterns;
- A fence for animals at the southwest of the building.

The construction of a building that was most probably used as a domestic space is missing an essential element when people are not included. Houses were built to accommodate the needs of the Neolithic population facilitating aspects of their everyday lives such as sleeping and gathering, and possibly food storage, preparation and consumption. However, both the inclusion and the absence of human figures that by definition give life to the scene and produce visual statements about roles and relationships have been criticised (Martinez 2001: 13-15). Although digital (re)constructions in this thesis are seen as working hypotheses and experimental approaches to built space, it was initially decided to omit any human characters from the visualisations. This would allow to observe how users see digital images that are missing such an essential element. This decision also derived from discussions with staff members of the project who emphasised that since research about basic elements of the structure still is at a preliminary stage, the inclusion of humans, especially in case they were going to be portrayed undertaking an activity, e.g. flint knapping, would have created a story that would be much more influential than the depiction of objects themselves. This however could obviously achieve an enhanced perception of space and three-dimensionality, which is a requirement in this thesis.

Before proceeding to the next part about rendering Building 1, I ought to reflect on the differences and similarities between building interpretations made to inform computer graphic simulations and these made for other purposes, e.g. a publication. My interpretations of architecture are admittedly based on preliminary results since study

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14 The various structural models were manually built without the use of procedural modelling which automatically produces structural variations based on a set of predefined rules (see for example Harrison et al. 2013).
of the material is still ongoing. Therefore, great part of these interpretations is derived from archaeological and ethnographic parallels, as well as discussions with team members and other colleagues. This means that when research and excavation will progress, some interpretations might be confirmed whereas others invalidated and the models amended accordingly. Although these interpretations, right or wrong/possible or impossible, might be soon published as part of the 3D modelling process in a relevant book or journal, it is unlikely that they could stand on their own in a purely archaeological journal or that an archaeologist would have chosen to publish them in such a preliminary stage. As previously discussed, archaeologists’ authority does not allow ambiguity, but only definitive answers. In other words, although the process of interpretation that an archaeologist should follow is relatively the same in both analogue and digital media, digital (re)constructions give the freedom to visually express what would have been impossible in verbal or written arguments. This of course does not mean that fellow archaeologists and the research community will unquestionably accept anything digital; my experience has shown exactly the opposite. What the process of 3D modelling essentially does is that it allows diverse interpretations materialised in the form of computer graphic simulations to become heuristic sources and working hypotheses in the production of archaeological knowledge.

5.3.b. Rendering Building 1

Apart from constructing the alternative structural models for Building 1, a significant factor in the impression made by the final product is the decision regarding the rendering style of the models. There has been a clear tendency over the last decades to construct photorealistic models, i.e. to make them look like photographs. There are numerous such examples in archaeological contexts, which have been simultaneously praised and severely criticised. The main argument against such approaches, which I am not going to analyse here, is that since reconstructions are in essence only constructions of the past in the present, presenting them in a photorealistic style does not leave room for expressing doubt or for constructing alternative hypotheses. Several research papers have used highly original titles to describe this relationship, such as The good, the bad and the downright misleading (Miller and Richards 1995) and The compelling computer image: a double-edged sword (Eiteljorg 2000), suggesting that what is presented to the viewers is a historical truth of the past.

It is true that photorealistic images, due to their resemblance to photographic images leave only small room for thought and the construction of alternative hypotheses. Also, the fact that technologies have significantly advanced in the last decade makes it even
more difficult to escape from the route of photorealistic rendering, since an attractive computer image is always needed for publicity purposes even by archaeologists, who are in principle against such approaches (Frankland 2012: 36). However, it is believed that studies on photorealism and 3D visualisations in archaeology have over-emphasised the impact of this approach on the various interest groups, leaving aside major issues regarding the ways that these images are produced. These works also tend to underestimate users’ critical ability, while neglecting people’s responses in various surveys for such projects, who argue that archaeologists should only provide a single image that will present their final interpretation for the site.

The last decade, photorealistic archaeology has moved beyond this often sterile debate by justifying the extreme realism with the use of formal analytical tools to simulate space in a particular moment in time (see for example Devlin and Chalmers 2001; Sundstedt 2004; Dawson and Levy 2007; Papadopoulos and Earl 2009). In such a way, photorealism becomes an inescapable route, since in order to simulate real-world properties, physical accuracy, and therefore realism, it is a prerequisite.

To overcome issues related to the perceived truth of the modelled scene (Murgatroyd 2008: 1.3), the involvement of a certain level of abstraction has been often seen as the solution. However, the small scale experiment in the first section of this chapter showed that in order to get some understanding of space and of the three-dimensional character of archaeological evidence, this abstraction should not be based on geometry. Conversely, some abstraction or reduction of realism can be introduced by implementing different styles of rendering. The most well-known style, which has been often used in archaeological and cultural heritage contexts is non-photorealistic rendering (NPR). NPR is a technique for rendering 3D models in more artistic and expressive styles, similar to these that different artistic techniques can produce (Strothotte and Schlechtweg 2002: 7-12). Gooch and Gooch (2001) have given emphasis to the fact that NPR is more about the communication of the content of the image rather than about the process of building this image. Back in the 90s, although the term was not yet established, Foley et al. (1995) had first mentioned this issue by arguing that if it is needed in the context of computer graphics to produce images that convey some information, such images should be set free from photographic realism. However, it should be noted that when NPR is implemented in an attempt to exactly mimic non-photographic illustration styles, it takes on many of the tropes of photorealism.

Frankland (2012) interviewed several interest groups including people of different age, sex and profession to canvass their responses regarding NPR and its impact to
archaeological interpretation. It is interesting that the analysis of the results showed a mixture of responses highlighting that the style of rendering should depend on the intended outcome. Specifically, results underlined that digital constructions rendered in NPR style can enhance both understanding and the interpretive process for archaeologists, while photorealism is still the preferred method of depicting the past, especially for communicating knowledge and engaging the general public.

Although all the images presented for Building 1 are physically real, which means that they retain the properties of the real world, different styles of rendering were chosen to represent the various interpretations of the site. Based on Hagen’s book on *Varieties of Realism* (1986), Ferwerda (2003) has proposed three varieties of realism in computer graphics: physical realism, photorealism and functional realism. As mentioned above, all images in this thesis are to a certain extent physically real, since objects’ properties correspond to real-world equivalents. However, based on the message that has to be conveyed some of them have been rendered in a photorealistic style, whereas others are functionally realistic. For the latter, non-photorealistic rendering has been employed.

NPR has been used for cases where 3D models present alternative structural components of the building or when it is not required to provide the same visual stimulation as the real scene: in other words, when a sense of the real world is not vital. Yet, these images provide the visual information that was deemed necessary to convey the knowledge about essential properties of the scene. On the other hand, photorealism has been employed for those cases where accurate simulation and analysis of light was required to construct understandings regarding both the alternative structural models and the sense of using that space. In some cases, the same renderings have been produced in both PR and NPR styles to canvass people’s responses regarding their impact on them and their usefulness in presenting archaeological knowledge. In addition, there are some images, which despite their use of properties related to the real world (e.g. colour, texture, form etc.), are not photoreal. This style was particularly employed for cases where the evidence is quite abstract, but some of the information of the real world should be conveyed (see for example the renderings of the settlement – fig. 125).

As it was made apparent in chapter 2, vision is the least reliable of the senses; thus, senses of place cannot be constructed solely by visual means. Cognitive processes, personal capacities, such as memories and emotions, and the interaction of all senses are required in order to get a full-appreciation of a given environment (Hamilakis 2011, 2014). However, attempts in computer graphics to incorporate different senses and
produce sensory engagements with the past either have not been successful or they are still quite problematic (see for example Chalmers and Zányi 2009 and discussion in 6.2.b.). On top of that, a physically real image does not presuppose that it will be perceived as such, since aspects such as viewing conditions, monitors’ properties, personal visual capacities etc. constrain its fidelity (see chapters 1 and 2; also Devlin 2012). Therefore, the visualisations produced in this section will be primarily used to evaluate the construction of understandings in the modelling process, as well as staff’s and students’ responses regarding the processes that lead to the products and the products themselves.

5.3.c. Simulating and Analysing Light in Building 1

As mentioned above, ambiguous datasets are not suitable for structural analysis, since it is an engineering technique that primarily works for more regular volumes and less abstract material. This is something that could be potentially explored in a thesis solely focused on this aspect of computer graphic simulations, but in the current research this would put an unnecessary load with quite ambivalent results. This is primarily because in order to perform the various tests, all objects should be drawn in computer-aided design (CAD) software or specialist structural analysis software, which is mainly used for detailed engineering of two dimensional drawings or 3D models. The firm principles that should be followed in structural analysis software, such as Autodesk’s Simulation (Autodesk 2013d), cannot be efficiently applied to datasets of such irregularity, as seen in the case study, and therefore there are currently no research projects that have attempted the simulation of the static stress of reconstructed prehistoric structures.

In the context of physically accurate archaeological computer graphic simulations, there have been several cases which have tried to incorporate some kind of structural analysis to investigate the validity of the simulated buildings. For example, Chalmers and Debattista (2005) attempted to simulate the strength of limestone slabs used to construct Maltese temples in order to examine if the proposed roofing techniques were feasible. Levy and Dawson (2009) followed a similar approach to test the construction of Thule whalebone houses by exposing each of the models to physical elements, such as snow and wind. Also, Papadopoulos and Earl (2009; also see Papadopoulos 2010) performed a structural simulation for two burial buildings at the Minoan cemetery at Phourni, Greece, by using physics software to position the stones which were corresponding to the actual properties of such material. This indicated that vaulted roofs could only stand if there was a counterweight for the forces exerted by the
masonry. More recently, Miles et al. (2013) have structurally analysed historic buildings in order to assess hypothetical forms and alternative structural models.

In the case of Building 1, although the items were positioned by using the physics simulation software NVIDIA MassFX (NVidia 2013c) integrated in 3ds Max at the time, no further structural analysis could be performed for this dataset. However, the construction of the building was ideal to perform a lighting simulation and analysis, which was used to inform the structural models regarding openings that they could originally have, as well as to understand what kind of activities the different lighting models could facilitate.

The lighting simulation and analysis for Building 1 was performed within 3ds Max and followed the same principles as described elsewhere (Papadopoulos and Earl 2009; Papadopoulos 2010; Papadopoulos and Sakellarakis 2013). Sunlight and daylight systems were employed to simulate in a physically accurate way the angle and the movement of the sun at a specific location throughout the day. The analysis of the direct and indirect light at the interior was performed in three different ways by employing image overlay render effects (fig. 121A), pseudocolour exposure control (fig. 121B) and light meters (fig. 122, 123). Image overlay, calculates and displays the lighting values on the rendered scene, and is view-dependent. Pseudocolour exposure control, which is also view-dependent, translates the scene into the lighting values obtained. Lastly, light metres are used to calculate and display the lighting levels in viewports and are view-independent. Image overlay and light metres display the actual values of illumination which get a colour from blue to red depending on the intensity of light, whereas pseudocolour exposure control ‘paints’ the scene with these colours, also providing a legend with the corresponding values. The accuracy however of the view-dependent solutions is determined by the rendering settings, since the analysis is performed on the rendered output. Also, the fact that they are view-dependent means that renderings from different viewpoints will give different results. Lastly, light metres only calculate illuminance, i.e. the amount of light incident on a surface, whereas the other two can also display luminance values, i.e. the amount of light reflected off a particular surface, which is related to how bright or dark this surface will be perceived by the human eye. Still, none of these methods have managed to incorporate personal capacities, such as the perception of the environment in relation to the human eye’s adaptability to different lighting conditions (see for example Ledda et al. 2004; Irawan et al. 2005).
Fig. 121 Lighting analysis of the interior of Building 1. A. Image overlay on the 21st April 9am; B. Pseudo-colour exposure control on the 21st April 9am. Both are view-dependent and highly rely on rendering settings and the position of the camera (images author's own).
The lighting analysis of Building 1 showed that illumination values do not vary when the model with a higher stone foundation is tested. On the other hand, the illuminance values obtained at the level of human eyes, both when standing (~1.50m) and kneeling (~0.65m) are slightly different when alternative roofing techniques are rendered (fig. 122). Specifically, the analysis highlighted that the higher the roof, the greater the values are. For example, the average illuminance value at the southeast corner of the structure when there is an opening at the roof is 313 lux with a slightly gabled roof, 420 lux with a saddled roof and 530 lux with a gabled roof. Given the available methods and the research completed to date on the ethnography of light, we cannot at the moment gauge whether such variations were significant for the Neolithic inhabitants. However, in all three cases described above, according to the Western standards of the Illuminating Engineering Society of North America (IESNA 2000: 464), the southeast corner is adequately lit for common visual tasks where visual performance is important. Values closer to 300 lux are ideal for the performance of visual tasks of high contrast and large size, while values closer to 500 lux for visual tasks of high contrast and small size or low contrast and large size.

The main opening at the south wall of the structure, if not blocked by animal skins and/or removable reeds and straws facilitates the diffusion of light to such an extent so as to consider the structure a place where tasks that required high visual acuity were performed. To be more specific, lighting values exceed 500 lux at the area close to the opening in the south wall and linearly decrease as light reaches the north and east walls. However, values do not seem to fall under 200-250 lux. Light behaves similarly when the model is tested with an opening at the roof, which is highly probable since a permanent hearth seems to have existed. In that case, lighting values are greater by approximately 30-50 lux (fig. 123).

In all experiments, the northwest corner, where the two vessels have been positioned, seems to be the area with the smaller amount of illumination. In cases where the main opening was blocked, it is likely that one more opening might have been needed in order to provide sufficient light, along with the hearth, to perform activities other than sleeping. However, it is not believed that an additional opening, which would have significantly affected the static properties of the building, would be the preferred solution. Lastly, it is really interesting that an opening at the roof creates a sun clock, and an interplay of light, dust and shadow, similar to these discovered by the painter Eva Bosch (forthcoming) at the experimental house at Çatalhöyük. More specifically, the tested times of the day (8am – 6pm) showed that a narrow beam of light first appears at the west wall of the building gradually expanding and moving towards the east during the day. Therefore, a pattern of light and shadow that could be quantified in time is produced (fig. 124).
Fig. 122 Lighting analysis of the interior of Building 1 with light metres positioned at human eyes’ level when standing and kneeling. A. Lighting values with/without an opening in the saddled roof at 10am; B. Lighting values with/without an opening in the gabled roof at 10am; C. Lighting values with/without an opening in the slightly gabled roof at 10am (images author’s own).
Fig. 123 Lighting analysis of the interior of Building 1 with light metres positioned at human eyes' level when standing and kneeling. A: Lighting values at 9am, 12pm, 3pm and 6pm without an opening at the roof; B: Lighting values at 9am, 12pm, 3pm and 6pm with an opening at the roof. White colour indicates that illuminance values exceed 500 lux (images author’s own).
Fig. 124 ‘Sun clock’ produced by light entering through the opening at the roof on the 21st April from 8am to 6pm. Photorealistic/Physically accurate renderings (images author’s own).
5.3.d. Visualising and Rendering the Settlement

Contrary to the visualisation of Building 1, for which there is some archaeological evidence to support the process of reconstruction, as well as ideas derived from the ethnographic parallels and experimental approaches, the visualisation of a larger part of the settlement proved to be more problematic. The only evidence on which such a work could be based is the recent magnetometer survey. Still, the only information that can be derived is the fact that positive geomagnetic anomalies indicate the existence of buildings and other features, while negative anomalies suggest some kind of gaps on the ground, which probably belong to ditches. However, for none of these features, especially given the multi-temporality of the site and the constant agricultural activity, can it be definitely argued either that they belong to the Middle Neolithic period, or that they were simultaneously in use. In addition, research regarding the palaeoenvironment of the region is still at a preliminary stage. Therefore, the attempt to visualise the whole settlement in order to get an approximate idea of how such a site would have looked cannot be based on concrete evidence, at least not at this stage, where the project is still at an early phase and the study of the material is ongoing.

The purpose of this process, however, was not only to present to the members of the team an idea of how Koutroulou Magoula might have looked like, but also to produce a visual output of my own understanding of a Neolithic settlement. This output is obviously a mixture of my readings and observations about the Greek Neolithic, of the ideas derived from the study of Koutroulou Magoula, and of the discussions with the directors and team members during the fieldwork seasons. All these are also enhanced or constrained by my computational skills and the capabilities of the software used. In order to construct this impression of Koutroulou Magoula, which could clearly be a visualisation of any Neolithic settlement, since there are no particular identifiable references to the site, I used the 3D model of Building 1 as the basis for the other structures (fig. 125, 126, 127). In some of them slight changes were made to their superstructures, to the material of which the roofs are made of and to their overall dimensions. The idea that in such settlements abandoned, collapsed and destroyed buildings co-existed with newly built structures was also depicted in the 3D model by incorporating a collapsed building and one under construction (fig. 126C). The scene was also enhanced with paved areas and hearths, indicating that communal activities, such as cooking and gathering, might have been taking place in certain areas of the settlement. Both of these ideas are supported by the evidence, since close to Building 2, a hearth and a concentration of quern stones have been unearthed (fig. 96, 97). Also, layers of cobbles were found at the south of Building 1, indicating that some
paved open areas might have existed. In addition, vegetation and gardening plots were incorporated given the suggestion that in Neolithic tell sites there were areas for cultivation between the houses. Also, since certain areas might have been used for keeping animals, fences were added, while pigs, sheep and goats were modelled to range within the area of the settlement delineated by a ditch.

It was not deemed necessary to produce alternative structural models since the ambiguity of the material, would render the options to consider endless, while it would not have significantly enhanced knowledge production and archaeological understandings. However, it is worth mentioning that even slight changes in the geometry of the buildings, significantly change the overall image of the settlement, probably exerting some influence to the construction of understandings (compare for example figure 126, where houses have slightly gabled roofs with figure 127, where houses have been rendered with saddled roofs).

As far as the rendering of the model is concerned, it was chosen to produce visualisations that are not wholly photorealistic, with some of them using properties of the real world (fig. 125), and others being stylistic representations of the site (fig. 126, 127). Also, an archaeological illustrator, who is not familiar with Neolithic material, was asked to produce, based on the information presented in chapters 3 and 4, a hand-drawn version of the settlement (fig. 128). According to her comments, her intention was to produce the visualisation by reading only once the relevant notes. Therefore, a more abstract view of the site, which does not directly refer to a Neolithic settlement, was produced. The illustrator also argued that the drawing was made in colour since the relevant descriptions provided a sense of colour. Even though there is no indication of colour in the chapters about the Greek Neolithic and Koutroulou Magoula, which were the basis for this illustration, this argument is reasonable since memory colour (see 2.2.a.3.), i.e. previous knowledge about objects’ colour properties, might have provided this information.
Fig. 125 Photorealistic views of the settlement. A. Aerial view with the ditch encircling the settlement at the top of the image; B. Perspective view of the settlement with the ditch at the front of the image (images author’s own).
Fig. 126 Non-photorealistic views of the settlement. A. General view of the tell with the ditch at the front side of the image; B. Perspective view of the settlement; C. Close-up view of the settlement. At the front there is a collapsed building, while on the left another building is under construction. Life continues in the rest of the buildings at the back of the image (images author’s own).
Fig. 127 Non-photorealistic view of the settlement with most of the houses built with saddled roofs (image author’s own).

Fig. 128 Hand-drawn illustration of the settlement based on the archaeological material presented in chapters 3 and 4 (courtesy of Kalliope Theodoropoulou).
Conclusion

In the first section of this chapter, I mainly discussed the utilities in 3D modelling graphics software that condition users to interact with the modelling environment and their creations in particular ways. In this discussion it became evident that the three-dimensionality of the real world is an essential element that dictates the process of 3D modelling in such software packages. To contextualise the discussion about three-dimensional interfaces and interaction in an archaeological scenario, the wall unearthed in Trench Z1 during the 2011 Koutroulou Magoula field season was visualised. Several approaches were employed, evaluating in each case the extent to which the various modelling choices were influencing my perception and understanding of the archaeological material. The results of this attempt demonstrated that the closer a model is to the real world, the better is the understanding of the depicted information. Based on computer graphic simulations’ problems, this section also addressed issues of documentation as these highlighted by the London Charter, arguing that direct links between research sources and 3D images cannot be drawn. Lastly, additional variables that affect the process of 3D visualisation and emerged from the examination of the records for Trench Z1, such as authority and hierarchical divisions, were also critically discussed.

In the second section, the same principles were applied on a larger dataset; this of Building 1, which was the first complete structure revealed in the 2001-2002 Koutroulou Magoula field seasons. Based on the evidence presented in chapter 4, as well as the information in chapter 3 regarding the Greek Neolithic and my existing knowledge and experience on the period and this type of settlements, 3D visualisations of this material were constructed, presenting the decision-making process regarding both modelling and rendering choices, as well as the different hypotheses and alternative structural and lighting models.

This chapter, by approaching 3D modelling with two very different but interrelated ways, highlighted the fundamental elements of the reconstruction process and demonstrated that when computer graphic simulations are implemented as thinking mechanisms, heuristic sources, working hypotheses and scientific tools, they provide the means to visualise the processes of understanding and interpretation as well as enhance knowledge about the reconstructed subject. In the next chapter, the process and the products of modelling are going to be used to reflect on their influence on my understandings of Neolithic spatialities, also assessing the impact that the processes and products of 3D visualisation have on the people involved in the excavation, study and publication of the site.
Chapter 6
Evaluating the Processes and Outcomes of 3D Modelling and their Impact on Knowledge Production

Introduction

In the previous chapter, the decision-making process regarding the various structural and lighting models of Koutroulou Magoula were presented and contextualised in the discussion concerning the process of 3D modelling within a computer graphics software package. In this section, I will investigate the influence that the process of digital reconstruction and its outcomes has both on myself, i.e. the modeller, and the community engaged with the excavation, study and publication of the material, especially in relation to their understanding of Neolithic space. For this reason, two online surveys were designed in which the decision-making process, the outcomes and their interpretation were presented, while team members were invited to evaluate 3D visualisations’ contribution to knowledge production, as well as to express their concerns and ideas.
6.1. The First Survey: Modelling Process and the Products

6.1.a. The Survey

The design of an online survey was necessitated because of colleagues’ hesitation to leave comments on the blog posts published while the 3D modelling of the site was in progress, and the difficulty to arrange a meeting where all staff members and students would be present. The survey was developed in Kwiksurveys (https://www.kwiksurveys.com), an online platform for designing user-friendly questionnaires in a variety of formats and extracting both quantitative and qualitative data.

The first survey (https://kwiksurveys.com/s.asp?sid=hriww3t3cvg0j100356), which was addressed only to staff members and students of the Koutroulou Magoula Project, was divided into six main thematic sections: the process of modelling; non-photorealistic renderings; photorealistic renderings; lighting analysis; experimentations; and, the settlement. In each of these themes, participants were presented with both the decision-making process and the outputs, and were asked to respond to both closed-ended and open-ended questions. The close-ended questions were in the form of statements, while the responses were in the agree/disagree format (Larossi 2006: 64) in order to ensure consistency, and also make possible their meaningful comparison and analysis. Since the questionnaire was quite dense because of the amount of textual and visual information included so as to provide stimuli to participants, close-ended questions could be more easily answered (Foddy 1993: 140-152). On the other hand, open-ended questions, mainly regarding the things that participants liked the most and the least in each section, allowed respondents to express their thoughts and describe any limitations or advantages of both the processes and the products (for limitations and suggestions for alternative structural and lighting models see 6.3.). Since open-ended questions do not suggest answers, participants’ responses in several cases clarified their replies in close-ended questions, aided interpretations, as well as identified what is important for them in the process of 3D visualisation (ibid.: 126-131). The difficulty with the open-ended questions was to filter out the responses and extract valuable information for each case. This was mainly because of participants’ word choices and verbal skills, as well as their knowledge on the topics addressed in each theme.

As a principle, it was tried to design brief, simple and specific questions as much as possible. However, since the surveys were addressed only to the staff and students participating in the project, who all had a good overall idea about both the Neolithic and my work, in several cases I included more textual and visual information and asked more complicated questions. This is also because this questionnaire replaced an informal discussion that never took place while my work was in progress. Participants’ responses, especially in the open-ended
questions, as well as in our personal communications, showed that the content and the structure of the survey worked as intended.

In total, 16 out of 21 staff members responded to the questionnaire, while 4 of those initiated a discussion by sending further comments to my email address. The same questions were also addressed to the 26 students who participated in the last three years in the project, of whom 8 replied to the survey. The sample of the survey especially regarding staff members should be considered adequate since three quarters of them replied to the questions. Students’ responses are primarily used to observe any clear similarities and differences in the subjects involved. The quantitative data presented in the form of graphs below should not be considered a means to make inferences for larger samples or for other research projects. This survey is site-specific and was produced to canvass staff’s and students’ responses regarding this particular 3D visualisation approach. Numbers are only used to show a tendency rather than formal metrics.

The section about the demographics (Appendix II – 1.9., 2.7.) was not focused either on the age and sex of the participants or on their profession, since it was considered more crucial to canvass their responses in relation to their familiarity with the Greek Neolithic, traditional and modern visualisation tools, the site and the material presented. However, the small sample of team members made it impossible to extract some patterns regarding their responses in relation to their occupation or their familiarity with the material. Yet, people that had some previous knowledge/experience of the presented material and have studied or excavated aspects of Building 1, had a tendency to be more supportive for the various 3D models, also trying to improve the results by providing more feedback and references to additional evidence from this and/or other sites.

In the following part, the key messages derived from both close and open-ended questions in each thematic section are presented and accompanied by relevant graphs. In the next section a longer analysis and interpretation of the data is attempted. All responses to the survey, and graphs for staff and students can be found in Appendix II.
6.1.b. The Process of Modelling

In the section about the modelling process (tables 1-3, Appendix II – 1.1.), alternative structural models and different hypotheses, as well as the rationale behind these were presented, and participants were asked to evaluate both the process of modelling as well as the probability of the products. It is worth mentioning that since the same principles were followed for the modelling of all different hypotheses, participants were not asked to evaluate each of the outputs separately, but to evaluate general statements regarding their impact on archaeological reasoning and understanding.

Close-ended questions
- 3D models are propositions and working hypotheses open to discussion.
- 3D modelling is a process to test alternative hypotheses and help archaeological reasoning.
- 3D models should be accompanied by text about the decision-making and the modelling process to make visualisations more comprehensible.
- Non-photorealistic rendering styles are adequate to show the structure of the building.
- Non-photorealistic rendering styles are more trustworthy since they resemble archaeological drawings.
- Video animation is a good way to show step-by-step the process of reconstruction and the structural components of the building.

Open-ended questions
- The presentation of alternative structural models is important.
- It is valuable to have direct references to the archaeological data on which the various models are based.
- It is useful to use archaeological and ethnographic comparators in the process of modelling.
- Non-photorealistic renderings do not show real colour, materials, texture.
- Lack of scale.
The Process of Modelling

You understand how the modelling process helps archaeological reasoning by testing alternative hypotheses and models.

Accompanying images with text about the decision-making and the modelling process that led to the visual outputs makes the visualisations more comprehensible.

The three photorealistic images of the interior of Building 1 provide a better indication of size and sense of space in comparison to the rest of the images which are non-photorealistic.

The images resemble archaeological drawings and therefore are more trustworthy than the very realistic models that 3D graphics produce.

You would prefer something more realistic to show the actual structure of the building.

The models give a good indication of how the building was structured indicating that a definitive answer about the Building cannot be given.

The video gives a good indication about the process of reconstruction and the main structural components of the building.

Table 1 Chart showing staff’s responses to the close-ended questions about the modelling process of Building 1 (image author’s own).

Table 2 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the most in the modelling process of Building 1 (image author’s own).
Table 3 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the least in the modelling process of Building 1 (image author’s own).
6.1.c. Non-photorealistic Rendering

Regarding non-photorealistic renderings (tables 4-8, Appendix II – 1.2.), the members of the team were briefly informed about the meaning and content of the term and were then presented with images of the interior of Building 1 and the area outside in order to evaluate the role of this rendering style in each case. Also, respondents were asked about the sense of space and three-dimensionality that this rendering style provides.

Close-ended questions
- The minimal style of non-photorealistic renderings emphasises that they are propositions and working hypotheses.
- Non-photorealistic renderings retain a sense of space, scale and three-dimensionality.
- Images provide a good indication about both the structure and the content of the building.

Open-ended questions
- Non-photorealistic images is a good way of illustrating hypothesis without imposing particular views.
- Non-photorealistic images are seen as drawings.
- It is important to include other elements apart from objects and architecture, e.g. animals.
- Lack of humans.
- Real colour is missing.
**Non-photorealistic Rendering**

A fence for animals was constructed according to the geomorphologist's report which suggested the existence of a permanent place for animals based on the large quantities of dung. Do you think that the last image adequately represent this suggestion?

Non-photorealistic/ drawing-like images do not provide a good sense of space in comparison to photorealistic images which depict reality in a way that is more familiar to us.

At the moment, the excavated material and its study by the various specialists cannot provide any other indications about the interior and the outside area of Building 1. These reconstructions should be considered adequate as working hypotheses.

Although much of the content presented in the building was not found in the excavation, these images provide a good sense of space and give a good indication about the structure and the content of this Neolithic building.

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**Table 4** Chart showing staff's responses to the close-ended questions about non-photorealistic renderings of Building 1 (image author's own).

**Table 5** Wordle showing frequency of keywords in staff's responses to the open-ended question about the things that they liked the most in the non-photorealistic renderings of Building 1 (image author's own).
**Table 6** Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the most in the non-photorealistic renderings of Building 1 (image author’s own).

**Table 7** Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the least in the non-photorealistic renderings of Building 1 (image author’s own).
Table 8 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the least in the non-photorealistic renderings of Building 1 (image author’s own).
6.1.d. Photorealistic Rendering

Regarding photorealistic renderings (tables 9-14, Appendix II -1.3., 1.4.), the members of the team were briefly informed about the meaning and content of the term and were then presented with images of the interior of Building 1. They were asked to evaluate their sense of space and three-dimensionality in comparison to traditional approaches of representation used in archaeology, and to the non-photorealistic images of the same building. Finally, they were asked to assess the ‘sun clock’ in relation to the enhancement of time, as well as the impact of photorealistic images on the understanding of Neolithic space.

Close-ended questions
- Understanding data which are not easily comprehensible by conventional means.
- Enhanced perception of space and three-dimensionality in comparison to conventional methods of presentation used in archaeology.
- Enhanced perception of space and three-dimensionality in comparison to non-photorealistic renderings.
- Enhanced sense of time.
- Equal preference to photorealistic and non-photorealistic renderings.
- Photorealistic images are ideal for public dissemination.

Open-ended questions
- Enhanced perception of texture, materials and colour.
- Evocation of senses.
- Importance of considering and simulating light in archaeological visualisations.
- Lack of humans.
- Difficult to see photorealistic images on a computer monitor.
Table 9 Chart showing staff’s responses to the close-ended questions about photorealistic renderings of Building 1 (image author’s own).

Table 10 Chart showing staff’s responses to the close-ended questions about the ‘sun clock’ effect in Building 1 (image author’s own).
Table 11 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the most in the photorealistic renderings of Building 1 (image author’s own).

Table 12 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the most in the photorealistic renderings of Building 1 (image author’s own).
Table 13 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the least in the photorealistic renderings of Building 1 (image author’s own).

Table 14 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the least in the photorealistic renderings of Building 1 (image author’s own).
6.1.e. Lighting Analysis

In the section about lighting analysis (table 15, Appendix II–1.5.), participants were first presented with the visual outputs and the interpretation of the results (see 5.3.c.), and then, they were asked to comment on the suggested models and the usefulness of formal analysis in the decision-making in archaeology.

Close-ended questions

- Lighting simulation and analysis enhance archaeological interpretations.
- Results are more comprehensible when lighting values are ‘painted’ on the scene (pseudocolour exposure control).

Open-ended questions

- Other factors, apart from light should also be considered in such interpretations.
- Lighting simulation and analysis is speculative when essential data are missing.

Table 15 Chart showing staff’s responses to the close-ended questions about the lighting analysis of Building 1 (image author’s own).
6.1.f. Experimentations

In the section about experimentations (tables 16-18, Appendix II – 1.6.), it was decided not to present all different experiments that were tested in the modelling process, but to choose one of the most characteristic; the interior of the house at night time with light coming from the hearth, and the walls decorated with red-coloured patterns. Based on these, respondents were asked to evaluate the extent to which the visual outputs could influence the perception of space and the sense of three-dimensionality, as well as the suitability of the method for testing different hypotheses.

Close-ended questions
- 3D models provide the chance to experiment unlike other methods used in archaeology.
- Enhanced sense of space.
- Images for public dissemination.

Open-ended questions
- Lack of humans.
- Difficult to see dark photorealistic images on a computer monitor.
- Important to consider other times of the day, i.e. night, seasonal variations and weather conditions.

Table 16 Chart showing staffs’ responses to the close-ended questions about the experimentations in Building 1 (image author’s own).
Table 17 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the most about the experimentations in Building 1 (image author’s own).

Table 18 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the most about the experimentations in Building 1 (image author’s own).
6.1.g. The Settlement

The section about the settlement (tables 19-23, Appendix II - 1.7.), presented the rationale behind its visualisation and asked respondents to evaluate photorealistic and non-photorealistic outputs and respond regarding the enhancement of space and three-dimensionality.

Close-ended questions
- Non-photorealistic images are more appropriate for this kind and quantity of evidence.
- No need for abstract images even though the evidence is scarce.
- Enhanced sense of space.
- Images for public dissemination.

Open-ended questions
- Variability of the structural models enhances realism and sense of space.
- Cartoon-like illustration not adequate as a means of visualisation.
- When photorealistic and non-photorealistic images are compared they should be given in equal numbers.
- Lack of humans.
The Settlement

Table 19 Chart showing staff’s responses to the close-ended questions about the decision-making process and the renderings of the settlement (image author’s own).

Table 20 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the most about the rendering of the settlement (image author’s own).
Table 21 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the most about the experimentations in Building 1 (image author’s own).

Table 22 Wordle showing frequency of keywords in staff’s responses to the open-ended question about the things that they liked the least about the experimentations in Building 1 (image author’s own).
Table 23 Wordle showing frequency of keywords in students’ responses to the open-ended question about the things that they liked the least about the experimentations in Building 1 (image author’s own).
6.1.h. Summary

In the summary section, participants were asked to express their level of agreement with several statements which summarised the results of the modelling process as these presented in all previous thematic sections (tables 24, 25, Appendix II –1.8.).

Close-ended questions
- 3D visualisations are a means to disseminate knowledge to the public.
- 3D visualisations augment the understanding of archaeological material.
- Both photorealistic and non-photorealistic 3D visualisations provide an augmented sense of three-dimensionality.
- The process of modelling enhances archaeological understandings.
- 3D modelling offers a means of experimentations.
- 3D visualisations should accompany archaeological research the same way as conventional practices.
- 3D visualisations help archaeologists to understand abstract and problematic archaeological material.
- Interactivity between the user and the models is important, but their static nature is not necessarily a problem.
- The 3D models and the process of modelling have augmented the flat nature of Koutroulou Magoula’s records.

Open-ended questions
- 3D visualisations can often be misleading.
Although the models are three-dimensional the way they are presented through a computer screen make them rather static. If they were presented in a more interactive way the sense of space and three-dimensionality would have been significantly enhanced.

Three-dimensional reconstructions help not only the public, but also archaeologists to understand abstract and problematic archaeological material.

Three-dimensional reconstructions should be part of archaeological research projects, the same way as photography, field notes and drawing.

You understand the way that the modelling process in a three-dimensional programme can enhance the way that archaeological reality is perceived.

Although the model of the settlement is hypothetical - working hypothesis, it provides a good sense of 3D space, enhancing the flat nature of conventional archaeological records, also helping to understand how a tell would have looked like when populated.

Although the virtual reconstructions of Building 1 are to a great extent hypothetical - working hypotheses, they provide a good sense of three-dimensional space, enhancing the flat nature of conventional archaeological records.

You realise that virtual reconstructions offer a means of experimentation with the data unlike any other methods or physical reconstructions.

Virtual reconstructions, either photorealistic or not, offer an augmented sense of three-dimensionality.

You see the potential of virtual reconstructions as a means to understand aspects of archaeological material, which are not comprehensible by conventional means of recording and presentation.

You see the potential of virtual reconstructions as a means to disseminate knowledge to the public.

Table 24 Chart showing staff’s responses to the close-ended questions about the use of 3D visualisations as heuristic sources and scientific tools in archaeological reasoning (image author’s own).
Summary (students)

Although the models are three-dimensional the way they are presented through a computer screen make them rather static. If they were presented in a more interactive way the sense of space and three-dimensionality would have been significantly enhanced.

Three-dimensional reconstructions help not only the public, but also archaeologists to understand abstract and problematic archaeological material.

Three-dimensional reconstructions should be part of archaeological research projects, the same way as photography, field notes and drawing.

You understand the way that the modelling process in a three-dimensional programme can enhance the way that archaeological reality is perceived.

Although the model of the settlement is hypothetical - working hypothesis, it provides a good sense of 3D space enhancing the flat nature of conventional archaeological records, also helping to understand how a tell would have looked like when populated.

Although the virtual reconstructions of Building 1 are to a great extent hypothetical - working hypotheses, they provide a good sense of three-dimensional space enhancing the flat nature of conventional archaeological records.

You realise that virtual reconstructions offer a means of experimentation with the data unlike any other methods or physical reconstructions.

Virtual reconstructions, either photorealistic or not, offer an augmented sense of three-dimensionality.

You see the potential of virtual reconstructions as a means to understand aspects of archaeological material, which are not comprehensible by conventional means of recording and presentation.

You see the potential of virtual reconstructions as a means to disseminate knowledge to the public.

Table 25 Chart showing students’ responses to the close-ended questions about the use of 3D visualisations as heuristic sources and scientific tools in archaeological reasoning (image author’s own).
6.2. Interpretation and Analysis of the Responses

A very common phenomenon in most projects that involve some kind of 3D visual construction is that after the delivery of this product, both the visualisation project and the whole research project end. This is because visualisations are usually the last stage of a fieldwork or project. In most cases, the modeller has rarely asked about others’ ideas or communicated his/her work while in progress; only the supervisors have access to the visualisations and therefore additional options, hypotheses and theories are not heard. Therefore, the visualisation becomes an end in itself, as well as a process abstracted from the core of the archaeological project, thus diminishing its actual value to only one of the visual outputs of the dataset. The result cannot be refined or changed, and even when additional evidence comes to light the visualisations remain intact and continue to illustrate articles in the press, funding proposals and publications. This is what I tried to avoid in this work by opening the decision-making and the modelling process to staff members as well as students, who have a certain experience and knowledge of the site.

The results of the survey clearly demonstrated that the various visualisations of the site instigated discussion among members of the project in a way that had not been possible in the past. It is probably the pace of the excavation that restricts such discussions during the field season and also the fact that stimuli were up to now quite limited. Also, since all members of the team are occupied with different work and research commitments, gathering and discussing about such matters out of the field seasons was impossible. Moreover, the fact that all records for Building 1 and the surrounding area are in Greek, makes it difficult for the English speaking members of the team to have access to this information and discuss the various issues involved. Therefore, the fact that interpretive visualisations of these recordings were produced and presented in this survey along with textual information about the process of modelling, seems to have provided the ground to initiate a discussion regarding different aspects of the site. The decision-making process and the products of this process were in most cases constructively criticised, while alternative ideas, views and solutions were often suggested.

Participants’ responses especially to the open-ended questions provided the chance to clarify the answers to the close-ended questions and identify what participants consider important in relation to the process of 3D modelling and its connections to the archaeological material from Koutroulou Magoula. The key messages, as these emerged from the examination of participants’ responses will be addressed below.
6.2.a. Enhancement of Three-dimensionality and Sense of Space

It is rather encouraging for this and any other 3D visualisation project that participants enthusiastically in most cases responded that both photorealistic and non-photorealistic images provided an augmented sense of space and three-dimensionality. In overall, students were more enthusiastic about the process and the products of 3D visualisations. Their enthusiasm for the images, and especially for the most successful photorealistic depictions can be partly explained by their resemblance to those produced for television, cinema and video games. The latter was also mentioned in one of the open-ended questions.

It is obvious that the level of agreement with these statements varied depending on the visual stimuli that participants had to comment on. Photorealistic images for example, and especially those that were making use of daylight or light from the hearth provided the greatest enhancement of sense of space and three-dimensionality. It is characteristic that one of the directors said: ‘In some of them [images], especially renderings of the interior where light varies according to the time of the day and the openings, it’s like living in there.’ This sense of being there/presence that the director and other respondents mentioned is very important for this work, as it completely transforms experiences and conventional engagements with the Neolithic. The concept of presence has been thoroughly addressed in the context of the ‘Performing Presence’ project in which researchers discussed the different ways through which presence is achieved in live and mediated performances and simulated environments (Giannachi and Kaye 2011; Giannachi et al. 2012). Especially regarding presence in computer generated digital spaces, the concept indicates that users react to sensory data from such environments as if they were real. Experiments conducted in UCL’s CAVE15 by the Virtual Environments Computer Graphics team, demonstrated that when such immersive environments trick perception regarding their resemblance to reality, then users report a greater level of presence (Slater et al. 2009). It seems though that the level of visual realism in these environments is of less significance, since humans’ perception works by finding correlations to real situations rather than visual resemblance to reality.

Going back to the results of the survey, participants praised the sense of space and three-dimensionality – though to a lesser extent – for non-photorealistic depictions as well. However, the sense of three-dimensionality in these images is by definition diminished since there is no direct reference to elements of the real world, e.g. texture, light and colour. It seems therefore that the most important aspect in these images is the three-dimensionality of the depicted forms, since they provide a completely different visual knowledge in comparison

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15 A room with screens on the walls and the floor, on which computer graphics are projected so as to immerse users into a perspective correct virtual environment.
to the flat and usually incomprehensible methods traditionally used in archaeology (see chapters 1, 2).

The fact that the computer graphic simulations produced are static, and thus do not involve any kind of movement within those spaces, is a hindrance to the augmentation of the experience and the enhancement of both sense of space and three-dimensionality. What matters most, however, is not the static nature of the digital constructions *per se*, but the fact that viewers experience space by virtually positioning themselves in the angle of the camera used for the rendering. Since the world is not an image and people experience space by moving their eyes and bodies, the static nature of those images is diminishing their experience.16

It is characteristic that half of the respondents would have preferred a more interactive way of presenting the 3D models. Particularly, one of the students argued that ‘a Google Street view of the Neolithic’ might have been more appropriate for the public. On the other hand, several participants mentioned that the static nature of digital constructions is not a problem: ‘interactive is not necessarily better’ and ‘...a more interactive way might be preferable but what we have here is not at all lacking in offering a very clear 3D sense’.

What emerges from the latter is that 3D images, even when static or missing some elements of the real world, e.g. light and texture or even humans, manage to provide a sense of realism unlike any other methods used in archaeology. On the night scenes (see 6.1.f.) a participant said: ‘these images feel more personal and I find them more engaging and interesting. I would stop and look at these images, (probably not the others so much). I like that the focus isn’t just on the structure of the building but also the lives of the inhabitants’. Participants not only supported the enhancement of their perception about the Neolithic building and its ‘life’, but they also argued that these images work as evocative media, stimulating apart from vision, the rest of the senses. This might be related to the previously discussed concept of presence; this sense of being there and consequently the evocation of senses is not probably the result of high fidelity graphics, but of triggering humans’ perceptual mechanisms to find connections with these images based on what is depicted there.

16 In archaeology, this issue of corporeal experience has been mainly introduced by phenomenologists especially in British prehistory (see for example Tilley 1994; Thomas 1993, 2001, 2006), while more synthetic approaches have been published in the last decade (see for example Hamilakis et al. 2002). Corporeal experiences cannot be considered without taking into account the rest of the senses (see for example Hamilakis 2011, 2014; also see Cytowic for synaesthesia), as well as the role of memories (see for example Hamilakis 1998; Van Dyke and Alcock 2003; Jones, A. 2007; also see discussion in 6.2.b.).
6.2.b. Evocation of Senses

Contrary to the very common criticism towards digital constructions, which suggests that the stimuli to understand the past are only visual, it is really important that the Building's photorealistic images also evoked senses (Tables 11, 12, 17, 18). In several cases, participants argued that the visualisations produced, and especially photorealistic renderings, were quite engaging as they evoked materials, texture, and colour: "strong feeling of the texture of the material", ‘the image makes you feel as if you are getting a realistic glimpse into the past', ‘senses evoked'. Although these environments are static and seemingly two-dimensional, the mechanisms of perception (see 2.1., 2.2.a.) enable an enhanced reading of the images by evoking more than one sense. That is probably the reason why the majority of the participants believe that it is not only the public but also researchers who can get an augmented sense of space unlike the methods traditionally used in archaeology.

However, by arguing about a sense of space by evocation, it is not meant that observing a photo is like being there – even though a few participants said so. The concept of evocation cannot come anywhere close to real experience, in a similar way that a real modern experience of space cannot come anywhere close to the experience of a Neolithic dwelling. Experiencing a particular space does not only depend on how senses and the human body work to adapt and integrate all the available information. It is also the mental, emotional and experiential package of a person that counts in the formation of the experience. For example, even if the perfect replica of a Neolithic settlement would have been produced, living in one of the houses would be in most cases a completely different experience for the modern human (Thomas 2004: 143, 216-217). This is because modern humans are not familiar with most of the aspects of the Neolithic life; they do not have to plan subsistence strategies, their animals are cured by veterinary doctors and their houses are built and maintained in a more mechanised and professional manner, to say a few.

To clarify the latter I will use the Eva Bosch’s blog post, which accounts her experience living for a night in the experimental Neolithic house at Çatalhöyük (http://www.evabosch.co.uk/evaboschblog/?s=sleep): ‘During the night I thought I was hearing sounds coming from underneath the floor. It had been plastered to represent the area inside the house where the dead would have been buried. It was obviously a trick of the imagination, but interesting. I woke up with the sensation of having my lungs full of plaster. This problem might have been solved by placing layers of fabric e.g. a carpet like covering, all over the floor. In this way the dust would not be inhaled during sleep'. In a personal communication, she also added: ‘During my stay, I often felt very isolated as the scientists and archaeologists were busy immersed in their own worlds, and I felt like an outsider; a bit like a Neolithic woman. I made clay statuettes, played with shadows on the walls of the experimental house very much in the same
way that the Catals would have done. I watched the sunrise and the sunset from the roof of
the unit. I listened to the birds and watched the noisy wind shaking forcibly the leaves of the
trees. I felt scared when the wild dogs of the farmer were set loose, and wondered what would
I do if they attacked me...Were my feelings any different from those of our ancestors? I dare to
say that those sensations were probably comparable to those of the Catals but time was
different'.

Bosch raises an important point in those lines: sensations were comparable but time was
different. However, the fact that her experience took place not only in a different temporal
context, but also in a different cultural context made it unique and quite different from this of
the Neolithic inhabitants. Çatalhöyük’s dwellers would have heard the rustle of the leaves,
watched the sunset and played with light, shadows and clay figurines; they might have had
very similar sound- and vision-scapes, but still, their Weltanschauung, memories and
experiences would have formed a completely different experience of this Neolithic house. For
these reasons, I argue that evocation is quite far from (a sense of) being there, and similarly,
experiencing a physically constructed environment is far from the environment that would
have been experienced by its Neolithic dwellers.

Bosch’s description above about the Neolithic house makes apparent that there is a great level
of complexity to transform this real experience into an experience of the digital world. It is
not only vision, but also the rest of the senses, as well as movement that play a major role in
the construction of this vision-, sound-, smell-, touch- and taste-scapes (Tilley 1994: 27-33,
2004; MacGregor 1999; Hamilakis 2014). Since the content of this thesis is limited to the
visual aspects of perception, it is out of the scope of this research to extensively consider a
theory of the senses. However, it is worth mentioning that because of the realisation that
digital constructions on a computer monitor (also see the problem of reproduction – 2.2.c.1.,
6.1.d., 6.1.f., table 14) or on a paper are often inadequate as a means to understand or
experience space, researchers in archaeology, computer science and human-computer
interaction have tried to find new ways to augment such experiences by incorporating stimuli
for the senses.

Before the advent and widespread use of digital technologies, and the invention of Virtual
Reality, which added another dimension to the static nature of (re)construction, one of the
first attempts to consider senses in an archaeological experience was undertaken three
decades ago by the York Archaeological Trust, at the Yorvik Viking Centre (Addyman and
Gaynor 1984). Apart from a normal exhibition, which was quite pioneering for its time, York
Archaeological Trust produced a physical (re)construction of Yorvik, a village that was
occupied by Vikings. Visitors could travel in the Viking village on a suspended six-seater, 21st
century time capsule and most importantly to hear and smell, while passing for example in
front of a fisherman’s dwelling or a blacksmith’s workshop. As far as I am concerned, this exhibition, which I visited in 2008 before the 2010 refurbishment with ‘incredibly lifelike characters’ and ‘state of the art animatronics’ (http://jorvik-viking-centre.co.uk/about-jorvik/jorvik-in-2010/), neither made me travel back in time, nor offered a multisensory experience. The constructions, especially of humans were quite controversial, while smells and sounds did not arouse any memories or feelings at all. Especially the failure of smells to trigger off powerful memories (Beer 2007) rendered this experience problematic. However, it is not only the problematic simulation of smells and sounds that made it partially unsuccessful; it is the fact that the experience of this space did not involve real movement. Visitors had to travel on a predefined track, and therefore get a sense of this ‘village’ by moving, while seated, and from particular – sometimes unnatural – viewpoints.

Several attempts have been made to mimic the real world by producing wearable devices. These were limited to the simulation of sight and sound, and also touch by the use of specially designed gloves. However, cost, weight and lack of realistic sense stimulation have all been limiting factors. Similarly, immersive virtual reality environments, known as CAVE systems (see for example Cruz-Neira et al. 1992; DeFanti et al. 2009) have attempted to combine 3D graphics and 3D sound, also allowing users to move within these environments. The latter is a significant improvement, since the position of the user is captured in real time and therefore the stimuli are adjusted accordingly. However, movement is limited in a relatively confined space, while the stimuli are only visual and acoustic. In some cases however, these systems have been enhanced to incorporate haptic feedback as well.

In 2009, five UK universities, and especially scientists from York and Warwick universities introduced the concept of the Virtual Cocoon (Chalmers and Zányi 2009). The technology, funded by the Engineering and Physical Sciences Research Council (EPSRC), was described as a step change in virtual reality. Virtual cocoon, a quite big helmet, promised to be a device that will incorporate all five senses in a way that the virtual environment will be indistinguishable from real life, unlike anything previously available. As a device, it seems interesting. Smell would be simulated by a tube running beneath the wearer’s nose, much like a hospital oxygen feed, that would deliver puffs of chemicals to mimic scents. It would also emulate taste with the help of an in-mouth device that could also simulate textures. Heat and humidity inside the helmet would be controlled by a fan and heater system, while surround sound and systems akin to haptic-feedback devices would have existed. This description sounds as an Intensive Care Unit rather than the simulation of real life. This device which promised the simulation of real world modalities in a virtual environment failed to continue its journey until completion. Probably, the reason is that the following questions could not be answered: Is a multisensory experience limited to our head? Could we simulate real life by using prosthetics, such as a
tube in our nose? What about other parts of our body that would have normally participated in a real environment? And finally, how is it possible to experience space without movement?

Finally, there is a technology that although it has some inherent problems, users have the chance to experience the real world with the addition of computer-generated elements. In other words, the physical environment is not replaced by digital content, as is the case in Virtual Reality, but on top of the real world, digital information is added. This is called Augmented Reality (AR). AR is primarily visual, while the term can be also applied to acoustic and haptic augmentations. About a decade ago, the Ename Visitor Centre in Belgium (Callebaut 2002) implemented a projection technology to superimpose computer-generated content over the archaeological site, while at the same time, Archeoguide produced a head-mounted AR display with an outdoor tracking technology for Ancient Olympia in Greece (Vlahakis 2001). The first attempts for mobile AR popularised the technology, which was gradually incorporated in mobile phones and tablet PCs. The application of AR outdoors in mobile devices is at the moment quite problematic, since wireless network coverage is required, while devices’ monitors are not suitable for viewing under extreme weather conditions or strong daylight. In addition, software and hardware limitations, such as processing power limits the capabilities of the technology, whose wide adoption will delay for several more years according to the latest Gartner’s hype cycle of emerging technologies (Gartner 2012). However, experiencing the real world by looking at the screen of a device is still problematic (Jones 2011). This is an issue that the Google Glass Project (http://www.google.com/glass/start/) is trying to solve by launching a pair of glasses that will facilitate the process of projecting digital content onto the real world without the interference of a device that would interrupt the process of experiencing the world directly through our vision. The next step would be to replace glasses with contact lenses (Parviz 2009), therefore experiencing the augmented world through our own eyes.

Contrary to Virtual Reality technologies which attempt to reproduce the real world by causing or evoking senses in an artificial environment, AR technologies have the potential to dominate the archaeology, mainly because they mix the real and the virtual, enabling the users to follow a more natural process of experiencing the world. This discussion was initiated by participants in the survey, who argued that more interactive engagements with the past would be preferable. From their responses and our off-line discussions it became obvious that most of them have in mind animations and virtual reality environments. However, as explicitly stated, the problem with these is that users experience the past in an artificial manner, without involving kinaesthesia, and often replicating the senses by using prosthetics (Chrysanthi et al. 2012). AR technologies can significantly improve the experience of space and possibly are the step forward for an improved understanding of the past.
An AR application would have definitely benefited our case study by adding movement and the real environment in space perception. However, several participants suggested that the images produced, although static and primarily visual, are not lacking the evocation of the senses. It is also important that participants’ responses showed that it is not only photorealistic, but also non-photorealistic images that can efficiently evoke the senses. However, the majority considered photorealistic images more appropriate means for this.

6.2.c. Photorealistic and Non-photorealistic Renderings

Students and members of staff gave similar responses to the close-ended questions about photorealistic and non-photorealistic images. However, students’ responses to the open-ended questions raised a few points that perfectly illustrated the tendencies towards the positive and the negative ends of the spectrum. For example, one of them argued that ‘Non-photorealistic pictures seem to be a good way of illustrating hypothesis without imposing a particular view since, unlike pictures, we know that drawings might not be entirely true’. This is an interesting point which is in contrast to staff’s argument who argued about the trustworthiness of the drawings.

Participants are thinking highly of drawing as a practice in archaeological research and fieldwork, proving to some extent the ‘fetishism’ discussed in chapter 1 (see 1.4.c.1.). Although, there is no substantial difference between the photorealistic and the non-photorealistic images – apart from the style of rendering, it seems that the resemblance of non-photorealistic 3D models to archaeological drawings brings to the forefront a pseudo-objectivity that turns hypothetical 3D visualisations into authoritative representations of the past. Especially members of staff not only replied that NPR models seem more trustworthy since they resemble drawings (table 1), but they also referred to them as ‘drawings’ (tables 6-8). It is worth mentioning however, that contrary to staff’s responses, students’ answers were quite dispersed towards both the positive and negative ends of the spectrum with a slight tendency to disagree with the statement. The reason for that is probably their short experience in archaeological fieldwork and their unfamiliarity with conventional practices.

Also, students were trained at the University of Southampton, which emphasises a holistic preparation for fieldwork with a great emphasis on the use of technologies for recording archaeological information, therefore considering drawing only as one of the tools – probably rusty – in archaeologists’ toolbox.

Regarding NPR images, there was a thought-provoking response arguing that ‘they look amateurish and not engaging at all’. The argument that they are not engaging is among others, a matter of personal taste and perception. However, the fact that images were described as amateurish is worth examining further. It is true that NPR images bear some
ambiguity. It is probably the plain colours and their resemblance to drawings that make them feel like hand-drawn illustrations produced for children’s books. Although it is not clear what made the student refer to the images as amateurish it could be worth knowing if the word also refers to an amateur 3D modeller or an amateur archaeologist. In the first case, the response would be reasonable, since 3D modelling is closely linked to ultra-photorealistic visual products usually seen in films, television and video games. Therefore, a product that is not in agreement with the idea of realism would have definitely looked amateurish. However, if the word implies an amateur archaeologist, in terms of not knowing, and consequently not depicting the truth because of the simplicity and/or inherent ambiguity of NPR images, further discussion is required. This might probably derive from the notion that archaeologists are the authoritative agents of the past (see 5.2.b.1.), who should know all its facets and present an unambiguous image of it to the public.
6.2.e. The Sense of Time

Respondents were very enthusiastic about the simulation of different times of the day and the feeling of time passing achieved by both the ‘sun clock’ (see 5.3.c.) and the night scenes (see 6.1.f.). The so-called ‘sun clock’ is a pattern of light produced by a sun beam entering through the roof and moving from the west to the east wall of the building during the day. This simulation, however, only assumed a sunny day without any variations based on season and/or weather. This limitation was also mentioned by several respondents, who suggested that this experimentation and the consequent interpretations could benefit from further simulations of light and time (see Appendix II – 1.4).

Participants’ engagement with the issue of time through the digital constructions is vital. One of the reasons why 3D visualisations are primarily seen as problematic depictions of the past is because they are usually a-temporal, failing to depict time, and, consequently, to take into account that different times of the day and days of the year would have played a crucial role in everyday practices. In the same context, it is often neglected that most activities, such as building a house or a monument would have had a certain duration, taking months or even years to be completed; during that period of time, the levels of daylight and/or weather conditions would have also influenced the pace and progress of the work. Such aspects of the archaeological record also emerged from the digital simulation of light in different times of the day, since several respondents commented on the lack of seasonal and weather variations of light and the potential enhancement of space interpretations based on these.

Time is a fundamental component in the understanding of an archaeological site. The natural law of superposition indicates a temporal sequence, whereas the various finds suggest relative chronologies. In several cases, multi-temporalities (evidence from different periods found at the same stratum and/or scattered at the whole site) are also evident but duration is missing. For example, we are in most cases unable to identify and record the amount of time that a deposit took to be formed; was the fill deposited at once, over a short period of time or over a longer period? (see Lucas 2005: 38-43). On the other hand, indications of time are given by the temporality of activities. For example, depending on weather and geographic location, it is known that the production cycle for winter wheat starts in September with ploughing until August, when wheat is harvested. Given that wheat has been identified at Koutroulou Magoula, the temporality of this activity provides indications about the occupation of the site and the times of the year that inhabitants were performing particular activities, which could also have a ceremonial dimension. However, what is more crucial and relatively absent is time in relation to the examination of everyday practices, ideologies and rituals.
The archaeological evidence, and especially this of prehistory where no written records existed, cannot provide strong indications about rituals, ideologies and everyday practices in relation to time (ibid.: 67-77). This of course comes into sharp contrast with anthropological research, since the concept of time can be more easily examined in living cultures (Gell 1992). However, it is vital in our study of the past to investigate facets that could potentially spark discussion regarding these matters. For this reason, a simulation of time, mainly by means of illumination could initiate discussion about both everyday activities and rituals. In this context, staff’s response that the ‘sun clock’ enhanced the perception of time in the Neolithic dwelling proves that digital constructions can significantly contribute to this matter, since they can potentially give birth to theories and ideas about activities, different uses of space and the role of light in different aspects of daily routine. For example, in the computer graphic simulation of Phourni, a Minoan Bronze Age cemetery (Papadopoulos 2010), a simulation of light has suggested that ‘times of the dead’ might have existed, when a ray of light was directly striking the interior of the tholos tombs and the living were visiting the burial buildings to perform various rituals. Although definitive answers were not provided, this research revived the interest of the academic community regarding the relationship that the relatives of the deceased might have had with their ancestors, as well as the role of light in the symbolic consumption of the dead bodies.

In such a way physically real digital constructions become instruments of interpretation which not only can provide quantitative data about the illumination of particular structural models in different times of the year and under diverse weather conditions (see 6.3.b.), but they can also enhance understandings by exploring facets of everyday life that usually remain underexplored.
6.3. Refining the 3D Models/The 2nd Survey

The experimental nature of digital constructions is a crucial component that makes imperative the inclusion of such an instrument in the archaeologist’s toolbox. Given that vision, although the least reliable, is actually the most powerful of the senses, it is important that such tools provide direct visual outputs of thoughts and ideas, regardless of their credibility. A participant’s response in a private communication regarding this matter perfectly illustrates the latter: ‘A photorealistic depiction can develop to something really trustworthy and productive in a bidirectional process: I construct my ideas, I see that they do not work, I try something different, I ask for the help and ideas of specialists and non-experts, I try again, until I will reach a result that seems in the common sense or in a spontaneous thought as the most probable’. This bidirectional process was fundamental in the process of reconstructing Building 1. The visual stimuli, the responses, the agreements and disagreements as well as the constructive criticisms have given birth to a series of new interpretations. Most of all, they have stimulated discussion among the members of the team for the first time in the history of the project. Although there were a few cases where comments were limited to the fact that models could be different (e.g. ‘assumptions like the opening in the roof are not always correct’; ‘each building could be more complex’; ‘3D reconstructions can often mislead and frame a picture in the observers mind, especially considering that many are based on hypothetical renderings of scant evidence’) and some participants were hesitant to suggest alternative hypotheses, team members were in most cases keen on discussing new ideas and tentative constructions.

To be more specific, one of the critiques for the models was that all of them present an ordered arrangement of contents, indicating that the settlement is uninhabited or not disturbed by human occupation. Participants also argued that this sense of emptiness is enhanced by the absence of people, who could also be used as a scale. Also, some of the respondents would like to see some reuse of space rather than abandoned structures. Regarding alternative ideas, it was suggested to model a window at the east side of Building 1, based on the evidence from the unearthed house model which depicts more than one opening (fig. 81), which would have enabled dwellers to have visual contact and control over other areas of the settlement and/or the animals. Also, it was proposed to render the scenes in different lighting conditions (e.g. cloudy day) and in different months of the year to see differences in light all year round. Similarly, they would like to see how flames and smoke from the hearth would have changed the perception of the interior. Besides, ideas such as the stabling of animals in the interior, internal partitions, or the roof without an opening for the smoke of the hearth in case it was thatched were also suggested. As well, staff members would like to see visual representations regarding the means through which any openings were closed (e.g. animals’ skins, thatches etc.).
Based on these comments, existing models were refined and new alternative structural and lighting models were constructed. Staff members and students were again asked to evaluate the models produced in an online survey ([http://kwiksveys.com/s.asp?sid=xc0bkj6llbqq7rr123457](http://kwiksveys.com/s.asp?sid=xc0bkj6llbqq7rr123457)). Questions were mainly comparing those with the previous models especially regarding the extent to which senses of space and three-dimensionality were enhanced. The survey was divided in 5 thematic sections: alternative structural models; lighting simulation/analysis; experimentation; humans; and, the settlement. Initially, participants were presented with a brief account of the results of the previous survey. In each thematic section, there was a reference to the comments in the previous survey on which the refined models were based. This time 17 people responded to the survey, 3 of whom were students. Since less people responded, while not many enlightening responses were left to the open-ended questions, it was more difficult to clarify participants’ responses to the close-ended questions and extract clear patterns. Therefore, only the key messages as these emerged from the close-ended questions will be presented in this section (for details see the Appendix II) along with a few brief remarks on some particular responses.
6.3.a. Alternative Structural Models

Different structural models were produced, which present Building 1 with the effects of fire and smoke, as well as 1) an opening/window in the east wall (table 26, fig. 129); 2) animals in the interior and internal partitions (table 27, fig. 130); 3) various means to cover the doorway and the window (table 28, fig. 131). The same set of questions were asked for all different structural models (Appendix II - 2.1.).

Close-ended questions

- It is Important to consider alternative interpretations.
- Good combination of different elements in the scene.
- All images provide a greater sense of space in comparison to those of the previous survey.

Comments

1. As a participant mentioned, the augmented sense of space may be the result of the improved sense of reality in comparison to the previous rendered models. This comment follows the conclusion in the first section of the previous chapter (see 5.2.b.3.), which showed that the closer to reality a model is, the greater the sense of space and three-dimensionality are. On the other hand, this comes to contrast the findings from the research in virtual environments (see 6.2.a.), which suggested that presence is enhanced not because of the resemblance to reality but because of people’s perceptual system that identifies common frames of reference between the virtual environment and the real world.

2. One of the participants was highly critical about the use of the house model as a source of information for the window by saying that ‘few Neolithic house models have no roof; should we then take for granted that Neolithic houses had no roofs as well?’. This response however, is indicative of the erroneous way that digital constructions are usually seen; not as processes which stimulate discussion, but as products which aim to provide definitive answers. I do not intent to analyse this response further, since this thesis vividly showed that computer graphic simulations are processes which help archaeological reasoning and enhance understandings.
Fig. 129 Hypothetical window in the east wall with a view to the surrounding landscape. The window is covered with animal skins, while next to the tree trunk there is the house model found in the structure. Flame and smoke create a dim atmosphere within the house (image author’s own).

Fig. 130 Alternative structural model in which some animals have been placed in the interior, while an internal partition has been added. Also, animal skins were placed at the doorway to control sunlight (image author’s own).
Fig. 131 Two structural models of the interior of Building 1. A. Animal skins covering both the doorway and the window; B. Thatch covering the doorway, used to control the impact of the sun and/or to maximise the privacy of space (images author’s own).
Table 26 Chart showing participants’ responses to the close-ended questions about the alternative structural model with a window in the east wall (image author’s own).

Table 27 Chart showing participants’ responses to the close-ended questions about the alternative structural model with animals and internal partitions, as well as skins at the doorway controlling light in the interior (image author’s own).
Table 28 Chart showing participants’ responses to the close-ended questions about the alternative structural models with the window and doorway covered with animal skins and thatch (image author’s own).
6.3.b. Lighting Simulation/Analysis

Apart from the structural models, new lighting models were produced based on participants’ comments regarding the lighting conditions in different times of the year and under various weather conditions (table 29, Appendix II - 2.2.). Therefore, light was simulated during the Spring and Autumn equinoxes, and Winter and Summer Solstices (fig. 132). Also, the illumination in the interior of Building 1 was simulated with a low, medium and high overcast, as well as a high level of haze (fig. 133, 134). Lastly, lighting analyses were performed for all the aforementioned conditions, while light was measured for the doorway and the roof opening covered, partially or fully, with animal skins (fig. 135). The results of the simulation showed that different weather conditions significantly affect illuminance values in the interior of the Building. For example, haze in the atmosphere can affect lighting values by 100 lux, while in a day with high overcast, light from the hearth would have been needed. Regarding the skins covering the door, it became clear that different means of blocking light could result in an environment suitable for different activities during the course of the day.

Close-ended questions

- It is important to consider alternative interpretations.
- Digital constructions provide opportunities of experimentation unlike any other methods used in archaeology.
- Images and the underlying concepts stimulate discussion about the impact of daylight in the interior and its role in the life of Neolithic people.
Fig. 132 The interior of Building 1 during the year. A. 20th March 12pm (Spring Equinox); B. 21st June 12pm (Summer Solstice); C. 22nd September 12pm (Autumn Equinox); D. 21st December 12pm (Winter Solstice) (images author’s own).
Fig. 133 The interior of Building 1 in a cloudy day. A. Low overcast; B. medium overcast; C. high overcast (images author’s own).
Fig. 134 Lighting analysis of the interior on 20th March 3pm. Pseudo-colour exposure control. Left: Haze 0%; Right: Haze 15% (maximum) (images author’s own).

Fig. 135 Lighting analysis of the interior on 20th March 6pm with the roof and the window closed/covered. Light metres. A. No animal skins at the doorway; B. Half of the doorway covered with animal skins; C. The whole doorway covered with animal skins (images author’s own).
Table 29 Chart showing participants’ responses to the close-ended questions about the lighting analysis and simulation in the interior of Building 1 (image author’s own).
6.3.c. Experimentations

In the previous survey the experimentation was mainly regarding the red painted patterns on the walls. This time, given the fact that the light from the hearth creates an interplay between lighter and darker areas, as well as a show of shadows, some of the figurines found on-site were used to create a shadow puppetry (table 30, Appendix II –2.3., fig. 136; also see Bosch forthcoming).

Close-ended questions
- Experimentations can initiate discussion and enhance the interpretations about Neolithic space.
- Experimentations can offer new or help researchers visualise existing interpretations.
- Such experimentations are not possible by any other means traditionally used in archaeology.
- It is important to consider light, darkness and shadows in archaeological reasoning.
Fig. 136 Experimentation with light and shadows. Both images depict a different arrangement of shadows created by four figurines unearthed from the site. Shadows from humans and objects could be used as a shadow puppetry (images author’s own).
**Table 30** Chart showing participants’ responses to the close-ended questions about the experimentations with light and shadows in the interior of Building 1 (image author’s own).
6.3.d. Humans

One of the major critiques was the absence of human models in the various scenes. Although it was initially decided not to incorporate humans, a few human figures were added, however attempting to avoid any direct reference to relationships or tasks (fig. 137, 138). The reason for incorporating these was to examine the visual impact of the presence of human figures, who were the main users of this space, and canvassing participants’ responses regarding the augmentation of this environment (table 31, Appendix II – 2.4.).

Close-ended questions
• Humans in digital constructions enhance the comprehension of reality, also augmenting the sense of space and scale.

Comments

In the summary section, participants were presented with 3 images and were asked to choose the most representative for Building 1 (fig. 139). It is interesting that the image chosen by most participants is not the one that depicts the human figures, contrary to their responses in the previous survey which highlighted that the major drawback of these visualisations was the absence of humans, thus diminishing the sense of space, scale and three-dimensionality. However, this choice is understandable, since the depiction of humans in 3D graphics is usually uncanny. The concept of the ‘uncanny valley’ has been firstly noted in robotics (Mori 1970) and was given further consideration in the field of computer graphics. In robotics, the term ‘valley’ was referring to the graph which indicated that when human replicas look like human beings, their imperfections can be easily spotted by the observers, causing a negative emotional response (fig. 140). This means that a humanoid robot which will not manage to persuade for its humanness will produce an uncanny feeling, failing to achieve the required human – robot interaction. In 3D graphics the concept is similar and was brought to the forefront by the movement of photorealism. In the realm of archaeological computer graphic visualisations, the uncanny valley has been rarely overcome, and digital constructions, even the most photorealistic, are usually depicted without any human figures to avoid observers’ negative responses. However, in computer animated imagery, and especially in the film industry, the solution to avoid the ‘uncanny valley’ has been found either by producing cartoon-like figures or implementing innovative motion-capture technologies with live actors to achieve ultra-photorealistic computer graphics characters (e.g. James Cameron’s Avatar).
Fig. 137 Human figures in the interior of Building 1. View from southwest (image author’s own).

Fig. 138 Human figures in the interior of Building 1. View from North (image author’s own).
Table 31 Chart showing participants’ responses to the close-ended questions about the incorporation of human figures in the interior of Building 1 (image author’s own).
Which of the reconstructions below you find more representative of Building 1?

33%

47%

13%

7%

None of the above

Fig. 139 Participants’ responses about the most representative image for Building 1 (image author’s own).
Fig. 140 The uncanny valley – simplified graph from Mori’s paper (Mori 1970).
6.3.e. The Settlement

Regarding the settlement, the main critique was the absence of humans too. There were also some comments about the aesthetics/style of the models, e.g. the grey colour of the sky, while there were a few additional comments about some structural models, such as the fact that no great variation is presented for the roofs of the structures, and that the abandoned structure could be reused as an animal pen. The latter is a well-known practice for abandoned structures, which are converted to animal shelters before their permanent abandonment (see for example Pluciennik et al. 2004). Therefore, new structural models were produced which fulfil to a certain extent participants' suggestions (fig. 141, 142, table 32, Appendix II – 2.5.).

Close-ended questions

- Humans enhance the sense of space and scale.
- It is important to have some variation in digital constructions so as to resemble real situations.
- In some cases a greater level of realism might be preferable.
Fig. 141 General views of the reconstructed settlement. Greater variation has been added to houses’ roofs, the colour of the sky has changed, while human figures performing various activities have been incorporated (images author’s own).
Fig. 142 Close-up views of the reconstructed settlement. At the forefront, the abandoned structure has been turned into an animal pen before its final abandonment (images author’s own).
Table 32 Chart showing participants’ responses to the close-ended questions about the reconstructed settlement (image author’s own).
6.3.f. Summary

In the last section of this survey (table 33, Appendix II – 2.6.), participants were asked more general questions about the role of three-dimensional visualisations in archaeological research and more specifically about their contribution to Koutroulou Magoula’s dataset.

Close-ended questions

- The process of three-dimensional visualisation is ongoing. All people involved should provide their feedback and discuss their concerns and ideas.
- The perception of three-dimensionality and space has been significantly enhanced for Koutroulou Magoula.
- 3D visualisations have given birth to new ideas and interpretations about particular aspects of the dataset.
- 3D visualisations in this survey were more successful in providing a sense of space.

Comments

The last statement about the success of these images in providing a better sense of space in comparison to these of the previous survey demonstrates that the process of presenting an intermediate model in order to be amended based on colleagues’ comments, worked well as a way of augmenting knowledge production. The initial visual interpretations and hypotheses were augmented by staff and student members’ comments, and then, their feedback was utilised in order to amend my own understandings and based on these to construct new 3D models. As a consequence, through a multivocal and reflexive process, the original perceptions of space and three-dimensionality were improved and additional, more complete and well-informed knowledge was produced.
Summary

The virtual reconstructions presented in both surveys have given rise to new ideas and interpretations about particular aspects of this dataset.

The images presented in both surveys have enhanced your perception of three-dimensionality and space for this particular dataset.

You agree that virtual reconstructions provide endless ways of experimentation unlike any other means traditionally used in archaeology.

You agree that the process of three-dimensional visualisation is ongoing and can be fruitfully applied in a research project only when all people involved in the project provide their feedback and discuss their...

The images of the interior of Building 1 presented in this survey give a better sense of space in comparison to those of the previous survey.

Table 33 Chart showing responses to the close-ended questions about the use of 3D visualisations as heuristic sources and scientific tools in archaeological reasoning (image author’s own).
6.4. Reflecting on my Understandings of the Modelling Process and its Products

Aristotle (384 – 322 BCE), in the *Nichomachean Ethics* (II, 1, 1103 a 33) wrote that ‘for the things we have to learn before we can do them, we learn by doing them’. The process of reconstructing Building 1 can be certainly characterised as a creative process, which not only enhanced aspects of the material for the people involved in the project, but also provided to me the chance to learn by doing, get an improved understanding of the evidence and experiment with different hypotheses.

Although I have not been involved in any large scale physical (re)construction project (see 3.4., 3.5.a.), I could certainly argue that the process of reconstructing the building in the way I did, is an alternative approach to experimental archaeology. Without a doubt, being in front of a computer screen significantly limits the sense of place and the multisensory engagement with the environment in comparison to being in the field. No physical labour is involved, the senses are diminished and the various decisions are not in principle dictated by physics and materials’ properties. In the case of experimental (re)constructions however no alternative hypotheses can be tested since the high cost involved, the building skills required and the human labour needed only allow a single output, which is often seen as the definitive answer to the research questions.

The 3D modelling of Building 1, although it did not involve tools and processes similar to those that Neolithic builders might have used, included computational approaches and digital tools which facilitated the formation of objects, colours and textures to come closer to those experienced in the Neolithic. The fact that thousands of individual stones and mud bricks were constructed, even these that are not visible in renderings, and then, following the principles observed in Building 1 were positioned to form the structure, provided a completely new understanding of the process of constructing such buildings. Although I doubt that the process of positioning every individual object made me get even the slightest sense of what a Neolithic builder or an experimental archaeologist could get (see 6.2.b.), it completely changed my way of studying such datasets.

In order to accomplish this construction a series of purely computational methods were applied; however, the questions raised during the process were primarily related to the archaeology of the building, the available evidence, the people that once dwelled there, their material culture and their interaction with space. The level of detail incorporated in different aspects and stages of modelling and rendering also promoted different levels of understanding ranging from the ways that such structures were roofed to the sense of living in a relatively confined space. Even though the initial 3D models of the building were rather
empty, due to the lack of humans, by incorporating everyday objects and simulating the interplay of light and shadows, they provided an evocation of human presence, allowing the three-dimensional appreciation of the structure and enabling a more complete idea for the interior space of such environments.

The original models were refined based on colleagues’ and students’ demand for realism. The impact that realism has in the perception of an environment became clear both in the theory of perception (see chapter 2), as well as in the first part of the previous chapter, where the various experimental structures for the wall in Trench Z1 showed that the model which resembled more the irregularity of a wall was much more comprehensible than the rest. It is worth however mentioning that between colleagues in the project and myself, there is a completely different understanding of realism. As far as I am concerned, the level of realism in the digital constructions was significantly enhanced because of the whole process of studying, recording and modelling the material, as well as experiencing the actual structures in the last three field seasons. In other words, images’ realism was adequate for me since it was augmented by my own package gained during the process of reconstruction. On the other hand, colleagues’ sense of realism was based on the visual products and the accompanying descriptions, without having access to the diverse range of knowledge gained during the process.

The experience of the actual site is definitely a determinative factor for an augmented perception. Most of the respondents have visited the site, while the majority have worked at the new trenches (2009-2012), which however do not have direct visual contact with Building 1. Probably this is also reflected in their responses, since people who had worked in the excavation of Building 1 and/or had constant presence on site, were much more enthusiastic about the results, without mentioning the issue of realism (or the lack thereof). Therefore, although most of them had some on-site experience, their demand for realism could have derived to an extent from the inadequacy of the visual products in conjunction with their limited existing package regarding (that particular) Neolithic space.

In addition, it is not only realism that is different between myself and the team members. As Bergson aptly argues (1911: 24) ‘There is no perception which is not full of memories’. In this context it means that each individual perceives in a completely different way the digital constructions, since their perception is filtered from their own package of experiences and memories. For example, inhabitants from Neo Monastiri would have responded differently to the stimuli provided by the 3D images. This is because the houses in the old part of the village were constructed with techniques and materials similar to these used in Koutrouloou Magoula. These people might have memories from these structures or might have lived in one
of these buildings. Therefore their response would be completely different in comparison to somebody who does not have any similar memories.

Since part of this modelling was completed prior to the final field season in 2012, my experience of the actual structure on-site was far more enhanced in comparison to previous years. It seems that my understanding and experience of space were informed by the modelling process, and that the modelling process was informed by my understandings moulded by spending several hours to clean, draw and photograph Building 1 in the last three years. My perception of the site in the 2012 field season was not related to its archaeology, but primarily to a sense of living in this space. The remains of the hearth were seen as an actual hearth providing light and warmth to the dwellers; the remains of the walls were seen at their original height supporting the gabled roof that was once protecting the people from adverse weather conditions. The sound of the rain on the steel sheet that covers the building made me travel back in time and imagine the rain that was once falling on the thatched roof. The area outside the building was not anymore seen as the baulk of the excavation that preserves the stratigraphy of successive layers of habitation, but as the area used for keeping domestic animals and cultivating crops. Similarly the sounds of the excavation were not heard as the aggressive noises of a transformative process, but resembled the Neolithic soundtrack that was once heard at the village.

Both the visual products as well as the process of constructing them stirred my imagination and enhanced my understandings. What I was able to see on-site, was not an augmented reality by mentally projecting the digital constructions to the Neolithic remains; it was my own perception about this particular structure, formed by the digital constructions and the process of constructing them. Unless the readers of this thesis have been involved in similar processes of experience and reconstruction, they will not get similar feelings. By observing the neat and finished models and reading my reflexion on the process, they will not get anywhere near my understandings of that particular space. Equally, my own understandings cannot be compared to these provoked by a physical construction and a re-enacted use of space.

Thinking about the impact that the reconstruction work had on me, I had to consider if this praised enhancement of understandings did not primarily derive from the 3D models and the process of constructing them, but from my experiences on-site. This experience is part of the process as well; however, is it the determinative factor in the augmentation of space? Although it is not feasible to draw apart the degree to which each of my different involvements with the site influenced my understandings and the overall production of knowledge, it is believed that it was the process of modelling that determined my perception of the site and its archaeology. This is primarily because the modelling process is quite diverse, involving different levels of understanding, communication and participatory learning,
decision-making, testing and refining, which altogether augment the overall idea about the site and its three-dimensional properties. In addition, contrary to physical constructions, which often provide definitive answers and conclusions, the process of digital reconstruction enabled the construction of a conceptual framework that worked as the starting point for the investigation of an infinite number of ideas, hypotheses and research questions.
Conclusion

Numerous examples and the related literature on archaeological visualisation have shown that it is not only the public that could benefit from the visualisation of archaeological material, but also archaeologists themselves, since it significantly enhances the comprehension of archaeologies which would otherwise remain imperceptible. It is to be hoped that this and the previous chapter made clear that it is not only the final product of the visualisation process which is of great significance in knowledge production, but also the whole process of digital reconstruction. As Gooding (1990) argues, the fact that leading scientists in the field of electromagnetism produced new data in various forms, not only provided new ideas to talk about this phenomenon, but also gave birth to a series of novel theories and methods which replaced traditional means of practicing, experimenting and theorising the field. This argument is very close to what the multi-dimensional process of reconstruction attempts to do; it provides the infrastructure to develop alternative ways of thinking and understanding spatial relationships, while it enables the refinement of methods and interpretive approaches.

This process and the products of the process were used both to reflect on their influence on my spatial understandings, and also to assess the impact that the whole approach has on the directors of the project and the members of the team. Concerning the former, it was realised that the process of modelling in conjunction with my presence at the excavation for three consecutive years enabled an entirely enriched understanding of the data. Up to the point of 3D visualisation, the material was not completely comprehended, even though I had thoroughly studied all the available recordings and I had discussed my concerns with the people involved in the building’s excavation and recording. This enhanced understanding is to a great extent the result of the visual stimuli, as vision is a powerful sense that shapes our understanding of the material world. However, the information and the processes that lead to the 3D visualisations should not be underestimated, since they structure in a subconscious but coherent way the formation of our knowledge about the subject-matter. Although the elements which led to the augmentation of the material cannot be quantified, it could be argued that all different components of this process provided the means to decipher and consequently improve the sense of space and three-dimensionality delivered by the records.

Regarding the impact of the modelling process and the products upon the members of the team, two online surveys were implemented and the responses were presented and evaluated. In the first survey, the various structural and lighting models were the result of my own understandings of the dataset derived from field notes, photographs, drawings, archaeological and ethnographic comparators as well as my participation in the excavation and the discussions with staff and students. The vast majority of the respondents identified the merit of producing 3D visualisations during a field project, realising that such attempts
provide endless opportunities to test hypotheses and experiment with new ideas unlike any other methods or techniques. On the other hand, there were more sceptical responses by people who have never used in their work 3D visualisation tools and/or do not have a clear idea about the way that such tools work. However, they agreed with the fact that 3D visualisations, especially the three-dimensional images produced for Building 1 and the settlement, have enhanced the flat nature of the conventional archaeological records, simultaneously augmenting the way that archaeological reality is perceived.

Based on participants’ comments and suggestions, as well as the discussions that were initiated, these models were refined and additional structural and lighting models were produced. The second online questionnaire was even more revealing regarding the role of 3D visualisations in research projects, since all participants agreed that the process of three-dimensional visualisation never ends, and can be fruitfully applied in a research project only when all people involved provide their feedback and discuss their concerns and ideas. In such a way, both the process and the products of 3D visualisation become reflexive and multivocal, augmenting the understandings of abstract evidence and enhancing the sense of space and three-dimensionality of Neolithic domestic environments.

Apart from the general statements about the role of three-dimensional visualisations in archaeological research, the most encouraging aspect of both surveys was that the vast majority of the participants highlighted that the images produced for Building 1 and the settlement have enhanced their perception of the site and have given birth to new ideas and interpretations about particular aspects of this dataset. This was also mentioned by both directors of the project, who agreed that such work should be part of any archaeological research project, and be undertaken during the field season or shortly after, since the three-dimensionality of the visualisations also affect how the site will be perceived and excavated.

If computer-based visualisations continue to be merely seen as products, then the whole attempt to incorporate these in the archaeological process will remain a utopia. The sense of authenticity that these images carry has been long debated in the related literature and alternative ways of approaching this by downgrading, blurring and colouring visualisations have been proposed. What is suggested here is to move a step further from this sterile criticism – not because we neglect the powerful visual impact they have – but because we have come to realise that different levels of ambiguity are inherent in the nature of archaeology and our work, and consequently in the images produced. This means that since there is no way to avoid the nature of these images, the stimuli that 3D visualisations provide should be used by thoroughly evaluating and critically approaching hypotheses and results. In addition to these, a discussion that reflects on the modelling choices, the modeller and the consumption of the process and the products by the various interest groups is deemed necessary in order to fully
appreciate the role of such tools and processes in the production of knowledge in archaeology. In such a way, a visualisation project gains transparency not only regarding the interpretation of archaeology, the ways that available technologies have been implemented and the means through which technological constraints have been overcome, but also concerning the impact that the whole process has on the production and/or refinement of three-dimensional understandings.
Conclusions

Three-dimensional visualisations are one more layer in the palimpsest of archaeologists’ cultural production which is gradually built during the various stages involved in their work, e.g. excavation, recording, study, publication etc. In all these very different stages, knowledge is produced both by the processes themselves and the context of these processes, i.e. the people involved, the conditions under which these processes take place, as well as other factors which act independently of the other two. These variables however, which lead to the production of knowledge in the form of an image have remained under-explored. This thesis has added a piece in the puzzle of knowledge production in the process of digital reconstruction by evaluating strategies and factors that influence perception, depiction, capture and reproduction of real and digitally simulated three-dimensional information. Moreover, it evaluated to what extent such processes can augment the already known and produce new understandings about Greek Neolithic space not only for the modellers but also for the people actively involved in knowledge-making. Finally, it highlighted and also demonstrated through examples the power of this approach as an inseparable element of any fieldwork project, as well as its transformative impact on archaeological sense-making.

Knowledge Production in the Archaeological Process: A Dialectic of Gain and Loss

Regardless of the nature of our intervention in archaeological knowledge-making and the character of excavation as a materialising, transformative or destructive process within situated practices, the archaeological process is a dialectic of gain and loss. Certain qualities of the past, such as materiality, locality and continuity are lost, but simultaneously mobility and standardisation are gained. As thoroughly addressed in the first chapter, in order to minimise the inevitable losses that archaeological practice brings, several methods have been invented so as to enhance understanding, interpretation and preservation of the past, and also infuse a sense of objectivity through the relationship to scientific vocabulary and modes of working. Different ‘languages’, i.e. grammars of documentation, standard terminologies and styles of writing, capturing and depicting the information, have been designed or adapted from other fields. These allow to document and consequently preserve material remains and produce a dataset that facilitates the publication and presentation of this information to the academic community and the public.

The various mechanisms used in the process of translating the past into present and future, seemingly allow the reconstitution of the excavated world at a later date. However, such processes are by definition reductive. An object of the real-world which has certain properties,
such as form, colour and texture is translated through non-homogenous ‘languages’ into a piece of paper or its digital counterpart. Reductionism is apparent not only when conventional tools and methodologies are employed, but also when modern methods and cutting-edge technologies are implemented. This is because the processes involved also depend on several human and non-human factors which by definition cause a certain extent of reductionism (Chrysanthis et al. 2012).

Recording is not ever a passive and mechanised process, and even when pre-defined fields, descriptions and interpretations are used, archaeologists have to become part of this ritualised performance, so as to familiarise themselves with material reality and produce their own, unique views of the past. The main problem, however, is that this rigorous documentation is part of the notion that the process is reversible (Witmore 2004) and that by recording information in another system of signs (Lucas 2012: 238), we can go back to the origins of this information. However, this is utterly problematic and to make it explicit we should think of a simple example; a Greek phrase should be translated in English. The two languages are considerably different not only in their grammar and syntax, but also in vocabulary, expressions and collocations. This means that a Greek phrase which has been translated in English, although it can be re-translated in Greek, its final version would differ from the first since the system of signs used in each language is substantially different.

The process of translation in archaeology is relatively the same (see chapter 1). A three-dimensional environment is translated in texts, drawings and photographs by using equipment and methods that often derive from other fields and cannot adequately depict the breadth of information of the real world. Paper and pencils, measuring tapes and EDMs, Munsell Color Charts and laser scanners, they are all employed in order to achieve the translation of the excavated information into an archive. For example, when an archaeological context should be documented in order to be removed, text recording, photography and drawing are used to facilitate the process of translation. These three mechanisms of recording, by using well-known conventions, will translate a feature that has form, texture and colour and is experienced by all our senses and our body, into a context sheet, a Munsell value, one or more photographs and a few drawings. By using their systems of signs, similarly to the case of language translation above, the information will be translated into their own language; however this language lacks by its nature the tools to support the translation of the whole range of information.

Translation also depends on the translator. This means that the unique ways that an individual records, perceives and understands the world also affect the process and the products of translation (see chapters 1, 2). For example, in my work for the ‘ceramics workshop’ at Zominthos (Papadopoulos and Sakellarakis 2013) I was trying to comprehend in the field
notes what some ‘red clay slabs’ were; they were described as such in the excavator’s diary, but the corresponding drawing did not give any indication of these features. Also, photographs did not exist. As a result, this was a piece of information that could not be traced. In that case, the problem was not the inadequacy of the recording methods, but the archaeologist’s choice not to translate this information in a visual format.

On the other hand, the way that something is recorded is also affected by the level of understanding or perception somebody has on a particular matter, as well as the conditions under which the recording takes place. For example, an archaeologist might not be able to distinguish two different layers of destruction at the same stratum, either because of his/her practical experience and skills or the conditions under which the excavation takes place. Experience however, is not easily quantifiable, and even when there is considerable experience on something it does not mean that the individual is by definition more capable of forming understandings in comparison to others with less experience.

There is also one additional factor that is worth taking into account in this discussion, and is related to the way that individuals perceive the world. It is not only the cognitive dimension of perception which is inseparable from sociocultural and physical contexts and influences understandings, but also individuals’ own baggage of experiences and memories which form knowledge about reality. People experience the world through the senses and bodily movement (Ingold 2000; Hamilakis et al. 2002; Hamilakis 2014; Day 2013). Ingold for example (2000: 243-287), by using as a starting point the metaphor of a passing train experienced visually and/or aurally discusses the role of sound and vision in human experience. He suggests that these two senses work in relation to each other and the human body, and therefore any attempt to study human experience by separating sensory modalities and consider independent sensorial interactions is vain. Hamilakis also agrees to the latter (2013: 411-412), arguing that experience is formed by ‘trans-corporeal sensorial relationships’ in which none of the senses or the body can be seen as separate entities. However, it is not only multisensory and corporeal experiences but also memories and their evocation that activate and structure perception by infusing references to the past.

Memories, i.e. the ability of the mind to store and recall past experiences in the form of knowledge, thoughts or sensations also influence perception and the understanding of material reality by structuring experience (Jones, A. 2007: 1-26). Places, objects and human interaction with those, send feedback to the human mind, turning perception into memories, and these into knowledge. Memories are evoked when an environment or situation triggers past experiences. These memories however are recalled not only when a particular place or object is re-experienced. As Jones argues for the case of place and objects (2007: 58-59; also see Casey 2000) evocation does not presuppose re-experience, since it can also happen from
a distance, when for example an object bound to the memory of a person is experienced far from the place of the original experience. In the context of this thesis, and based on some participants’ responses regarding a sense ‘of being there’ in some of the 3D images, it could be argued that images can also trigger viewers’ memories by evocation, thus influencing their understandings. This does not necessarily mean that people have experienced the same places or objects, but that memories were evoked and knowledge about digital spaces was produced due to images’ resemblance or reference to real spaces, objects and experiences. This means that people with such experiences/memories respond differently to such visual stimuli, probably regardless of their visual realism (see 6.2.a.), in comparison to people who have never experienced such environments or objects related to them.

The process of translation is not only influenced by the tools used, the methods applied, personal choices and individuals’ perception, memories and experience. There are other variables which are often beyond our immediate understanding and are ingrained in the way we experience the world through vision. Seeing is possible because particles of light reach our eyes and translate the three-dimensional properties of the world into a comprehensible, two-dimensional image upon our retina (see 2.1.). Yet, the experience of the environment through the eyes is much more complicated since it depends on how individuals and material reality interact with light. This means that not only differences in light and viewing angles result in different perceptions of the micromorphology and macromorphology of the environment, but also that different people would experience and understand the world in different ways based on their visual abilities (see section 2.2.a.). Vision however is not the only one of the senses that defines the perception of the real world, since the rest of the senses, as well as movement also have a fundamental role (see 6.2.a., 6.2.b.).

A site’s information is also reinterpreted for a publication. This means that the already translated evidence is translated again for another medium, which most often presents the information as definite and unambiguous. In addition, illustrations and (re)constructions often accompany textual descriptions, while reworked drawings from the excavation’s field notes play an auxiliary role as guarantors of an objective and scientific archaeological process. This information is also reproduced in other media and composite publications, which are then used as a basis for further elaborations of the initial ideas. Chapter 3 about Greek Neolithic space is such an example, since most of the discussion has been primarily derived from other composite works, ethnographic research and publications of case studies. Therefore, bibliographic literature sources incorporate an infinite number of translations, since they are the result of all processes described so far; excavation, recording methods, visual and textual representative styles, personal choices and cognitive mechanisms.
Based on the above, it becomes apparent that diverse variables act in the process of translating the evidence into an archive and the archive into a three-dimensional image. That image is based on several, complicated and often untraceable processes of knowledge production. Although we argue for the need of more and better provenance documentation, when it comes to the archaeological process and particularly to the sources and contexts of an image, it seems that provenance becomes a multifaceted pursuit. The origins of the material produced cannot be traced beyond certain elements as these are framed and afforded by data structures and standards. As explicitly addressed in the first two chapters of the thesis, the various conventions, limitations of tools and methods, cognitive mechanisms and personal capacities, invalidate the argument that we can go back to the initial information or that the process of translation can be circulated (Witmore 2004).

Knowledge Production in Digital (Re)constructions

In the previous part, I briefly referred to the multidimensional variables that influence knowledge production in the archaeological process. However, the examination of knowledge production through the process of digital reconstruction has additional variables that should also be considered.

Constructing three-dimensional models in a computer graphic environment is quite complex, since modellers rarely have experience of the data while being excavated, and their work includes the decipherment of the records. Nevertheless, the usual distance that a modeller or an archaeologist has from his/her subject-matter is not always negative. Especially in cases where a site is written up by someone other than the excavator, this distance can be beneficial and the results more revealing since they are released from the excavator’s authority and fixed ideas. Similarly, the distance of the modeller from the modelled site can also be constructive, provided, however, that there is access to all sources and that communication between different members of the team is possible; in such a way, the modeller can evaluate and possibly integrate in the decision-making aspects of the archaeological process that cannot be derived from the archive, and also form a multivocal approach by considering alternative ideas and approaches to the data.

Modellers should primarily consider a range of methodological issues posed by the software used in this translation, since most of these were not designed either by or for archaeologists and cultural heritage specialists. This means that they should design the best workflow to translate the two-dimensional archaeological palimpsest into a three-dimensional model (see 5.2.). However, the process of modelling in a computer graphics software, similar to recording in excavation, should not be considered a passive transformative process. It is a performance
which makes the modeller think about the different aspects of the archaeological material, and leads to the augmentation of perception and the production of new understandings.

This process leads to an image which most of the times is experienced in two-dimensions, probably on a screen or on paper. This of course is utterly problematic, since the world is not an image, but is experienced and lived. Also, the intended audiences, either academics or the public, since they do not have access to the original data and have not studied the evidence and its various translations, can rarely participate in its production, or become aware of the different parameters that influence this process. This means that their perception of the resulted images cannot be similar to that of the modeller or of the people who are directly involved in the project and have a more complete understanding or experience of the material evidence.

Members of the project contribute to knowledge production, initially by excavating, recording and studying the material, and then by participating in discussions and argumentations. When the modeller uses their multiple voices and understandings in the process of production, digital reconstruction becomes a multivocal process which encompasses or at least considers different ideas and approaches to the subject. Certainly, if the modeller is an autonomous agent who forms his/her own visual interpretations based on the various sources of knowledge, he/she also is the person who filters this information and decides what to be included and how. Nonetheless, the main criticism is that the results of this multivocal process are rarely handed back to the people that intentionally or not had some input to those images. This means that the process is to a certain extent multivocal, since it is based on multiple sources of data, but the process is not bidirectional since it follows a straight line, starting from the sources and concluding with the production of the image.

That image, even when it is the result of a discussion among members of the team, often reflects the ideas of an authority that gives the final shape to the visual product in the form of definite and unambiguous knowledge. This is because 3D visualisations are not produced while on-site and as part of the normal archaeological process, and therefore, they usually fail to become research environments for collaboratively negotiating interpretations. The production of such images is usually considered an asset that will give another perspective to the excavated data at the end of a project, mostly by attracting visitors and securing funding. Certainly, there are exceptions, and in some cases digital imagery is forming a locus for discussion. However, to my own knowledge, I have never seen any 3D visualisation projects that explicitly state how such discussions, collaborations and multivocalities have formed the visual interpretations. This thesis, managed to take into account different voices within the project and produce visualisations that reflect this process.
Computer graphic simulations are not the last and often unnecessary addition to the presentation of a dataset. They are part of a never-ending translation process, augmenting perception and providing stimuli to expand the interpretive vocabulary of the archaeological process. The knowledge that such images produce is both explicit and tacit (Hildreth and Kimble 2002), since on the one hand they provide direct visual information about the tangible elements of Neolithic environments, while on the other they do provide a sense of presence, therefore enhancing people’s understanding regarding their intangible nature. Both types of knowledge are essential for the construction of spatial understandings, and are apparent in all stages of knowledge production. It seems, however, that tacit knowledge primarily defines the nature and level of understandings at a personal level. It provides the means to internalise processes and products, and form a more holistic understanding which goes beyond the apparent information given by the visualisations themselves. Tacit knowledge provides the stimuli to think rather than to merely see, therefore enhancing the way that observers problematise the information provided and build their own understandings about the past.

Koutroulou Magoula was an exceptional case study which provided all the sources required to research the process of digital reconstruction. Different methods and systems of recording, a diverse range of archaeologists, my personal experience on-site, communication among members, various approaches to material culture and different views on computer graphic simulations have moulded in their own ways the production of knowledge about the site. Problematising the process of digital reconstruction for Koutroulou Magoula showed that such images are active producers of knowledge, since in order to be constructed, the processes involved in their making should be first deconstructed. The resulted images encompass an enormous amount of knowledge about different aspects of the archaeological process, including diverse ways of perceiving, capturing and reproducing the three-dimensionality of the evidence. Studying the origins of their knowledge not only enhanced the understanding of the variable and dialectic process between excavation, perception and visualisation, but also enabled the formation of a theoretical and practical framework for similar visualisation projects.

The 3D models resulted from this process were directed to the members of the team in order to evaluate the knowledge depicted and stimulate discussion regarding potential solutions to problematic aspects, as well as new hypotheses. Their responses in the online survey (see chapter 6), not only initiated for the first time in the project a productive discussion about all these matters, but also provided the chance to refine the models and produce alternative views of the same dataset. What is more crucial however, is that this bidirectional process significantly enhanced their comprehension of Neolithic space, while helped them to structure new hypotheses and further understand certain aspects of Greek Neolithic materiality.
The modeller, who is the vehicle of knowledge production in the process of studying and deciphering the different sources of knowledge has a primary role in the step-by-step translation of the real into the digital world. Therefore, since the modeller orchestrates and carries out the process, he/she should have an overall understanding of the material and a control over the processes and translations involved. This also means that since the modeller develops a holistic approach to the process, gains are greater, in comparison to the rest of the people who augment understandings and shape new knowledge depending on their involvement in the process. In the case of Koutroulou Magoula, the process of digital reconstruction significantly improved my understanding of the site, the spatial and temporal properties of the evidence, as well as the mechanisms of knowledge production in the archaeological process. Certainly, my experience on-site played a significant role; however, it was the deconstruction of all aspects of the process and the construction of computer graphic simulations that moulded these understandings, providing a sense of three-dimensionality and a better overview of the multi-layered processes involved.

On the other hand, team members’ knowledge, although primarily based on the presentation of fragments of the process and aspects of its products rather than on the comprehension of the various stages and the elaboration of their elements, was also improved. It is worth mentioning, however, that although they were invited to be involved in the first stages of modelling via the blog where all decisions were posted, team members preferred to provide their feedback only in the latest stages of the process, when the first 3D models were completed. As a result, their understandings and appreciation of the various levels of translation were not integrated as much in the problematisation of the process; still, their responses demonstrated that the enhancement of their knowledge was inevitable.

The Problem of Paradata: Knowledge for whom?

In such 3D visualisation projects somebody would expect an appendix with information regarding the resulted 3D models and their primary sources of information. Jones for example (2012), in his project about Medieval Southampton has included this kind of information in a tabular format, also mentioning next to the models their level of probability. This was the necessary solution to talk about ambiguity, since ‘the museum wanted an exhibit that was presented in a realistic manner, so any overlays or additions to the finished model were not possible’. Pletinckx (2012) moves a step further suggesting a recording methodology which includes a source database, assessments and correlations of the various sources and a tree of all possible hypotheses with conclusions. As he mentions in the guidelines for this methodology (ibid.: 207), ‘clear references to all sources used, no use of implicit knowledge’ should be made. According to the latter, implicit knowledge can and should be separated from the explicit knowledge derived from the various sources.
In the course of this thesis, it was demonstrated that explicit and tacit knowledge produced in the archaeological process and the process of digital reconstruction cannot be separated. Several factors which act beyond our immediate understanding mould knowledge in different stages, and any hypotheses, interpretations and visualisations always become an amalgamation of these. Thus, since explicit and implicit knowledge are ingrained in the sources and the various processes of knowledge-making, it is unrealistic to believe that a recording could ever manage to present in a clear manner the sources and the implicit knowledge involved.

Another problem is that the proposed methodology only uses examples of historical buildings for which there are many more and clearer sources in comparison to prehistoric sites. Besides, it does not take into account the fact that a visualisation is not only defined by the sources, but also by the methodologies used to transform these sources into 3D visualisations. Based on the suggestions for the documentation of the various sources, this would mean that thousands of stages in the processing of the 3D models in different software would also have to be documented and stored. As Havemann argues however (2012: 158), defining the standards according to which these data could be recorded and stored in a range of different software and technological platforms would be unfeasible and entirely problematic.

The idea that all sources of knowledge, their correlations, the resulted hypotheses and the visual products in a 3D visualisation project should be documented in a clear way so as to enable transparency, gave birth to the so-called paradata (Bentkowska-Kafel et al. 2012). In principle, the idea of paradata is based on the intention to open the process of visualisation to people not directly related to a given subject and enable revisiting hypotheses and results in a later date by different scholars. However, the logic behind that is based on a problematic concept; this is that the process of 3D visualisation transforms through reconstruction an archaeological object/building into its digital surrogate. This is the only reason why somebody would expect a detailed account on how for example a building in its current state was reconstructed to its original condition.

As I argued back in 2009, in the first year presentation for this thesis, what is required in this process is a leap of faith. The research community has overemphasised the need of transparency in the process of 3D visualisation, probably without seriously considering that the problems in this approach are also inherent in conventional means of interpretation, e.g. publication. Would anyone expect that archaeologists writing up for the publication of a site, would also compile endless lists with sources, correlations and hypotheses in order to prove that there is a linear relationship between the sources and their interpretation? In a conventional publication, archaeologists make references to the various sources, while in the
form of argumentations discuss different interpretations, usually concluding with one that is more probable. This does not significantly differ from the work carried out in a 3D visualisation project. In most cases, 3D models are accompanied by a detailed account of the various sources and the different aspects of decision-making. Especially in cases where the 3D visualisation is not only intended for public consumption, multiple versions of the same dataset are produced so as to demonstrate possible interpretations.

It seems therefore that the long debate regarding the different means to document 3D visualisations does not derive from a necessity to be transparent in this process, but primarily from the need to avoid the criticism of the conservative research community, and persuade that such approaches are not intended to deceive, but to provide stimuli, generate ideas and form hypotheses. According to the concept of paradata, this is done by producing a record that describes the process of reconstruction as a linear method that its various stages are interconnected; thus, by knowing this process, the visualisation can lead back to the source and vice versa. However, this process is not as linear as it seems, since each stage is bounded by its own opaque system of transformation.

Dismantling the Black Boxes of Knowledge Production

At the beginning of this thesis, I used Latour’s ‘black box’ to refer to the process of digital reconstruction. At that time, the term was used to indicate that although we are aware of the various inputs and outputs of this process, the processes which translate the inputs into outputs remain largely neglected or unknown (fig. 143A). This thesis showed that the latter is true, since it is the visual products of the reconstruction process that are primarily problematised. Visualisation projects are often problematising the inputs to show the complicated aspects of the datasets and the difficulty to produce faithful computer graphic simulations. This is also a way to demonstrate, in cases that a decent model is produced, that regardless of the inherent problems, the modeller or the visualisation team managed to produce a (re)construction that provides another dimension to the problematic aspects of the dataset. This work however highlighted that the term black box needs to be expanded so as to include other elements of the reconstruction process, since not only the processes which translate inputs into outputs are covered by an impenetrable black box, but also the inputs and outputs themselves.
Fig. 143 A. Original visualisation of the understanding of the term 'black box' in the context of digital reconstruction: Linear process in which inputs (archaeological evidence) lead to outputs (computer graphic simulations) through a black boxed process of translation; B. Visualisation of the expanded definition of the term black box in the context of digital reconstruction. All inputs and the processes of transformation that lead to outputs are black boxed. Each individual element of the process is bounded in a black box which should be dismantled prior to the process of translation in order to produce coherent outputs; C. Visualisation of the term ‘black box’ based on the conclusions of the thesis. Dismantled black boxes lead to transparent inputs. These are then used in computer graphics software in a process that should also be problematised in order to produce transparent 3D visualisations.
The problematisation of the digital reconstruction indicated that translation is not a linear process, and does not happen in a single black box that requires dismantling. Prior to this thesis, visualisation projects used to identify and discuss the problems of the archaeological evidence, which were then used to produce computer graphic simulations. The transformation of the original evidence into the various visualisations passed through simple processes of translation which were mainly related to decision-making and computational tools. However, as this thesis demonstrated, there is no single central black box that requires dismantling, since each and every element of the reconstruction process is by its nature bounded in a black box. For example, archaeological photography occupies a black box; this is an opaque system of transformation that gives substance to its elements, simultaneously hiding the mechanisms that influence its formation. As demonstrated in chapter 1, the black box of photography includes apart from the outputs, i.e. photographs, the original evidence and the mechanisms that translated these into photographs: in other words, inputs, translation processes and outputs. These translation processes which are unique for each black box influence how the output is formed. In the case of photography, conventions, technology and people are only three of the main elements of this process. As a result, if photography's black box will not be dismantled prior to its integration to the black box that transforms the real-world into digital space, i.e. software, its inherent problems will also pass to the rest of the processes and will be ingrained into the outputs, i.e. computer graphic simulations. Thus, the visualisations will also be produced within an impenetrable black box (fig. 143B).

At the centre of this process are the mechanisms which materialise the translation of two-dimensional information into three-dimensional space. These mechanisms of translation are also black boxed since there are several factors that define how digital space works. This is because the information gathered during excavation, recording etc., even if deciphered, it is not in the right format so as to be introduced in a computer software. Such programs use very specific methods to produce the attributes of three-dimensional space and interact with the operators; as a result they require skills and resources and thus, personal choices and technical factors play a major role in the process. Therefore, similarly to the first stage, i.e. the inputs, the mechanisms of reproduction should also be problematised and their black boxes be dismantled too.

From the above, it becomes apparent that behind a 3D visualisation, there are numerous mechanisms that act independently or in combination and transform the way that the elements of an image are formed. This means that if the problematisation of the process of reconstruction will start with the outputs, i.e. the images themselves, or will only be based on these, then the black boxes inherent in each and every part of the process will not be dismantled and will pass on to the computer graphic simulations. As a result, any attempt to evaluate knowledge in these 3D images will be incomplete, since a holistic understanding
about the complexity of knowledge-making through the process of reconstruction will not have been achieved.

This thesis vividly showed that the black boxes of the process of digital reconstruction can be successfully dismantled prior to their translation into computer graphic simulations (fig. 143C). In a step-by-step process these black boxes were unscrewed and their contents deconstructed. Regarding excavation recording for example, this work identified the various factors that affect the translation of three-dimensional evidence into two-dimensional formats. Parameters, such as conventions, skills, equipment and perception were thoroughly addressed. This was a necessary step in order to understand and methodically evaluate the underlying issues which pose certain theoretical and methodological constraints to the reconstruction process and the production of knowledge about Greek Neolithic space. As well, the connections between different black boxes and their functions were investigated in order to comprehend the various mechanisms which define the mode and pace of translations. For example, how are depictions of archaeology in photographs affected by people? To what extent excavation methodologies have an impact on field notes and drawings? The dismantled black boxes were then introduced into suitable computer software to materialise their transformation into 3D images. The black box of this process was also dismantled by addressing the factors that condition users' interaction with the software, and considering all technical, natural and personal variables that affect the production of materiality in digital space.

The images produced from this process incorporated multiple levels of translation, including the audience's feedback, which is also a translation of their experiences, memories and acquired understandings. Since all stages of the process have been scrutinised, the resulted images are not simple visualisations of ready-made knowledge materialised by a single person. Existing knowledge, documented in various sources, has been elaborated during the different stages involved, and new knowledge has been produced. This knowledge is not only a translation into a definite visual product, but an amalgamation of theory, method, experience and experiment, open to discussion and further elaboration by the people involved in the processes of knowledge production. In such a way, images become invaluable resources for approaching space, while the varying levels of translation render the process of digital reconstruction the only productive means to understand the three-dimensional properties of the evidence and augment the perception of space.

This thesis is the first 3D visualisation project that problematised to such depth knowledge production through the process of digital reconstruction by evaluating strategies and factors that influence how we perceive, capture, present and reproduce real and digital information, and discussing where the knowledge depicted in three-dimensional images comes from. By
using a case study from the Greek Neolithic, it managed to critically consider the concept of three-dimensionality in all aspects of the process and use 3D modelling to demonstrate the power of computer graphics simulations to augment understandings and produce new knowledge about Greek Neolithic space.
Appendix I: Tells and Flat-extended Settlements. Patterns, Organisation and Some Theoretical Considerations

This section examines the similarities and differences underlying the construction and habitation of these two distinctive types of settlements, discussing their patterns and internal organisation, as well as theoretical concepts that have been developed regarding their meaning to the Neolithic inhabitants, and the making of senses of place, memory and identity.

1. Tell Settlements

Tells are very common in the Balkans and the southeast Mediterranean, while in Greece they are located both in Thessaly (pl. *magoules*) and Northern Greece (pl. *toumbes*). Because of bias, but also as a coincidence of Neolithic research both in Thessaly and Northern Greece, all sites excavated until 1990 were tell sites. The only exception was the excavation at Sesklo in the 1970s, when Theocharis mentioned that there is part of the site which preserved characteristics that seriously departed from the model of tell sites.

According to Bailey (1999: 94-95) the identification of tell sites is based on five misconceptions which have been considered for a long time in Neolithic research. These assumptions have as a result the production of an erroneous image about tells, which are mainly defined as places of habitation and passive shelters for hunter-gatherer and farming communities. Tells’ main characteristics, according to more conventional approaches, are that the hills they occupy are formed after successive layers of habitation, while their boundaries coincide with the slope of the hill. The individual structures are organised in a dense layout, with a limited amount of open spaces in between, while a number of temporal and spatial factors, including the accumulation of fragile construction materials and the clustering of houses play an auxiliary role. However, as the evidence suggests, tells were not continuously occupied (Bailey 1990), while their boundaries were extending far from the actual circumference of the mound (Bailey 1999: 95). The latter has been confirmed in several sites of the Greek Neolithic, and that might also be the case in Koutroulou Magoula according to the latest geophysical research (see chapter 4).

Tells, as products of cooperation and competition (Halstead 1999: 89), are constructed through a deliberate set of choices to: i) use fragile materials for the buildings, i.e. mud bricks, which result in thick deposits, ii) build on top of older structures, and iii) concentrate
the houses into a coherent unit (Sherratt 1983; also see Kotsakis 1999; Perlès 2001: 174). Tell formation is defined by a temporal process during which the Neolithic inhabitants would adhere to their choices. However, these choices should not be considered part of a predetermined plan to create a visible landmark, but a gradual result reflecting the ways that they used to mould their social relationships (Nanoglou 2001: 313). However, even if tells were created unintentionally, the result, i.e. a material landmark, would act as a territorial marker having connotations of continuity, possession and identity.

Kotsakis believes (2004: 64) that the constancy of building the structures on top of older remains is indicative of a particular relationship that the Neolithic inhabitants had formed with built space. Both the maintenance of a tell, and its dominance in the landscape, symbolise the continuity, the possession and the construction of senses of place, memory and identity, and therefore, a feature of the landscape is turned into an idealised landmark and a territorial marker. Therefore, lived places construct biographies which go beyond the notion of survival. However, the analysis of settlements’ life history is quite often constrained to unilateral units of analysis, while any constructive interpretations of the datasets based on lived experience, as arenas which negotiate personal, social and cultural values are usually neglected (Pollard 1999: 76-79). However, taking Kotsakis’ argument further, two questions emerge: i) when should a site be considered a tell (Chapman 1990: 51-52)? What are the parameters that classify a settlement to this category? Is height the only determinant or should we also consider its extent? How many consecutive phases of habitation should be identified in order to talk about continuity and domination in the landscape? and ii) It must be the case that successive habitation phases in an area where ancestors lived created, consciously or not, senses of continuity and genealogy, reproducing notions that tied Neolithic farmers with their predecessors. However, were the mounds, which were not always clearly discernable, defined as symbolic expressions of the Neolithic cosmos by their inhabitants, or is this a subjective interpretation given by prehistorians in order to explain the formation processes? Is it a concomitant of consecutive layers of occupation, or a symbolic continuity which tied people not only with their past, but with their present and future? Therefore, is physical continuity related to social continuity as well, or do tradition and place foster a non-existing relation and the illusion of an ideological mechanism? (ibid., also see Chapman 1989, 1990, 1994, 1997 for discussions on the implications of these different practices in terms of the symbolisms involved in the formation of a visible landmark). Kotsakis (2006a), however, responds to this criticism by arguing that practical reasons, such as space availability, land condition and resources may have also played an equal role in the selection of the same places to settle. Also, Tringham and Krštić (1990: 587) suggest, when talking about Selevac, that tell formation is linked to specific environmental conditions, such as restrictions on settlement area imposed by environmental features. However, this notion of continuity might have been established not
only by rebuilding houses on top of older structures, but also by constructing house models (see 3.2.b.), common artefacts in the Middle Neolithic, therefore creating symbols of unbroken continuity with the earlier houses (Hodder 1994: 81).

2. Flat-extended Settlements

Recent studies in Northern Greece have revealed many sites of the flat-extended type, which depart considerably from the accepted model. Their basic difference is their size, with the average height being very small, rarely forming a perceptible rise in the landscape. Dwellings are not constructed vertically, i.e. one on top of the other, but are drifting horizontally through time, resulting in the occupation of a larger area in comparison to tell sites. Although the extent of these settlements may be considerable (more than fifty hectares identified in the case of Makriyalos), the density of habitation is rather low, as among the individual dwellings or the clusters, there is free space used either for communal activities or as demarcation of space, as well as for cultivation and animal breeding (Chapman 1989: 38; Andreou and Kotsakis 1994: 23; Kotsakis 2004: 61). Also, there are differences in the construction of the dwellings, which give the impression of ephemeral constructions as they are characterised by ‘negative features’ (e.g. pits dug in the ground), and the materials used are not durable in comparison to tell sites, which make use of stone as well. In addition, flat settlements are also characterised by the existence of walls and ditches, which separate or define particular areas.

The site of Vasilika was the first flat-extended settlement identified (Grammenos 1991), followed by Thermi (Pappa 2008: 67-100), as well as other sites identified by the Langadas survey project (Andreou and Kotsakis 1994). Makriyalos and its extensive excavation and analysis (Pappa 2008) was the site that strongly confirmed the existence of this type of settlement and identified the model of horizontal displacement in consecutive phases, which had already been identified in the Balkan Neolithic (Tringham and Krštić 1990; McPherron and Srejovic 1988). However, flat-extended settlements exist in Thessaly as well, such as in Galini (Toufeksis 2005: 424-426) and Sesklo B (also called polis by Theocharis), which seemed to depart from the accepted tell model in contrast to Sesklo A (fig. 58), the so-called Akropolis (Kotsakis 2006b, in prep.)17.

Dwellings in flat-extended settlements did not emphasise either the uniqueness of the buildings themselves, or the spatial and temporal continuity of habitation, both because of their relative uniformity as well as their distribution in time and space. This may be interpreted as an emphasis on collectivity rather than individuality (Halstead 2006: 15-16; Souvatzi 2012), indicating that the inhabitants were connected via a collective rather than an

17 For a list of flat-extended sites and related literature see Pappa 2008: 27-48.
individual identity. The available archaeological evidence, especially from Makriyalos, indicates that this hypothesis is not arbitrary. For example, burials were made in the communal ditches without any careful treatment of the dead, while the bodies were manipulated as part of the community rather than as individuals, as indicated by the finds which do not demonstrate a distinctive burial practice for each individual (Triantaphyllou 2001).

The greater size of flat-extended settlements has been often considered the result of an increasing population. This has also been amplified by the identification of buildings which indicate some social or other differentiation, i.e. central or megaroid buildings, potentially constructed to control the increasing population as it tends to result in instability and conflicts; therefore the inhabitants sought to establish a series of forms and hierarchical divisions to overcome these issues. However, it is more probable that their large size is connected to the organisation of space in the course of many generations, rather than anything else (Kotsakis 2004: 60-61).
3. Tells versus Flat-extended Settlements

The differences between tells and flat-extended sites are related to different processes of accumulation of their deposits due to the organisation of space, the arrangement of structures and the way that houses are replaced, either vertically or horizontally, reflecting different social and economic conditions, ideologies and symbolisms. Because of the morphological differences of these two types of Neolithic settlements, a series of antithetical concepts related to their function and meaning have been developed to illustrate, and actually prove, the not always clear incongruity. There are two main themes around which any discussions and interpretations are structured: i) Tells have been considered sedentary settlements, both because of the materials used in construction and the efforts spend in creating a symbol in the landscape. On the other hand, flat-extended settlements, which make use only of fragile materials and their real extent and duration cannot be satisfactorily identified by the evidence, have been considered indicative of seasonal occupation; and ii) Because of the organisation of space and the arrangement of structures, tell sites are synonymous with intensive habitation, while flat sites are synonymous to extensive habitation. These two pairs are partially based on erroneous assumptions, which will be briefly discussed below.

Sedentism and seasonality are two different ways of using space. Most societies have both characteristics, but there is no agreement regarding the duration of habitation that would allow us to consider a site seasonal or sedentary (Bar-Yosef and Rocek 1998: 1-2; Kaiser and Voytek 1983: 323-324). The fragile constructions of flat-extended settlements have been linked to seasonal habitation, while the more durable materials of construction and the building methods employed in tell sites are linked to places which were intended to be used for longer periods of time. The evidence from several excavated Neolithic sites suggests that this concept might not be valid. For example, although Makriyalos preserves all these characteristics that could safely classify it as a locus of seasonal habitation, the thorough study of the evidence suggests that it might have been a sedentary settlement or, at least, a place used for longer periods. However, it is not clear why Neolithic inhabitants were choosing either type of settlement; environmental conditions, or geomorphic factors, and, consequently, the availability of resources could be related to their choice. However, Souvatzi (2012) argues that this diversity is more a reflection of the social groups trying to define themselves and their identities in relation to their own or other groups.

Nanoglou (2008: 146) refers to these sites not in terms of their morphology, i.e. tell vs. flat, but in terms of their form of habitation, i.e. intensive vs. extensive. This different approach is supported by the evidence that suggests that although tells were formed through intensive habitation, not all intensively occupied sites turned into tells, therefore enabling the construction of different symbolic and ideological notions, as well as diverse.
relationships between the people and their living environment. The fact that people could
observe the ruins of the various structures in the landscape in flat-extended settlements,
could enable the relation of buildings and events, and evoke memories and senses of place
and identity. On the other hand, in tell sites, older remains were sealed below the new-built
structures, and therefore any sense of continuity and descendance was evoked by the
increasing height of the mound in the landscape. From these two different concepts, it
becomes apparent that the Neolithic inhabitants were forming a different relationship with
and within the built space. In the first case, where the older structures that were no longer
in use could be observed in the landscape, people continued their lives on a site which was
visually obtrusive, as their new and well-built habitats co-existed with deserted, ruined,
dismantled and burned buildings. The sense of continuity in time and space was
materialised through this co-existence, and was experienced differently by each individual,
as each building denoted tangible biographies and evoked diverse memories and narratives
about the past. This ‘domicide’ (Porteus and Smith 2001) or ‘domithanasia’ (Tringham 2005:
106-108), resulted in a memorial frozen in space and time, which, although caused by the
termination of a house’s existence, simultaneously contributed to the continuity of it in the
landscape. In the second case, where continuity was evoked by the Neolithic mounds and
not by individual structures, the inhabitants were experiencing a collective memory (Kovacik
1999: 160; Gedi and Elam 1996), without having a point of reference to individual buildings
or events. These actual and symbolic landmarks were materialising a group identity,
therefore becoming a point of reference for the whole community (Nanoglou 2001: 313).
Appendix II: The Surveys

Survey 1

1.1. The Process of Modelling

The video gives a good indication about the process of reconstruction and the main structural components of the building.

The models give a good indication of how the building was structured indicating that a definitive answer about the Building cannot be given.

You would prefer something more realistic to show the actual structure of the building.

The images resemble archaeological drawings and therefore are more trustworthy than the very realistic models that 3D graphics produce.
The three photorealistic images of the interior of Building 1 provide a better indication of size and sense of space in comparison to the rest of the images which are non-photorealistic.

Accompanying images with text about the decision-making and the modelling process that led to the visual outputs makes the visualisations more comprehensible.
You do understand how the modelling process helps archaeological reasoning by testing alternative hypotheses and models.

Could you mention three (3) things that you liked the most about the modelling process and its products presented above?

<table>
<thead>
<tr>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual comparison of alternative reconstruction</td>
</tr>
<tr>
<td>Synthetic view of all features</td>
</tr>
<tr>
<td>Visualization of details of structures</td>
</tr>
<tr>
<td>The cut-aways and exploded drawings are useful</td>
</tr>
<tr>
<td>Different interpretations</td>
</tr>
<tr>
<td>Minimalist style</td>
</tr>
<tr>
<td>Reasons for decision making</td>
</tr>
<tr>
<td>The presentation of several alternatives</td>
</tr>
<tr>
<td>The presentation of the construction as a process</td>
</tr>
<tr>
<td>The reference to the archaeological data on which the reconstructions are based</td>
</tr>
<tr>
<td>The shading of the wall mud bricks</td>
</tr>
<tr>
<td>The different propositions for the roof</td>
</tr>
<tr>
<td>The fact that a photorealistic interior proposition is given</td>
</tr>
<tr>
<td>Open-ended</td>
</tr>
<tr>
<td>Modest</td>
</tr>
<tr>
<td>Alternative scenaria</td>
</tr>
<tr>
<td>Modelling process are capable to prove to us if several assumptions that we make in the field are feasible or not</td>
</tr>
<tr>
<td>Ethnographic comparators to make your suggestion more comprehensibly</td>
</tr>
<tr>
<td>Accompany the house models with the video above, I believe that make more understandable the modelling process and the product you present</td>
</tr>
<tr>
<td>Great visual on the building</td>
</tr>
<tr>
<td>Proportions &amp; distances</td>
</tr>
</tbody>
</table>
### Alternatives roof types
- Opening of roof
- Stone foundation
- Low gabled roof

### The Alternative roof types in the non-photorealistic images
- The use of ethnographic comparators
- The way you manage several assumptions by the construction of alternative structural models
- Level of details
- Combination of images with text explanation
- Clarity in presentation
- The process of constructing the house step by step in the video
- The written explanations for the used models
- The comparison between the non-photorealistic exterior and the photorealistic interior of the house

### Students
- It was very interesting to visualize the different stages required in the construction that house.
- The artistic style used to represent the structures
- Sense of light produced
- Neutral, clear colours - easy on the eye
- The different textures given to the materials in the process of reconstruction helped me to recognize which material was being presented. i.e. I could tell that the difference between the mud brick and the clay
- Photo realistic images
- Variety of views, i.e. plan views, side views, etc.
- Those images allow us to see how the house could have looked like and what the remains look like on the site (which photo-realistic images does not permit.
- The attention to detail
- Sense of space
- Convincing images because of their good quality
- The photorealistic representation was quite helpful in providing a more spatial view of the structure.
- The you tube clip
- Shows the different variations of the interpretations.
- Using the non-photorealistic gives more a sense that the representations showed are hypothetical.
The 'step-by-step' construction video
Interior and exterior views
Gives lots of different views so can gain a better understanding of the structure
I like the fact that we were provided with different ways the structure could have been built, in terms of both the support system and roof.
Good quality of the non-photo realistic images. Nicely produced.
Has a mix of photo realistic and drawing style images, which shows realism whilst maintaining the feeling that it is still an interpretation.

Could you mention three (3) things that you liked the least about the modelling process and its products presented above?

**Staff**
The are no alternatives for the wall construction
Lack of access to sources used for rendering the re-construction
Colour palette bland and almost monochrome
No people / evidence of scale
Some pisé-like clay structures that were found are not included in the models
More detailed information of cross sections through building phases would be useful.
Information is macroscopic, needs more data on techniques used to construct footing walls and superstructure etc.
Built up sequence not stratigraphic
Isolation of the building from its surroundings (other buildings, yards, streets etc.)
Assumptions like the opening in the roof are not always correct
Does not allow the viewer to question assumptions made by modeller. Photos can provide this sometimes to those who do not see the feature first hand
Perhaps photos next to models for comparison
Wall decoration could be presented as an alternative, although I am not sure what evidence Koutroulou provides for this

**Students**
The three photorealistic images where very dark and hard to see.
The lack of scale
Difficult to judge scale
Lack of scale bar
In terms of the video it would have been nice to have some description to listen to as well
I find the colours dull and uninspiring.
<table>
<thead>
<tr>
<th>The background is a bit strong against the structures in the images.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal opinion. I do not really like the textures and colours used in the non-photorealistic images.</td>
</tr>
<tr>
<td>No photorealistic outsides, or non-photorealistic inside views for direct comparison</td>
</tr>
<tr>
<td>There is no indication of the scale compared to a human figure</td>
</tr>
<tr>
<td>I don't like the grey background.</td>
</tr>
<tr>
<td>Could be presented with more photos from the site so show the evidence from which the interpretations are done.</td>
</tr>
<tr>
<td>The video does not really show how the couple rows of mud bricks over the entrance could have been supported.</td>
</tr>
<tr>
<td>Difficult to understand the nature of the materials in certain models</td>
</tr>
<tr>
<td>Might be nice to have a bit more colour and texture</td>
</tr>
<tr>
<td>Some of the images could do with labels to make the items mentioned in the text clearer, i.e. the hearths.</td>
</tr>
</tbody>
</table>
1.2. Non-Photorealistic Rendering

Although much of the content presented in the building was not found in the excavation, these images provide a good sense of space and give a good indication about the structure and the content of this Neolithic building.

At the moment, the excavated material and its study by the various specialists cannot provide any other indications about the interior and the outside area of Building 1. These reconstructions should be considered adequate as working hypotheses.

Non-photorealistic/drawing-like images do not provide a good sense of space in comparison to photorealistic images which depict reality in a way that is more familiar to us.
A fence for animals was constructed according to the geomorphologist's report which suggested the existence of a permanent place for animals based on the large quantities of dung. Do you think that the last image adequately represent this suggestion?

Could you mention three (3) things that you liked the most about the non-photorealistic rendering of the images presented above?

<table>
<thead>
<tr>
<th>Staff</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adds a more complete picture</td>
<td></td>
</tr>
<tr>
<td>Minimalist style</td>
<td></td>
</tr>
<tr>
<td>Sense of space</td>
<td></td>
</tr>
<tr>
<td>The fact that it gives an impression it is made with colour pencils. It takes my mind away from photography and makes me not forget it’s a proposition</td>
<td></td>
</tr>
<tr>
<td>Cartoonish character</td>
<td></td>
</tr>
<tr>
<td>I think from the little evidence we have from the already excavated materials, you manage to produce a reliable hypothesis of how a Neolithic house was in the interior and exterior places</td>
<td></td>
</tr>
<tr>
<td>Presence of artefacts</td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td></td>
</tr>
<tr>
<td>I like that you have a view to the fence for animals from the interior of the building</td>
<td></td>
</tr>
<tr>
<td>Gives a good sense of scale and use</td>
<td></td>
</tr>
<tr>
<td>Lighting contrast between interior and exterior</td>
<td></td>
</tr>
<tr>
<td>The whole abstract feeling they give (for example the fact that the interior is not painted in the last one)</td>
<td></td>
</tr>
<tr>
<td>Use of archaeological knowledge</td>
<td></td>
</tr>
<tr>
<td>It’s a good idea that, you have a view from the interior of the house, to the fence for animals</td>
<td></td>
</tr>
<tr>
<td>Presence of animals</td>
<td></td>
</tr>
<tr>
<td>Exterior paved area</td>
<td></td>
</tr>
<tr>
<td>I believe that Non-photorealistic/ drawing-like images provide a good sense of space in comparison to photorealistic images</td>
<td></td>
</tr>
<tr>
<td>Shown in relation to other buildings in the settlement</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>The grey sky</td>
<td></td>
</tr>
<tr>
<td>Freedom of expression</td>
<td></td>
</tr>
<tr>
<td>I agree with the suggestion of the existence of a permanent place for animals based on the large quantities of dung, and I think the last image was correctly depicted</td>
<td></td>
</tr>
<tr>
<td>Attempt of representing light (inside/outside)</td>
<td></td>
</tr>
<tr>
<td>Hearth</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is not because those images are not pictures that we are less familiar with the particular codes of drawings. There are drawings all around us which are more or less realistic.</td>
</tr>
<tr>
<td>Again, great attention to detail</td>
</tr>
<tr>
<td>Preens of animals and small items make it more human and accessible</td>
</tr>
<tr>
<td>Unambiguous</td>
</tr>
<tr>
<td>I like that the images gave context to materials and provided a possible representation of life in and around that building</td>
</tr>
<tr>
<td>Picture 1: I like the birds’ eye view.</td>
</tr>
<tr>
<td>The items in the image were clear to see as they were outlined.</td>
</tr>
<tr>
<td>Non-photorealistic pictures seem to be a good way of illustrating hypothesis without imposing a particular view since, unlike pictures, we know that drawings might not be entirely true.</td>
</tr>
<tr>
<td>The inclusion of animals and tools gives it a more dynamic feel, e.g. it feels like it is being lived in</td>
</tr>
<tr>
<td>Day &amp; night views</td>
</tr>
<tr>
<td>Interesting angles that they are drawn from</td>
</tr>
<tr>
<td>The fact that they are not realistic means it is clear that they are an interpretation.</td>
</tr>
<tr>
<td>The shading looks promising</td>
</tr>
<tr>
<td>Non-photorealism makes it clear that it is a possible reconstruction rather than accurate scene</td>
</tr>
<tr>
<td>Convincing, reliable</td>
</tr>
<tr>
<td>Despite not being photo realistic they still adhered to real life conditions, i.e., light.</td>
</tr>
</tbody>
</table>

Could you mention three (3) things that you liked the least about the non-photorealistic rendering of the images presented above?

<table>
<thead>
<tr>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would expect a more every-day situation and not so ordered arrangements</td>
</tr>
<tr>
<td>Insertions can be misleading and suggestive</td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Colours used</td>
</tr>
<tr>
<td>No people</td>
</tr>
<tr>
<td>I don’t understand what the grey areas are in the last drawing. A huge stone closing the fence?</td>
</tr>
<tr>
<td>No humans</td>
</tr>
<tr>
<td>I think both, Non-photorealistic and photorealistic images depicts reality in a way that is more familiar to us but Non-photorealistic images makes the virtual reality more successful</td>
</tr>
<tr>
<td>Shapes far too geometric</td>
</tr>
<tr>
<td>Fence</td>
</tr>
<tr>
<td>Why you use only this types of domestic animals?</td>
</tr>
<tr>
<td>Exterior is limited in view</td>
</tr>
<tr>
<td>The angle in the top image (like hanging from above)</td>
</tr>
<tr>
<td>A proposition of how these doors were closed?</td>
</tr>
<tr>
<td>No weather conditions</td>
</tr>
<tr>
<td>Why you use only these types of domestic animals?</td>
</tr>
<tr>
<td>Exterior looks quite bad</td>
</tr>
<tr>
<td>Grass/plants (image 3)</td>
</tr>
<tr>
<td>I believe that in these images the interior space provide a better sense of space in comparison to the exterior</td>
</tr>
<tr>
<td>Animals could have shared built space with humans</td>
</tr>
<tr>
<td>For some reason the log on the floor of the first drawing seems like a stone column to me</td>
</tr>
<tr>
<td>Semi-empty houses</td>
</tr>
<tr>
<td>The interior places are well outputted but the exterior is not so obvious the several outside working areas</td>
</tr>
<tr>
<td>Main opening of building and content in the interior (images 1, 2)</td>
</tr>
</tbody>
</table>

**Students**

I know it is supposed to represent only Building 1, but with the representations of the exterior of the building, we do not really have a good feeling of the landscape, what was the place of that building in the settlement.

Although the inclusion of shading is nice, it's a bit TOO dark in the building - it's difficult to see things!

Not very colourful, all greys and browns

A little dull

I don’t like this style of drawing. I think it doesn’t look very professional.

The different textures of the materials not communicated.

A better sense of space could be given if we had a reference (like a representation of a
human being).

Again, a lack of scale inside the building

Some structures (E.g. the fence) are difficult to understand.

The last drawing definitely needs more colour e.g. green grass

Once again I really don't like the colours.

Shadow & lighting seems a little inaccurate
1.3. Photorealistic Rendering

All images provide a greater sense of Neolithic space in comparison to conventional methods of recording and presentation (photographs, drawings etc.).

All images provide a greater sense of three-dimensionality in comparison to conventional methods of recording and presentation (photographs, drawings etc.).

These images provide an enhanced perception of space/three-dimensionality in comparison to the non-photorealistic renderings presented in the previous pages.
The images could be used for showing to the public how an interior space of a Neolithic house might have been.

The images provide to researchers a means to understand some of the data that are not easily comprehensible by reading the field notes or seeing photographs and drawings.

Could you mention three (3) things that you liked the most about the photorealistic rendering of the images presented above?

<table>
<thead>
<tr>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gives a more realistic perspective on light in a house and perhaps working areas</td>
</tr>
<tr>
<td>Texture and senses evoked</td>
</tr>
<tr>
<td>Sense of space</td>
</tr>
<tr>
<td>They give a strong feeling of the texture of the materials especially the wood</td>
</tr>
<tr>
<td>Use of light</td>
</tr>
<tr>
<td>The management of light in the interior of house it was basic in the Neolithic life and you outputted very well</td>
</tr>
<tr>
<td>Light</td>
</tr>
<tr>
<td>Light coming from opening of the roof</td>
</tr>
<tr>
<td>You manage to give a great sense of how light coming from the roof and the door open</td>
</tr>
<tr>
<td>Helps understand diffused light in a structure</td>
</tr>
</tbody>
</table>
The specification of the time of day
The light coming from the roof opening really helps the sense of space
Texture
You manage very well the sense of space and the three-dimensionality of the scene with all these Small finds and objects
Colour
Wooden structure
I like how you use Small finds and objects from perishable materials
The fact that the reasons these choices were made are given in the description
Texture
Straw of roof as seen from the floor

Students
Those computerized models seem to be particularly useful for testing hypothesis and have a more realistic point of view of the building.
The lighting is a lot better
Clarity of light
Bright
The images make u feel as if you are getting a realistic glimpse into the past
Helps put the images in better context.
The texture of the materials is easily seen.
The computerized model could be useful in showing how the building interact with its environment and vice versa (as shown by the effects of outside light in the interior)
The textures look very good
Easy to understand the scale of the room
Good quality- not pixelated
I like the light consideration of these photos.
Can see how the interiors looked at different light directions and levels.
Easy to see the materials used
I like the detail in these i.e. the inside of the roof in comparison to the previous pics.
The overall finish it much easier to look at and understand.

Could you mention three (3) things that you liked the least about the photorealistic rendering of the images presented above?

Staff
Need to consider all weather and time of year lighting
<table>
<thead>
<tr>
<th>Lack of windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of people</td>
</tr>
<tr>
<td>The roof seems like it’s made of cloth or something</td>
</tr>
<tr>
<td>No humans</td>
</tr>
<tr>
<td>Absence of humans... inability to see the proportions between the space of the house and the size of its inhabitants.</td>
</tr>
<tr>
<td>Hearth</td>
</tr>
<tr>
<td>Why don't you use human images?</td>
</tr>
<tr>
<td>Does not allow for other light sources, hearth, lamps, torches etc.</td>
</tr>
<tr>
<td>Empty space</td>
</tr>
<tr>
<td>The angle in the top image</td>
</tr>
<tr>
<td>The light of the coals seem too &quot;electric&quot; &quot;neon like&quot;</td>
</tr>
<tr>
<td>Semi-empty houses</td>
</tr>
<tr>
<td>Walls</td>
</tr>
<tr>
<td>Clean</td>
</tr>
<tr>
<td>I cannot recognize what the object in the corner is in the last one</td>
</tr>
<tr>
<td>No evocations of smell</td>
</tr>
<tr>
<td>Main opening</td>
</tr>
</tbody>
</table>

### Students

<table>
<thead>
<tr>
<th>There is no sense of unity between the different elements of structure and decor. It looks more like a patchwork of things than a habited space.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A photorealistic render of the exterior or animal pen would have been good</td>
</tr>
<tr>
<td>Realistic light representation in the room does make it a little dark and harder to see</td>
</tr>
<tr>
<td>A bit ambiguous</td>
</tr>
<tr>
<td>Picture 2: the red blocks - I’m not sure what they are supposed to be?</td>
</tr>
<tr>
<td>Loss of some of the details on the items in the image due to the shadows.</td>
</tr>
<tr>
<td>Some objects appear to be floating slightly, or not quite fit right in to the photo view.</td>
</tr>
<tr>
<td>Lack of shadowing around</td>
</tr>
<tr>
<td>The images are too dark and harder those than those on the previous page.</td>
</tr>
<tr>
<td>The walls are a little too uniform to be believable.</td>
</tr>
</tbody>
</table>
1.4. The Sun Clock

These images provide an enhanced sense of space/three dimensionality.

![Staff Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

![Students Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

These images provide an enhanced sense of time.

![Staff Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

![Students Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

The fact that they are photorealistic make them more engaging in comparison to the non-photorealistic presented in the previous pages.

![Staff Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

![Students Pie Chart]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree
Virtual reconstructions provide the chance to test hypotheses and the visual impact of archaeological datasets in ways that could not have been possible even by a physical reconstruction.

Is there anything that you would like to add regarding the images and the rationale behind these? Feel free to write about anything you like or dislike about these.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>They seem to assume sunny days, no rain, clouds etc.</td>
<td></td>
</tr>
<tr>
<td>Passing of time on its own is a fact. Associations with other information is crucial. How movement of light affects sleeping quarters, working areas, storage. This relation is lacking but if used then it makes for a great interpretative tool.</td>
<td></td>
</tr>
<tr>
<td>I find it a very interesting idea to represent different times of day, as it enhances the sense of contingency and time. Just a suggestion: what about different weather conditions / seasonal variations?</td>
<td></td>
</tr>
<tr>
<td>The feeling of time passing would had probably been enhanced by having 2 hour steps in between the pictures and going into hours of the day that the light is more dramatically</td>
<td></td>
</tr>
</tbody>
</table>
changed (dawn, sunrise, at night). The light coming from the roof helps but I think it would have given a stronger impression of time passing to see the changes of the light in general inside the house (even if 2 - 3 pictures were just depicting shades at night)

It's true that Virtual reconstructions provide the chance to test hypotheses and the visual impact of archaeological datasets in ways that could not have been possible by traditional methods of illustration but also we must base them on rational methods, to be more trustworthy

And seasonality of light?

You may also need to add how the interior of the house is affected by the light and the smoke of the hearth

<table>
<thead>
<tr>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>The only issue I have is the lack of scale in the images, maybe this could be resolved by adding a person or some other object which could be used as a reference? Other than that, very impressive! Great work!</td>
</tr>
<tr>
<td>Although the quality is excellent, colours being more life-like could make the drawings a little more convincing, although they are overall very accessible and scientific</td>
</tr>
<tr>
<td>I really do not like the non-photo realistic images. I think they look amateurish and I don't find them engaging at all. I don't like the way in which they have been drawn or the 'sketch' appearance of them.</td>
</tr>
</tbody>
</table>
1.5. Lighting Analysis

Formal analysis of virtual reconstructions, such as lighting simulation and analysis, helps to enhance archaeological interpretation.

This particular lighting analysis for Building 1 indicated that no more openings in the superstructure would have been needed, as the large opening existing in the south wall provided sufficient illumination.

The first two images provide the results with 'light meters'. The third one is using the 'pseudocolour exposure control'. The 3rd image, which translates the interior into colours is more understandable since it retains the 3Dimensionality of the building.
Is there anything that you would like to add regarding the images and the rationale behind these? Feel free to write about anything you like or dislike about these.

<table>
<thead>
<tr>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>It assumes that light alone was the sole factor in design, does not consider other factors, such as smoke extraction, stabling of animals inside, internal partitions which may not leave a trace.</td>
</tr>
<tr>
<td>This kind of analysis is really not needed. Windows are not only to add light but also views and smells. The lack of accurate plans make this even more speculative. Also there is no need for this analysis since it is clear that light will be sufficient without the use of scientific jargon. Also if the roof was thatched there is no need for an opening since the smoke dissipates through the reeds.</td>
</tr>
<tr>
<td>Very useful.</td>
</tr>
<tr>
<td>&quot;White colour indicates that light exceeds 500lux. Cooler colours indicate a less amount&quot;. Cooler than white? Red is cooler than white?</td>
</tr>
<tr>
<td>I think that the use of several methods, could provide the best results.</td>
</tr>
<tr>
<td>Maybe the main opening was not that large.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>I really enjoy the last image. However, I find the text difficult to understand and know little about the 'lighting'.</td>
</tr>
</tbody>
</table>
1.6. Experimentations

Since there are several indications from ethnographic parallels and some archaeological evidence that colour was used in houses’ walls, 3D models provided the chance to experiment with these and examine to what extent the perception of space changes.

The images provide a good indication of a sense of space when no natural light was illuminating the building.

These are images which could be used to make the public aware about the structure and the content of Houses from Koutroulou Magoula.
The images provide a better sense of three-dimensionality in comparison to drawings and photographs of the building taken during the excavation.

### Staff
- Gives a good sense of realism and scale
- Use of light
- The idea itself
- These are the only ones the show what closes the door
- Colour on the walls/drawings
- Zig-zag pattern
- I like you use ethnographic parallels
- Play of light and patterns
- The fact such a different suggestion about the appearance of the walls is given after the ones before enhances the feeling that all these are suggestions
- Light from hearth
- I like that you prefer night time.
- The fact that a night time picture is given

### Students
- The light from the hearth fire makes the scene seem very ambient
- Representation of lighting during the night
- These are a lot more interesting than the previous photos
- The patterns helped to make the image feel more real.
- Representation of the prominence of the hearth in the building
- I like the detail
- The images showing how it would have looked in only firelight gives a different and interesting view,
Acknowledgment of the more decorative and colourful possibilities for the building

These images feel more personal and I find them more engaging and interesting. I would stop and look at these images, (probably not the others so much). I like that the focus isn’t just on the structure of the building but also the lives of the inhabitants.

Could you mention three (3) things that you liked the least about the experimentation presented above?

<table>
<thead>
<tr>
<th>Staff</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not allow for internal fixtures animal stabling or partitioning</td>
<td></td>
</tr>
<tr>
<td>Lack of smoke</td>
<td></td>
</tr>
<tr>
<td>The limited range of motifs</td>
<td></td>
</tr>
<tr>
<td>The coals when in a close up don’t look realistic</td>
<td></td>
</tr>
<tr>
<td>No humans</td>
<td></td>
</tr>
<tr>
<td>Maybe my computer screen needs contrast modification, but in the case of this representations, I hardly see anything.</td>
<td></td>
</tr>
<tr>
<td>'Fishbone' pattern</td>
<td></td>
</tr>
<tr>
<td>Light from stars and moon</td>
<td></td>
</tr>
<tr>
<td>How about plaster reliefs?</td>
<td></td>
</tr>
<tr>
<td>If we are in a realistic time where coals are burning and everything else is in its right place why are the pots broken around the hearth? Is that how they were found? It's a bit confusing</td>
<td></td>
</tr>
<tr>
<td>Empty houses</td>
<td></td>
</tr>
<tr>
<td>'Dot and zigzag' pattern</td>
<td></td>
</tr>
<tr>
<td>Where are the people?</td>
<td></td>
</tr>
<tr>
<td>The roof material. Are these stems? They feel too flat</td>
<td></td>
</tr>
<tr>
<td>Random position of patterns</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Students</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimenting with a variety of colours may have been interesting</td>
<td></td>
</tr>
<tr>
<td>Lack of human presence is very noticeable</td>
<td></td>
</tr>
<tr>
<td>Little bit too dark.</td>
<td></td>
</tr>
<tr>
<td>The uniform diffusion of the firelight was a bit unrealistic, although without a video this is hard to solve.</td>
<td></td>
</tr>
<tr>
<td>A wider variety of patterns could also be interesting - perhaps some similar to decorated pottery recovered from the site?</td>
<td></td>
</tr>
<tr>
<td>Hearth does not look particularly realistic</td>
<td></td>
</tr>
</tbody>
</table>
1.7. The Settlement

The first two photorealistic images provide a better indication about how Koutroulou Magoula might have looked like when inhabited in the Neolithic period.

Since the evidence does not provide a clear indication about the image of the settlement, non-photorealistic images are preferable in comparison to the realistic ones.

The images above could be used to show to the general public how a tell settlement would have looked like.
The images give a good sense of space and augment the three-dimensional character of the material evidence.

You prefer a cartoon-like illustration of the settlement (see last image), since the evidence for it is at the moment rather abstract.

To what extent do you agree with the textual interpretation presented at the beginning of this page?

<table>
<thead>
<tr>
<th>Staff</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>33%</td>
<td>18%</td>
</tr>
<tr>
<td>40%</td>
<td>25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Staff</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>33%</td>
<td>18%</td>
</tr>
<tr>
<td>40%</td>
<td>25%</td>
</tr>
</tbody>
</table>
To what extent do you agree with the visual interpretations presented in this page?

Could you mention three (3) things that you liked the most about the construction of the settlement presented above?

**Staff**
- Visualization of the terrain and the general space.
- Helps to imagine how the site looked.
- Non photorealistic images work best.
- Including buildings in different stages of their life-cycle.
- The fact that different suggestions are put in the same drawings.
- Hypothetical photorealistic reconstructions.
- Collapsed building.
- I like the non-photorealistic images.
- Colour palette if better the non-photorealistic would have been better. Do not use grey for sky.
- Sense of space.
- The close ups enhance the sense of space.
- Building under construction.
- The way you shows how Life continues at the rest of the settlement with collapsed building and another the one under construction.
- View of the settlement as a whole.
- In the settlement drawings the non-photorealistic ones give a stronger feeling of space, probably because it is harder to create a realistic feeling for the outside as it was done for the interior of the houses.
- Outdoor paved areas.
- The way you use two different type of roofs.
**Students**

- It presents the different images as hypothetical reconstructions.
- The representation of collapsed buildings and under-construction buildings makes the representations seem more realistic.
- Sense of settlement density.
- Good overview.
- Love the 1st 2 images.
- Multiple view points and angles of the images.
- It explains what we see in the images and what to understand from them.
- The variety in represented structures.
- Idea of the actual size of the settlement in terms of inhabitants.
- Easy to understand and realistic.
- Use of realistic and non-realistic images helps to give a balance between clearer detail and easy to digest information.
- The representation of the entire tell settlement.
- Different possibilities for terrace/ ditch construction.

**Staff**

- Quite clean, ordered and thus simplified (fake) appearance.
- Although it indicates the construction and ruin of the houses, it comes across as more 'lip service' than an actual attempt to investigate it or explain the processes, destroyed spaces can continue to be used, stabling etc.
- Photorealistic photos look clean.
- Absence of people / activities (sense of abandonment).
- I don't understand the ditch very well in the photorealistic ones.
- Cartoon-like illustration.
- Plants.
- I don't prefer photorealistic images.
- There are indications of open roofed areas. Each building could be more complex.
- Cartoon image is more childish.
- Where is time in the photorealistic ones apart from the shades?
- No weather conditions.
- Saddled roofs.
- The Cartoon-like illustration of the settlement after the above images seems to be useless.

Could you mention three (3) things that you liked the least about the construction of the settlement presented above?
Spaces look not lived.
The cartoon like one doesn’t feel more abstract as more like quickly drawn by a child.
No humans.
Scarcity of buildings on the tell.

<table>
<thead>
<tr>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are only two photorealistic images compared to 6 non-photorealistic images!</td>
</tr>
<tr>
<td>Assumption of similarity between the different houses.</td>
</tr>
<tr>
<td>Foreground and background isn’t correct for the last 2 drawings.</td>
</tr>
<tr>
<td>Dislike all the images except the 1st two!</td>
</tr>
<tr>
<td>Only saw a closer view of the non-realistic images, maybe one of the realistic ones would be good.</td>
</tr>
<tr>
<td>The cartoon-like illustration - I just don’t like the art style...!</td>
</tr>
<tr>
<td>Lack of representation of the surrounding terrain and environment.</td>
</tr>
<tr>
<td>Would prefer a pale blue background colour rather than dull grey.</td>
</tr>
<tr>
<td>Imbalance between the number of realistic and non-realistic images.</td>
</tr>
</tbody>
</table>
1.8. Summary

You clearly see the potential of virtual reconstructions as a means to disseminate knowledge to the public.

Virtual reconstructions, either photorealistic or not, offer an augmented sense of threedimensionality.
You realise that virtual reconstructions offer a means of experimentation with the data unlike any other methods or physical reconstructions.

Although the virtual reconstructions of Building 1 are to a great extent hypothetical - working hypotheses, they provide a good sense of three-dimensional space enhancing the flat nature of conventional archaeological records.

Although the model of the settlement is hypothetical - working hypothesis, it provides a good sense of 3D space enhancing the flat nature of conventional archaeological records, also helping to understand how a tell would have looked like when populated.
You understand the way that the modelling process in a three-dimensional programme can enhance the way that archaeological reality is perceived.

Three-dimensional reconstructions should be part of archaeological research projects, the same way as photography, field notes and drawing.

Three-dimensional reconstructions help not only the public, but also archaeologists to understand abstract and problematic archaeological material.
Although the models are three-dimensional the way they are presented through a computer screen make them rather static. If they were presented in a more interactive way the sense of space and three-dimensionality would have been significantly enhanced.

Please add any other comments if you think that they were not covered by the questions.

**Staff**

It needs to be careful, 3D reconstructions can often mislead and frame a picture in the observers mind, considering many are based on hypothetical renderings of scant evidence, the potential of giving an inaccurate and premature image is always present.

Virtual reconstruction can help to visually enhance the archaeological record and understand complex set of data. However, an archaeologists mind should be enough to analyse such data. Great tool to show the role of different hypotheses.

One of the Museum of Athens has 2 3D reconstructions for Athens and Ephesus (If I remember well), and the result presented to the public (where you can move and 'interact) is an absolute disaster both visually and from an educational point of view. 'Interactive' is not necessarily better.

Although I see the merit of the last statement, I don’t think that the static (in the literal sense) nature of the reconstruction at hand poses any kind of hindrance. Yes, a more interactive way might be preferable but what we have here is not at all lacking in offering a very clear 3-D sense.

**Students**

About the last statement: It is even more interesting for the public if they can navigate into the model like in a 360 degrees video, a google street view of the Neolithic.
1.9. Demographics

Choose one or more of the following that characterise yourself.

- You have a good idea of how 3D modelling in computer graphics works
- You use modern/computer-based visualisation tools in your work (CAD, 3D graphics etc.)
- You consider modern/computer-based visualisation tools important (CAD, 3D graphics etc.)
- You use traditional visualisation tools in your work (drawings, photographs, illustrations etc.).
- You consider traditional visualisation tools important (drawings, photographs, illustrations etc.).
- You have read field notes and seen drawings and photographs related to the excavation of Building 1...
- You have studied the archaeological material related to building 1 and the area outside of it
- You are a team member but you have NOT worked as a supervising archaeologist on site
- You are a team member and you have worked as a supervising archaeologist on site
- You have excavated or supervised the excavation of Building 1
- You participated in the excavations of the site as a student
- You are one of the directors of the project
Survey 2

2.1. Alternative Structural Models

*Hypothetical window in the east wall/ house model/ Fire & Smoke*

You find this interpretation useful.

![Staff/Students Pie Chart](chart1)

You like the way that the various elements (figurines, sunlight, fire, smoke etc.) have been added to the scene.

![Staff/Students Pie Chart](chart2)

This image provides a greater sense of space in comparison to those presented in the previous survey.

![Staff/Students Pie Chart](chart3)
Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>more objects: pottery, stone equipment</td>
</tr>
<tr>
<td>The addition of window is highly hypothetical, although it gives more light to the scene and ameliorates object visibility. Few Neolithic house models have no roof; should we then take for granted that Neolithic houses had no roofs as well?</td>
</tr>
</tbody>
</table>

*Stabling animals/close the doorway/internal partitions/Fire & Smoke/food*

You find this interpretation useful.

![Pie chart showing Staff/Students agreement]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

You agree with the level of detail added in the image.

![Pie chart showing Staff/Students agreement]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree
This image provides a greater sense of space in comparison to those presented in the previous survey.

Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please keep in mind that whatever you do, the interior of the house will remain fairly dark. All these details are brilliant, provided the screen used is of good-quality, and the lighting conditions proper for the use of a screen. If not, only dark shades will be easily observable.</td>
</tr>
<tr>
<td>I think some more partitioning would be better.</td>
</tr>
</tbody>
</table>

*Skins covering the door and window/thatch covering the door*

You find these interpretations/experimentations useful.

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td>30%</td>
</tr>
</tbody>
</table>
You agree with the level of detail added in the images.

Staff/Students

![Pie chart showing responses]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

These images provide a greater sense of space in comparison to those presented in the previous survey.

Staff/Students

![Pie chart showing responses]

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
<th>Textiles on the floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile on the floor</td>
<td>This is a comment for all of the above: I am not sure that these images provide a better sense of space than your previous ones. They certainly produce an enhanced sense of reality though.</td>
</tr>
</tbody>
</table>
2.2. Lighting Simulation/Analysis

You find interesting the inclusion of these alternative lighting models.

![Staff/Students survey chart]

You see that virtual reconstructions give opportunities of experimentation unlike any other traditional methods used in archaeology.

![Staff/Students survey chart]

These images and the underlying concepts stimulate discussion about the impact of daylight in the interior and the capabilities of Neolithic people to control/use it during the day.

![Staff/Students survey chart]
Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans in relation with the light coming to the dwelling</td>
<td></td>
</tr>
<tr>
<td>I think you need to somehow work in scales of variable, how much difference of light before it actually matters. You can still eat of its almost dark,</td>
<td></td>
</tr>
<tr>
<td>Very good!</td>
<td></td>
</tr>
</tbody>
</table>
2.3. Experimentations

You realise that such experimentations can initiate discussion/enhance the interpretations about the use and experience of space in the Neolithic.

![Pie chart](image1)

You understand that such experimentations might not be possible by any other means traditionally used in archaeology.

![Pie chart](image2)

This is an interpretation that you haven't thought before.

![Pie chart](image3)
This is an interpretation that you have thought before, but the virtual reconstructions provided the chance to vividly visualise it.

You realise the importance of considering light, darkness and shadows in archaeological reasoning.

Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placement of figurines on &quot;furniture&quot;</td>
</tr>
<tr>
<td>Admittedly, it is a great opportunity to play around with various ideas and excavated material. Experimentation is needed, but we should always keep in mind the actual excavation finds, their exact finding spot and the degree of their preservation; these, unfortunately, restrict our founded hypotheses.</td>
</tr>
</tbody>
</table>
2.4. Humans

The inclusion of human figures changed the way you first saw the reconstructions.

**Staff/Students**

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

The sense of space is enhanced by the inclusion of humans.

**Staff/Students**

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

The sense of scale is enhanced by the inclusion of humans.

**Staff/Students**

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree
You would prefer something more realistic, with an interpretation about relationships and activities.

Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>The gesture of the man gives a ritualistic feeling in the picture. How about a more neutral posture?</td>
</tr>
<tr>
<td>Visualising possible activities (sleeping, knapping stone, lighting the fire, cooking) would be very contributive.</td>
</tr>
<tr>
<td>Very good idea to add humans.</td>
</tr>
</tbody>
</table>
2.5. The Settlement

The addition of human-figures enhanced the sense of space and scale in the reconstructed settlement.

You agree with the interpretations - hypotheses that are presented in these images.

You would prefer something more realistic to better understand the suggested interpretations.
Is there anything else that you would like to add?

<table>
<thead>
<tr>
<th>Staff/Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater variability of houses in terms of doorways, windows, size, etc.</td>
</tr>
</tbody>
</table>
2.6. Summary

The images of the interior of Building 1 presented in this survey give a better sense of space in comparison to those of the previous survey.

You agree that the process of three-dimensional visualisation is ongoing and can be fruitfully applied in a research project only when all people involved in the project provide their feedback and discuss their concerns and ideas.

You agree that virtual reconstructions provide endless ways of experimentation unlike any other means traditionally used in archaeology.
The images presented in both surveys have enhanced your perception of three-dimensionality and space for this particular dataset.

The virtual reconstructions presented in both surveys have given rise to new ideas and interpretations about particular aspects of this dataset.

Which of the reconstructions below you think more representative of Building 1.

- Fig. 1
- Fig. 2
- Fig. 3
- None
2.7. Demographics

- You have a good idea of how 3D modelling in computer graphics works: 2
- You use modern/computer-based visualisation tools in your work (CAD, 3D graphics etc.): 12
- You consider modern/computer-based visualisation tools important (CAD, 3D graphics etc.): 11
- You use traditional visualisation tools in your work (drawings, photographs, illustrations etc.): 13
- You consider traditional visualisation tools important (drawings, photographs, illustrations etc.): 7
- You have read field notes and seen drawings and photographs related to the excavation of Building 1 and the area outside of it: 6
- You have studied the archaeological material related to building 1 and the area outside of it: 5
- You are a team member but you have NOT worked as a supervising archaeologist on site: 4
- You are a team member and you have worked as a supervising archaeologist on site: 4
- You have excavated or supervised the excavation of Building 1: 3
- You participated in the excavations of the site as a student: 2
- You are one of the directors of the project: 

0 2 4 6 8 10 12 14
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