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Understanding and Improving How Communication Formats Influence Lay Comprehension of Financial Information

by

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Abstract

Faculty of Social Sciences

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Understanding and improving how communication formats influence lay comprehension of financial information

By Danni Zhang

To engage with financial information and develop sound financial knowledge are crucial for informed financial decisions. While graphic displays have been largely adopted to impart financial information to the public, it is surprising that scant attention has been paid in finance studies to the efficacy of graphs in facilitating information comprehension for lay individuals. Therefore, this thesis presents three original studies that collectively investigate which types of presentation format (e.g., texts, numbers, and graphs) are more efficacious at helping individuals understand financial information and explores the factors affecting such efficacy. To achieve this, two quantitative studies (Study One and Study Two) were conducted via two sets of online questionnaires, followed by one qualitative study (Study Three) that used think-aloud and think-after methods in one-to-one participant interviews. The questionnaires and interviews were specifically designed to address the research questions in each study.

Study One focuses on the communication of financial probability information. A non-traditional graphic format – icon arrays – has been largely recommended by health communication studies to improve the comprehension of health-related probability information. However, no study thus far has examined whether icon arrays are effective at helping individuals understand probability in the finance sector. Therefore, Study One investigated the ability of icon arrays used alone to communicate financial possibilities compared to percentages and frequency formats. Surprisingly, Study One found that regardless of participants' numeracy, icon arrays used alone did not enhance participants' understanding of financial information. Notably, adding numerical scales in the y-axis in icon arrays compromised the comprehension even more. In contrast, percentages and frequencies appear to be superior in catalysing more accurate financial information comprehension, particularly among participants with lower numeracy.

Study Two addressed the need and investigated the extent to which formats (namely, text-only, graph-only, and text-and-graphs) can assist mortgage novices to better understand mortgage products. In particular, given the frequency of bar charts used in the financial domain, they were employed for the investigation in the study. Interestingly, this study identified that simply combining texts and graphs (cf. text-only or graph-only) to echo the same mortgage information did not achieve a better understanding for mortgage novices with either higher or lower debt literacy. Moreover, those with lower debt literacy achieved better mortgage knowledge from the text-only format, whereas those with higher debt literacy benefited the most from the graph-only format. This finding strengthens the idea that the benefits of utilising graphs to communicate financial information are limited by individuals' relevant prior knowledge. Another important finding was that participants' present preference (i.e., the tendency to overvalue current benefits at the expense of long-term rewards) moderated the influence of presentation formats on the perceived importance of mortgage product characteristics (e.g., monthly repayment). This suggests that graphic displays (cf. texts) may impact on an individual's propensity towards present preference, highlighting the potential visual influence on financial information communication.

Study Three is motivated by the findings from Study One and Study Two. The study explored how individuals engage with, react to, understand and evaluate financial information when it is presented in different formats. Importantly, the study focused on identifying what attributes and premises in icon arrays and bar charts may impede recipients from understanding financial information. The verbal protocol analysis suggests that graphic formats are useful in relaying *gist* information (i.e., general information) but ineffective in ascertaining *verbatim* information (i.e., precise and detail information). Importantly, the study identified the factors that impeded individuals from engaging with and developing a sound financial understanding from graphic displays. Specifically, (1) individuals experience greater difficulty and confusion to process and understand icon arrays-represented information in a financial context, (2) without written texts, advanced graphic comprehension is too arduous and error-prone for individuals to generate deeper insights of financial information and precise financial data, and (3) arresting colours (e.g., red) and patterns (e.g., significant tall bar) in graphs can reduce individuals' attention on less prominent graphic details,

which induces disproportionate weighting and affective reactions towards the represented information.

Overall, the thesis' findings provide valuable contributions to the related body of academic literature. First, it suggests that icon arrays are not effective in communicating financial information, which is different from health communication studies' suggestion. Indeed, the thesis provides further evidence showing that because icon arrays (cf. number-based formats) are rarely used in the finance sector, recipients are confused and experience greater difficulties processing the format and obtaining financial knowledge. Second, the thesis provides new knowledge that the benefits of using multiple formats to disseminate intrinsic financial knowledge are overestimated. Further, the findings from this thesis provide new insights into what kind of factors in multiple formats settings could induce individuals' cognitive overload and then impede the processing of financial information engagement and comprehension. Third, the thesis highlights that graphic displays might be detrimental to financial comprehension and, therefore, could elicit poor financial decision-making. Thus, graphic displays should only be employed in the financial context where there is robust empirical evidence of their efficacy, to which far too little attention has been paid by previous financial research. More research is needed to explore the relationship between presentation formats, financial communication, and financial decisions.

The thesis also provides valuable implications for finance sector practitioners. Communicators should be aware that: (1) uncommonly implemented graphic formats may impede information engagement and understanding, (2) recipients' information capacity and cognitive resources should be given extra attention when imparting intrinsic financial information in multiple formats presentation, (3) the efficacy of presenting graphs alone to impart financial information is constrained, and (4) graphs have visual influences that may unduly bias recipients' information judgement. Overall, this thesis suggests that the traditional formats – namely, written texts and numerical formats – are still the most effective forms in communicating financial information, particularly among those with lower numeracy and financial literacy.

Research Thesis: Declaration of Authorship

I, Danni Zhang, declare that this thesis titled “Understanding and improving how communication formats influence lay comprehension of financial information”, and the work presented in it is my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. 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;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. 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;
5. I have acknowledged all main sources of help;
6. None of this work has been published before submission;

Signature: Date:

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Therefore, with all my heart, I dedicate this thesis to my mum, my aunt, my grandpa, my boyfriend, and of course myself.

Chapter One

Introduction

Introduction

Prolegomena:

This introduction chapter provides an overview of the thesis. First, Section 1.1 introduces the research context and topic of the thesis. It outlines the importance of building effective communication with individuals to better engage with and acquire accurate finance-related knowledge. Research motivations and gaps are then highlighted alongside a brief discussion of the key literature, which concerns the influence of different types of formats in facilitating the comprehension of numeracy-related information, particularly graphic displays. Section 1.2 provides the key research objectives for the whole thesis. Its subsections present each chapter's research aims and methods, as well as their respective findings and contributions. Section 1.3 is a description of the thesis structure.

1.1 Research Background and Motivations

The importance of obtaining a sound financial understanding from information provided

In the last few decades, financial markets have become more accessible and introduced various new products due to technological advancements (Lusardi, 2012). For example, online trading platforms enable individuals to enter and trade in global financial markets more easily (Ning et al., 2014) and online financing allows individuals to access a greater range of loans. Although these changes promote more financial activities, and individuals can be involved in their finances more, the burden of being responsible for making their own financial decisions has increased. There is an increased danger that the increasing range of financial products in the market requires individuals to have a higher ability to understand and evaluate various products. Since financial decisions (e.g., stocks selection, debt decisions, or retirement plans) affect decision-makers' welfare significantly (Lusardi, 2019), they are expected to obtain a sound understanding of finance products from information provided to make informed decisions. For example, it is necessary to understand associated financial consequences and risk when taking out different types of mortgage. Thus, having a good comprehension of financial-related information is crucial for better decision-making.

It seems that, in today's information age, a large amount of financial information is publicly available, suggesting that individuals' financial knowledge and decision-making are enhanced. For instance, websites for banks, finance sector institutions or other statutory organisations (e.g., Money and Pensions Service in the UK) have provided a large body of financial knowledge. However, evidence shows that financial products and financial knowledge remain too complicated for the public to understand (INFE, 2017). Another concern is that excessive financial information is likely to bring additional challenges and require more cognitive resources in information processing and understating. Thus, the value of information for enhancing their decision-making is eventually reduced, regardless of how worthy it is (Sweller, 2010).

As studies found, naïve investors still make suboptimal financial decisions in today's information environment (Disney and Gathergood, 2011, Lusardi, 2012). To illustrate, Miles (2004) suggested that many individual mortgagees in the UK do not fully understand mortgage rates and, therefore, are more likely to underestimate debt costs, and borrow more than they can afford to pay back. More seriously, insufficient understanding of financial information can unwittingly put the economy at risk at both the individual and national levels. For example, immediately preceding the global financial crisis of 2007 to 2008, numerous banks had provided excessive subprime mortgages to thousands of mortgagees. However, those mortgagees subsequently defaulted on their repayments, which suggested they did not sufficiently understand their repayment capacity and the associated financial risks. Unfortunately, empirical research regarding how to facilitate the comprehension of financial information to the public is scarce in the financial domain.

Furthermore, information on financial products contains numbers and abstract financial concepts. To make the best use of financial information, individuals need some level of financial and numerical literacy (Garcia-Retamero et al., 2019). Unfortunately, numeracy and financial literacy in the adult population is very low across many countries, such as in the UK and the US (e.g., Lipkus and Peters, 2009, Lusardi, 2012, INFE, 2017). This is problematic because individuals with lower numeracy or financial literacy are more likely to have difficulties understanding numerical information (Cho et al., 2014, Dawson and Johnson, 2014) and in managing their wealth properly (Lusardi and Mitchell, 2011a). Although financial policymakers have implemented

various "Edu-regulatory techniques" to enhance public financial literacy, those programmes have little or no positive impact on improving individuals' financial knowledge and decision-making (Cole et al., 2012, Fernandes et al., 2014, Sobkow et al., 2020). This indicates that to improve financial literacy for better financial decision-making via education is a long-term programme, and the consequences are uncertain. As Bhutoria et al. (2018) proposed, it is imperative for policymakers to resolve to assist individuals in developing a better understanding of financial information in a different manner.

The importance of identifying effective financial communication formats

Against the aforementioned background, there is a pressing need to explore an alternative communication manner for enhancing laypersons' comprehension of financial information. Cumulative evidence has demonstrated that the way information is presented could affect the extent of information comprehension, cognitive efforts, and decision behaviour, given that differing formats convey the equivalent information content (e.g., Schwartz et al., 1997, Fraser-Mackenzie et al., 2015, Dambacher et al., 2016, Kansara et al., 2020). However, to the best of my knowledge, no study has examined which presentation formats are more productive at helping individuals better engage and acquire accurate financial information. Notably, how the information is presented is the initial stage in information engagement and comprehension phases. Previous financial studies only investigated the relationship between presentation formats and investment behaviours, indicating that presentation formats have altered the individual's risk attitudes and quality of their decision-making (Rubaltelli et al., 2005, Anagol and Gamble, 2008, Bateman et al., 2014, Kansara et al., 2020). Surprisingly, the investigation of the extent to which different presentation formats can help individuals to better understand financial information has not yet been closely examined.

Given the challenges of information comprehension, graphic formats seem to be utilised for improving numerical information understanding. Graphs have been adopted in various domains, such as health, accounting and education, to present numeracy-related knowledge to the public (e.g., Galesic et al., 2009, Garcia-Retamero and Dhami, 2011, Cho et al., 2014, Sithole, 2016,). Its influence for facilitating the comprehension of health-related statistic information has been receiving more attention in health

communication research (Lipkus, 2007, Gaissmaier et al., 2012). Some studies support the idea that graphic formats are more effective than number-based formats at improving health statistic comprehension for both lower and higher numerate individuals (Fuller et al., 2002, Ancker et al., 2006). It has been suggested that graphs have the ability to transform abstract concepts into concrete visual-spatial forms, and visualised patterns allow individuals to observe relationships directly (Cairo, 2012; Yang, 2020). These capacities are assumed to reduce the needs for mathematical computation and numeracy-related information processing. For example, compared to extracting value differences from texts, a bar chart requires less effort to compare numerical values via a simple visual comparison of bar heights (Bertin, 1983, Jones, 2015). Although graphs are widely used in the finance sector – for instance, employing a line chart to demonstrate a stock's performance over time – the research of graphs for enhancing financial information understanding has been largely neglected in the financial literature.

Of particular concern is that graph comprehension is not intuitive to all individuals and some people have problems in understanding graphs (Carpenter and Shah, 1998, Okan et al., 2012, Marlow and Dabbish, 2014). Recent evidence has shown that graphs did not, or only offered limited help to, improve information comprehension. For example, a study by Tait et al. (2012) found no difference in the understanding of medical treatments between text-based formats and graphic displays. Indeed, Bhutoria et al. (2018) showed that more than 60% of their participants misconstrued a simply financial line chart.

More importantly, to promote effective communication to the public, other important factors cannot be taken for granted. One crucial factor is the characteristics of the information being communicated. That is, (1) which disciplines' information is displayed (e.g., finance, accounting, health, or marketing), (2) whether the information is simple or complicated, and (3) how easily the information can be represented in one graph or more than one graph, could affect the efficacy of presentation formats in the communication of information to the public. As a result, the expected effectiveness of graphs in imparting finance-related information may differ from what health communication literature found. It is plausible that financial information is sophisticated and about money, so that individuals may be more intuitive to process

and trust the information presented in written text alongside precisely stated numbers. Specifically, the recent recommended icon arrays graph for enhancing the understanding of medical probability information may be less effective than numerical formats if used for communicating financial probabilities. This might be because icon arrays are rarely implemented in the financial industry, and this unfamiliarity factor could result in more difficulties in acquiring financial knowledge. So far, how these factors have associated with the effectiveness of different types of presentation format on information comprehension has received scant attention in the extant communication literature, particularly the finance literature (for more discussions, see subsections of Section 1.2).

Such a research gap could be because graphic displays were not widely used until the 20th century, and therefore research on the influence of graphic displays remains in its infancy. The development of various graphs to represent statistical information emerged in the 18th century because of an increasing interest in empirical data collection in economic and political domains (Friendly, 2008a). For example, line graphs, as one of the most widely used graphs, were created by the Scottish economist William Playfair at the end of the 18th century. Other statistical graphs (e.g., histograms, time-series plots, or pie chart) were developed during the first half of the 19th century (Wainer and Velleman, 2001, Friendly, 2008b). However, English statisticians appeared to hold little interest in using graphs until the early 20th century. Therefore, the efficacy of graphs and their relative influence remains somewhat unknown. Specifically, there is little understanding of how different graphs affect individuals differently in terms of information processing and comprehension in different contexts.

1.2 Research Objectives

Up to now, no previous study has directly investigated the influence of presentation formats on information comprehension in the financial domain. To fill this research gap, three original research studies were conducted. Although each study was examined and presented as an independent paper, the core of this thesis' objective running through all three studies is to investigate and produce valuable insights into how various kinds of presentation formats (i.e., texts, numbers, icon arrays, bar charts) could affect the extent of comprehension of financial information for the public. Special emphasis was placed on comparing graphic formats and textual (numerical) formats to impart two types of

financial information – probability information and mortgage products. Both qualitative and quantitative methods were used in this investigation. The first two studies were quantitative studies using online surveys to investigate the extent to which present formats (e.g., texts, numbers, icon arrays and bar charts) facilitated laypeople to understand financial information better. These were followed by one qualitative study used interviews to explore how different types of formats motivated and hindered the processes and understanding of finance-related information.

In detail, Study one (Chapter Two) focuses on the examination of whether the non-traditional graphic format, *icon arrays,* are more effective than the numerical formats, *percentages* or *natural frequency,* at helping individuals better understand financial probabilistic information. Study 2 (Chapter Three) was an extension of Study one, but instead of focusing on the infrequently used icon arrays, this study assessed whether the commonly used bar chart as an additional tool to written texts for imparting complicated financial products, *mortgages*, can facilitate naïve borrowers achieve better comprehension, as compared to text-only and graph-only presentation formats. As a continuation, Study Three (Chapter Four) was motivated by the findings from Study One and Study Two. This study took a step further to identify what kinds of challenges hindered individuals from acquiring accurate financial knowledge from icon arrays and bar charts, as well as how such formats could be redesigned to improve comprehension. In short, three studies were designed from different aspects to assess whether the use of graphic formats to communicate finance-related information can facilitate the public to achieve better information comprehension, as compared to the more traditional numerical and textual formats.

A number of insightful findings have merged from these investigations, and substantial contributions have been made. These three studies have collectively documented that graphic displays in communicating finance-related information do not necessarily help laypeople have better comprehension. That is, the thesis findings shed new light on the effectiveness of different presentation formats in communicating finance information. Furthermore, mixed research methods achieved a rich understanding of the relationship between the comprehension of financial information and presentation formats in greater detail and offset possible shortcomings from using a single method. Overall, this thesis provides the first comprehensive assessment of which formats (texts/numbers versus

graphs) can help individuals better understand financial information and identifies what factors affect such efficacy. Specific research motivations, aims contributions, and findings of each core study are presented in the following subsections.

1.1.1 Study One: Are icon arrays effective at communicating financial probability?

Effective communication of financial probability information, such as the probability of loss, is important to help investors understand whether a risk is worth taking. However, evidence shows that probabilistic data (e.g., 15%) are not concrete in nature in comparison to the non-probability data (e.g., £15) and individuals have more difficulties in assessing and understanding probability information (Tyszka and Zielonka, 2017).

Over the past decade, a considerable amount of health communication literature has suggested that, compared to other types of graphic displays or numerical formats, icon arrays format is more effective at facilitating the understanding of health-related probabilistic information. It is claimed that icon arrays represent the probability information into a part-whole frequency form and allow recipients to identify specific representation by simply counting individual icons (Hess et al., 2011). As such, icon arrays are better to help individuals to acquire both general (i.e., gist) and perceived numerical (i.e., verbatim) knowledge (Hawley et al., 2008, Tait et al., 2010). Therefore, icon arrays have been widely promoted in the health practice for communicating medical risk (see Appendix A.1. for examples). Typically, clinician.iconarray.com is a well-known project developed for the promotion of the applications of icon arrays in clinics, which aims to make risk-related probability information more understandable.

Icon arrays are a special type of graphic format that has received significant attention in the 20th century. They are derived from pictographs ("isotype") system which was initially innovated by Otto Neurath to represent economic statistical information rather than health statistics (see Appendix A.2. for the display; Kurz-Milcke et al., 2008, Spiegelhalter et al., 2011). Health decision-making reflects financial decisions in that laypeople have to make decisions with massive uncertainty, so it can be extrapolated that icon arrays could facilitate the comprehension of financial probability information as well. However, the icon arrays is mostly employed in the health communication

sector instead of the finance sector. In the finance industry, icon arrays only occasionally present financial data (see Appendix A.3. for example). Surprisingly, no study has investigated the efficacy of icon arrays as a means to communicate financial probability information and why they are rarely used. In other words, the uneven distribution of icon arrays across domains indicates that there may have been some limitations of applying icon arrays in the finance industry, which needs to be investigated. One possibility is that the appearance of icon arrays may not be a good fit for communicating monetary-related information. That is, recipients could experience some confusion and more uncertainties from icon arrays-presented information than other standard formats such as percentages. As suggested, the selection of probability formats should consider the communicated content (Ancker et al., 2006, Visschers et al., 2009, Smerecnik et al., 2010, Dambacher et al., 2016).

Moreover, the findings of health studies examining the efficacy of icon arrays at improving the understandability of probability information against other types of formats remain inconclusive. The icon arrays investigated in the existing studies were varied in their design (e.g., Hawley et al., 2008, Tait et al., 2010), suggesting that the differences in the usage of icon arrays could be the reasons for inconsistent findings. Specifically, there are two unclear questions about the use of icon arrays: (1) Whether icon arrays should be presented alone or displayed as a supplementary to numerical formats for enhancing probability communication, and (2) whether adding numerical scales in icon arrays will have an impact on the effectiveness of how individuals obtain information (e.g., Hawley et al., 2008, Kreuzmair et al., 2017). I extrapolate that the efficacy of icon arrays may be influenced by how they are presented. Thus, the details of how to use icon arrays need to be better understood.

As mentioned in Section 1.1, an individual's numeracy affects the way they process information and obtain knowledge from presentation formats (Payne et al., 1993). Most studies have found that, compared to higher numerates[1], those with lower numeracy are more susceptible to presentation effects (e.g., Lipkus and Peters, 2009, Reyna et al., 2009). Importantly, Kreuzmair et al. (2016) using eye-tracker, observed that icon arrays did not help lower numerates to generate better precise numerical information. Therefore, it is also necessary to investigate whether individuals' difference in

[1] Higher/lower numerates refers to people with higher/lower numerate ability, respectively.

numeracy affects the efficacy of icon arrays in helping the comprehension of financial information. Additionally, no study has explored whether the effectiveness of icon arrays for financial information communication is affected by individuals' numeracy as well. That is, the relationship of an individual's numeracy associated with icon arrays calls for more research in a different domain.

Summary of Study One

Accordingly, Study One focuses on exploring the efficacy of icon-based formats alone (i.e., icon arrays, and icon arrays with numerical scales) and the effectiveness of standard number-based formats (i.e., percentage and frequency) in promoting individuals' comprehension of gist and verbatim knowledge concerning financial probability information. Further, the study investigated whether the format's efficacy was associated with an individual's numeracy and assessed the individual's subjective perceptions of the format regarding their confidence in obtained information, question difficulty, and format usefulness.

To accomplish these goals, an online questionnaire study was conducted in which 285 participants were randomly assigned to read financial probability information using one of four presentation formats. This study's findings were inconsistent with health communication studies, suggesting that icon arrays used alone is less effective than numerical formats at facilitating individuals to obtain both types of knowledge of financial probability information, regardless of their numeracy. One unanticipated finding was that including a y-axis numerical scale in icon arrays lessened recipients' comprehension even more. This finding provides new knowledge to the extant literature, suggesting that the design feature (i.e., y-axis) of icon arrays affects the accuracy of information understanding, which needs further investigation. Furthermore, the results of examining the icon arrays isolated from numbers and texts could be used to explain the inconsistent results of icon arrays' ability at imparting verbatim information knowledge in the previous studies, which seems to be caused by dissimilar ways of presenting them.

1.1.2 Study Two: How well do commonly used presentation formats facilitate the comprehension of complicated financial information: mortgage products?

Financial products are commonly intricate that need to be understood and interpreted by decision-makers. Typically, mortgage products have several inter-related characteristics, such as total interest cost, monthly repayments, and financial resource allocation changes throughout the mortgage term. These characteristics are difficult to evaluate, especially by individuals with limited debt knowledge (Gathergood and Weber, 2015, 2017a). Mortgage financial regulators and researchers have largely addressed the importance of enhancing mortgage understanding for lay individuals (Lusardi and Mitchelli, 2007). While properly presenting mortgage information is a substantial step to imparting mortgage knowledge, no study has directly explored the extent to which divergent presentation formats can convey mortgage information in an accessible manner to enhance borrowers' understanding.

Written texts are the traditional manner of communicating financial information that directly states numerical information. Graphic displays are an alternative format that transforms financial information into visual-spatial forms; for example, using time-series charts to display the financial changes of mortgage repayments over a mortgage term (e.g., 30-year term). In such a case, texts are better for acquiring precise data, whereas graphs are more suitable for data visualisation (Penrose, 2008). Surprisingly, the use of graphs at communicating complicated financial information has not been investigated, as compared to written texts. In addition, mortgage products include several factors that are unable to be presented in one graph, so more than one graph may increase the difficulties of constructing accurate understandings among graphs. Therefore, empirically investigating graphs alone in communicating complicated mortgage information can provide precise knowledge of their efficacy.

Given that texts and graphs both have their advantages, multiple formats (i.e., presenting both graphs and written texts) are suggested assuming that recipients can develop a better understanding from both visual and verbatim sources (Paivio, 1990). However, the studies that supported multiple formats have not investigated if the communicated information is complicated. Cognitive load theory argues that if one format is sufficiently intelligible to the users, it is unnecessary to provide another type

of format as it has no new benefits for information understanding (Clark and Feldon, 2005, Sweller, 2005). Accordingly, it is important to investigate the influence of presenting both graphic and textual formats (cf. text-only and graph-only) on mortgage comprehension accuracy.

Due to the concern of employing infrequent graphs (e.g., icon arrays) in the financial domain, it is worth using commonly viewed bar charts to impart mortgage information and examine their effectiveness. Bar charts are the most common graphs for imparting numeracy-related knowledge in various sectors such as education, business, or the media (Zacks et al., 1998). Evidence shows that bar graphs are preferred by individuals over other common graphs (e.g., line graphs) and are better for making comparisons (Lipkus and Hollands, 1999; Lipkus, 2007). On the other hand, the extant studies on examining the efficacy of bar charts seem to depict a relatively simple message (see Appendix A.4. for examples; Ali and Peebles, 2013, Okan et al., 2018); that is, the efficacy of bar charts in communicating complicated financial information remains unclear.

As mentioned, debt literacy is another paramount concern when considering mortgage comprehension and decision-making. Borrowers with limited debt literacy are more likely to have difficulties in understanding and analysing mortgage products (Conklin, 2015, Van Ooijen and van Rooij, 2016, Atlas et al., 2017). It is important to identify with which formats that lower debt-literates are more likely to engage with and assimilate better mortgage knowledge. Moreover, evidence shows that graphic displays could affect recipients' judgements on the information provided and decisions made (Chin and Bruine de Bruin, 2019, Walker et al., 2019). This raises a particular concern for the graphically displayed mortgage information. This is because that those borrowers with more focus on current benefits than future benefits (known as "present preference" or "present bias") are more attracted to the mortgage with lower monthly repayment (Agarwal et al., 2014b, Atlas et al., 2017, Gathergood and Weber, 2017a, Xiao and Porto, 2019). Since graphs are able to direct recipients' attention to presented information via prominent patterns (Lipkus and Hollands, 1999, Lipkus, 2007), graphically presented information of monthly repayment and outstanding balance may evoke individuals' intrinsic propensity of present preference, which subsequently affects the evaluation of the importance of such mortgage-related characteristics.

Therefore, it is necessary to investigate whether an individual's present preference will moderate the relationship between presentation formats and the perceived importance of mortgage-related information.

Summary of Study Two

Accordingly, Study Two investigates the effectiveness of three different formats (i.e., graph-only vs text-only vs the combined format) to promote the comprehension of mortgage products, and how they interacted with an individual's debt literacy. The study also sought to examine whether individuals' present preference moderated formats influence the perceived importance of mortgage product characteristics, including "outstanding balance", "monthly repayment" and "total interest cost".

To achieve these aims, another online questionnaire study was undertaken. A total of 183 mortgage novices were randomly allocated to review two types of mortgage presented using one of three formats. The study found that presenting both textual and graphic formats (cf. text-only or graph-only) to iterate the same mortgage information impeded participants' comprehension, regardless of their debt literacy. These findings provide new knowledge that when the information is complex, multiple formats are less beneficial to facilitate information comprehension. Importantly, for individuals with lower debt literacy, the text-only format led to higher comprehension than the graph-only format. This highlights that an audience's prior debt knowledge impacts graphic presentation effectiveness for mortgage information communication. The study also found that the more (cf. less) present-preferred participants are more prone to be influenced by the graphically displayed information, which has a subsequent influence on their perceptions of the importance of mortgage product characteristics. These findings indicate that the implementation of graphic displays in communicating financial information needs to be carefully reviewed and should concern their potential influence on information judgement.

1.1.3 Study Three: How can graphic displays more effectively communicate financial information?

Although research on the efficacy of graphic displays for facilitating comprehension of numeracy-related information is increasingly undertaken, most studies have employed

questionnaire instruments to compare accuracy levels among participants' comprehension. Given the limitations of questionnaires, these studies fail to explore how individuals engage with, obtain and construct knowledge from different presentation formats. Meanwhile, the extant findings are mixed and fragmented (Lipkus, 2007, Hildon et al., 2012). Unfortunately, the underlying reasons behind the inconsistent results are rarely addressed; for example, empirical evidence is lacking to explain why one format (e.g., texts) can be more efficacious than others (e.g., graphs) in communicating financial information in a specific context.

Notably, the results obtained from Study One and Study Two reveal that graphic formats (i.e., bar chart and icon arrays) do not facilitate individuals to better understand financial information, as compared to textual- or numerical-based formats. Although the results from these two studies were compatible with some studies' findings and theories, and suggested some plausible analyses, a more comprehensive study would be valuable to explore why the efficacy of formats is varied in different conditions. That is, it is important to investigate the influence of icon arrays and bar charts in detail and identify what attributes in these graphs can enhance and/or hinder financial information engagement and understanding. Furthermore, the processes of how individuals transform the obtained information in their minds and how such information affects their judgement have received little attention in the literature. However, such exploration can generate some suggestions for financial practitioners to communicate their financial products more effectively with their customers and generate greater trust.

Summary of Study Three

Therefore, Study Three employed qualitative methods aim to investigate individuals' cognitive and affective processes that occurred when financial information was presented in icon arrays, bar charts and written texts.

To this end, I recruited 40 participants, and they were asked to understand two sets of the financial information presented by different formats (i.e., financial probability of stock risk employing icon arrays; mortgage products using text and bar charts). Specifically, the study employed think-aloud and think-afters manners in the interviews to assess participants' levels of information comprehension, cognitive processes, and judgements. Qualitative methods are particularly useful in enriching the results of

previous quantitative studies and contributing new knowledge to the extant literature, which could not be obtained via quantitative approaches (Smith, 2003, Taylor and Trumbull, 2005).

The verbal protocol analysis expands previous literature, suggesting that although graphic displays can facilitate gist knowledge acquisition, they were not effective in helping recipients process and generate deeper insights of financial information compared to textual format. The obvious reasons to emerge from the analysis are that because graph comprehension requires recipients to integrate graph details and construct meanings behind the graphic patterns by themselves, this increases the likelihood of making errors. In contrast, texts state the numerical data and relationships directly, and are thus more straightforward to understand. Ironically, the results demonstrated that while arresting colours (e.g., red and black) in graphs are useful in bringing people's attention to identify gist knowledge, they are more likely to reduce people's attention on other graphic details and then induce incomprehension, disproportionate weighting, and emotional sway. Another important finding is that in terms of financial communication, the standard formats of written texts and numerical forms were preferred by recipients, but graphic displays are evaluated as error-prone and less reliable.

The study also enriches the findings of Study One and Study Two. Its results identified that it was the position of the numbers on the y-axis that misguided participants to obtain inaccurate verbatim knowledge in icon arrays, which provides a new understanding of Study One's findings. Its results also confirmed the speculation that icon arrays are infrequently used in the financial domain which resulted in participants being initially disoriented and having more difficulties in engaging with and understanding financial information. Additionally, its findings contribute to a better understanding of Study Two that using various presentation formats to communicate complicated financial information overwhelmed participants' cognitive processing capacity and, thus, they failed to effectively utilise both visual and verbatim sources to achieve better understanding.

1.3 Structure of the Thesis

This thesis is structured as follows. Chapter Two presents the investigation of the first study concerning the efficacy of icon arrays to enhance the comprehension of financial probability information compared to number-based formats. Chapter Three is Study Two; it presents the influence of bar charts as additional tools to the written texts (i.e., presenting both texts and graphs) to communicate intricate mortgage information compared to the presentation of texts alone and bar charts alone. Chapter Four is Study Three, which introduces how individuals understand financial information when the information was presented in different types of formats. In the last chapter (Chapter Five), the conclusions are drawn, and each chapter's contributions are consolidated. Therefore, Chapter Two, Chapter Three and Chapter Four presented in this thesis investigate different type of formats to impart different kinds of financial information. The relationship between these three chapters is illustrated in Table 1.1.

Table 1.1. An overview of the three research studies presented in this thesis

Study	The investigated financial context	The examined formats	Research aims	Research Method
Study One (Chapter Two)	The communication of financial probabilities.	• Icon-only format. • Icon-scale format. • Percentage format. • Frequency format.	• To examine whether icon-based formats are more effective than number-based formats (i.e., percentage and frequency) in enhancing the comprehension of financial probability information. • To examine the extent to which higher and lower numerates understand the financial probability in different format conditions. • To compare individuals' perceptions of information provided (e.g., confidence in information comprehension) in different format conditions.	Online Questionnaires.
Study Two (Chapter Three)	The communication of sophisticated mortgages.	• Graph-only format. • Text-only format. • Combined format (i.e., both graphs and texts). **Note: the graphs in this study consisted of different types of bar chart.*	• To investigate the effectiveness of different formats (i.e., graph-only vs. text-only vs. the combined format) in promoting comprehension of mortgage products. • To investigate the extent to which higher debt literacy group and lower debt literacy group understand the mortgage information. • To investigate the extent to which individuals' present preference moderates the relationship between presentation formats and perceived importance of mortgage product characteristics (e.g., monthly repayment).	Online Questionnaires.
Study Three (Chapter Four)	Both financial probability information and mortgage-related information.	• Icon-scale only format (probability information). • Combined format (mortgage information).	• To examine why icon arrays did not enhance the understanding of financial probability information. • To investigate how individuals obtain mortgage knowledge when the information is presented by both text and bar charts. • To explore what kinds of factors in the formats inhibited and facilitated the understanding of financial information. • To explore how these formats affected the individual's preferences and judgements in the financial contexts.	One-to-one interviews (via think-aloud and think-after data collection approach).

Chapter Two

Are Icon Arrays Effective at Communicating Financial Probability?

Are icon arrays effective at communicating financial probability?

ABSTRACT

Numerous studies show that the format used to present probability information can significantly influence the ability of individuals to understand it. While most of these studies have examined the extent to which presentation formats influence comprehension of probability information related to health issues, there is a dearth of studies assessing how different formats might influence comprehension of financial probability information. To fill this research gap, I conducted a study in which 285 participants were presented with financial risk information using one of four presentation formats (i.e., percentages, frequencies, icon arrays and icon arrays with numerical scales). It measured participants' (1) level of comprehension via both gist and verbatim knowledge, (2) numerical ability, and (3) evaluation of the information provided. The results showed that icon arrays alone were not effective at helping participants understand financial probabilities and, notably, did not help participants with lower numeracy. By comparison, number-based formats (i.e., percentages and frequencies) were more effective in assisting financial comprehension for both less and more numerate participants. In contrast to the previously observed influence of icon arrays in communicating health-related information, this study indicates that icon arrays may not be an effective format for communicating financial information. It is plausible that this is because the presentation of icon arrays to specifically impart financial information is uncommon and, hence, may require more cognitive effort to obtain the knowledge than number-based formats, particularly verbatim knowledge. The implications of the findings on the communication of financial probability information to individuals with divergent numeracy are discussed.

2.1. Introduction

While financial investments always involve uncertainty about the (future) outcomes, for example, a fund with uncertain loss or return, decision-makers can utilise probability information to make a critical evaluation of their choices to ensure that a selected investment is consistent with their investment goals (e.g., the expected rate of returns and their tolerance of loss). Probability information is produced by professionals to quantify the level of uncertainty about an event's occurrence (Borovcnik, 2015). Specifically, financial risk probability shows the level of the potential losses for an investment in a given time period (Mcneil et al., 2015). For example, a typical probability information tool – Value at risk (VaR) – can be provided in communicating an estimation risk that, if taking fund A, there is a 0.36 probability of losing at least 15% of investment value in an economic downturn. This probability information reflects the risk exposure level that investors might experience. In such a case, financial probability information is a way of evaluating whether an investment is worth playing by comparing it with alternatives. Thus, investors are expected to understand such probability and take it into account for risk analysis of financial decision-making. Also, understanding financial probabilities could reduce the likelihood of investors to largely rely on their gut feelings to make emotional decisions. Thus, accurately understanding the probability inherent in risk is essential for informed investment decisions (van der Bles et al., 2019).

The assessment of probabilities is based on empirical evidence and statistics analysis via experiments, or prediction models constructed from historical knowledge and data (e.g., stock return, economic data: Feller, 2008). A great deal of research has sought to establish better estimation models that quantify uncertainty. However, investors are the ultimate users of the output and how well they utilise such probability information determines its helpfulness. If the financial probability information was not conveyed to investors effectively, the value of the probability information was reduced despite how effective the estimation models are that have been established to quantify uncertainties. Unfortunately, individuals tend to have limited interest in receiving and using probability information in their decision-making, or often make errors in interpreting such information (e.g., Dawes, 1998, Huber et al., 2001, Lipkus, 2007, Amelung and Funke, 2015, Walker et al., 2019). One suggested reason is that probabilistic data (e.g.,

a 5% chance of losing) are not as tangible as non-probability data (e.g., a £15 loss), which can be more directly experienced; therefore, the former are more difficult to understand (Tyszka and Sawicki, 2011). This indicates that regardless of how well a task is performed to produce valid statistical data, it is less useful when the output is not communicated effectively (Mattern et al., 2009).

Ineffectiveness in relaying financial probability information may endanger players in the financial investment environment. Indeed, the lack of awareness surrounding risk and the poorly communicated probability information in financial portfolios containing subprime mortgage instruments were among the reasons for the global financial crisis of 2007-2008. Immediately preceding the crisis, newly innovated financial products such as Collateralised Debt Obligations (CDOs) allowed global institutions to invest large quantities of money without fully understanding the probability for the underlying risk (Simkovic, 2013). The crisis caused many individuals to fall into serious debt, poverty, and homelessness. It also triggered bankruptcies in many large organisations, like Lehman Brothers, and the provision of significant "bailout" loans from central governments.

An individual presented with numerical financial information may need to extract, process, select and utilise both generalised (gist) and precise (verbatim) knowledge quickly and accurately before making any related decisions. The efficacy of this process may be influenced by the way in which the numerical information is presented and by factors such as an individual's numeracy (Peters et al., 2006, Keller and Siegrist, 2009, Garcia-Retamero et al., 2012, Peters, 2012). Differing formats or a simple change in the format presenting numerical content can affect an individual's comprehension and decision-making (Lipkus, 2007, Visschers et al., 2009, Fraser-Mackenzie et al., 2015, Dambacher et al., 2016). This implies that it is important to investigate the impact of the presentation of probability on retail investors' comprehension. Nonetheless, this interrelation is under-researched in the financial literature.

Numerous health communication studies have sought to compare the effectiveness of different formats in presenting probability information to the general public. A non-traditional graphic format – icon arrays, also known as pictographs – has been promoted in communicating probability within health-related information (Ancker et al., 2006,

Garcia-Retamero et al., 2012). Some health communication studies have found that these icon arrays are superior to other types of graph or numerical display in enhancing the accuracy of individuals' comprehension of health probabilistic information (e.g., Galesic et al., 2009, Kreuzmair et al., 2016). However, to the best of my knowledge, no study thus far has examined the ability of icon arrays to communicate probabilistic financial data to lay individuals, as compared to the traditional numerical formats: percentages or frequency. This is important not only because experimental research on the ability of icon arrays to impart probabilistic financial information is scarce, but also as several questions remain unclear on how to use icon arrays optimally.

Consequently, this study aimed to identify how individuals can be helped to better understand financial probabilities and, therefore, become better placed to make more informed financial decisions. Specifically, the study examined whether icon-based formats (i.e., icon arrays and icon arrays with numerical scales) are a more effective approach than number-based formats (i.e., percentage and frequency) for the information communication of financial probability.

The rest of the paper proceeds as follows. Section 2.2 reviews the relevant literature from which the research hypotheses are identified. Section 2.3 describes the methodology employed to test the hypotheses. Section 2.4 presents the results, and Section 2.5 discusses the results. Section 2.6 provides potential limitations for future research, and Section 2.7 is the conclusion.

2.2. Literature Review

2.2.1 Financial Probability Format and Comprehension

Concerning the communication of financial probability information, it is necessary to assist individuals to obtain both gist and verbatim knowledge intuitively and accurately. Gist knowledge represents the ability to identify gross-level information and ordinal relations between quantities from the provided content, whereas verbatim knowledge refers to the ability to extract the quantitative information from the presentation (Reyna, 2004, Feldman-Stewart et al., 2000, Gaissmaier et al., 2012, Reyna, 2012). For example, the presentation of probabilistic information is expected to facilitate individuals in identifying stocks with the lowest risk or highest potential return from several that are

recommended, without specifying exactly how much the potential risk is lower or potential return higher (Feldman-Stewart et al., 2007). Gist knowledge can be used initially to identify which options are in line with an investor's financial goals. After the preliminary selection, it is necessary to ascertain the precise differences in the probability of loss or return between the options. In finance, as little as 1% or 2% difference can have a significant monetary impact. Therefore, the best way to present probability information for informed financial decisions should embrace the processing of both types of knowledge.

Probability formats can be presented in either numerical or graphic formats. Percentage (e.g., 36%) and frequency (e.g., 36 in 100) are two standard numerical formats that are commonly used in the financial industry (Schapira et al., 2001). For example, investors may be informed that the fund has a 36% chance, or, similarly, a 36 in 100 chance[2] of declining in value by at least 5% during the three-month time frame. These formats allow recipients to better gather verbatim knowledge by simply reading from numbers and lead to a more precise understanding of risk than graphic displays offer (Feldman-Stewart et al., 2000). Also, they are easily transformed from one form to another (Lipkus, 2007). The study by Girotto and Gonzalez (2001) suggests that as long as percentages and frequencies are presented the same denominator rate (e.g., "36 of the 100 people tested were infected" corresponds to "a 36% chance that a person was infected"), these two formats support adequate statistical reasoning.

Graphic displays are considered superior in conveying gist knowledge over numerical formats, but not in imparting verbatim knowledge (Hawley et al., 2008, Gaissmaier et al., 2012). Nevertheless, Tait et al. (2010) found that icon arrays can improve both gist

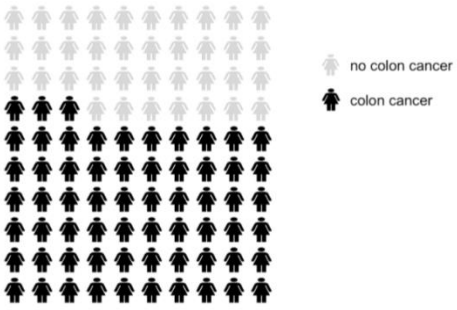
[2] Gigerenzer and Hoffrage (1995) suggested two types of frequencies: natural frequencies and relative frequencies. A natural frequency is derived from natural sampling; however, a relative frequency is normalised numbers (see Gigerenzer, 2000). Although Hoffrage et al. (2002) argued that the expression of "numbers of chances" are natural frequencies, the "X in 100 chance of losing" used in the current study is relative frequencies. As mentioned in Section 2.1, financial probability information is quantified on the basis of statistic models, which follows normalised frequencies. Additionally, the representation of frequency in the extant health communication studies used relative frequencies for their investigations as well (for an example see Tait et al., 2012). It is worth addressing that the focus of this study was the comparison between graphic format and the numerical formats rather than the difference between percentage and frequency formats. More research on probabilistic reasoning and the representations between natural frequency and relative frequency in the financial domain would be fruitful for future research.

and verbatim knowledge of probabilistic health-related information. Icon arrays consist of a matrix of icons (e.g., stick figures, circles, squares, or other symbols). The display is usually 100 or 1000 icons set out in a uniform grid pattern that represents a total population, with a portion of the icons denoting the number of individuals expected to experience an adverse event (usually highlighted by a darker colour) and the number of individuals not expected to experience that adverse event (usually highlighted by a lighter colour: Galesic et al., 2009). Figure 1 demonstrates an example of icon arrays, which is used for the communication of health-related information derived from data. The authors use different colours to classify proportional information into disentangled categories; therefore individuals can identify gist information easily by comparing highlighted and non-highlighted icons from the overall content provided (Garcia-Retamero et al., 2012, Okan et al., 2012). Further, icon arrays enable individuals to identify discrete units of probabilistic information – namely, verbatim knowledge – by counting icons and rows in the graph (Ancker et al., 2006, Zikmund-Fisher et al., 2008, Fagerlin et al., 2011). Thus, icon arrays may be applicable in promoting the comprehension of financial probability information. Surprisingly, this has been largely neglected.

On the other hand, icon arrays (cf. percentage or frequency formats) are rarely implemented to impart financial information; thus, individuals may find it less intuitive in acquiring the financial knowledge sought. That is, the impact of the context in which the probability is communicated can influence a format's effectiveness (Ancker et al., 2006, Visschers et al., 2009). More importantly, the extant studies that explore icon arrays' efficacy reveal inconsistent findings. For instance, Hawley et al. (2008) found that icon arrays conferred lower levels of verbatim knowledge than tables (i.e., in frequency format). In contrast, Tait et al. (2010) found that icon arrays were superior to text and tables in facilitating the comprehension of both gist and verbatim knowledge. These inconsistent findings might be due to different presentation forms of icon arrays examined in their experimental conditions. The display of icon arrays in Tait et al.'s study alongside frequency and percentage explains the probability information (see Appendix B.1.), while Hawley et al.'s icon arrays condition did not include any numerical information. A further study by Tait et al. (2012) found that the text which used both percentages and frequency to communicate the probability information of

medical treatments was shown to be as equally effective as icon arrays were. Other studies also found that, compared with the presentation of numerical information alone, adding icon arrays as an additional format did not improve laypersons' comprehension of Bayesian statistics (Micallef et al., 2012, Ottley et al., 2012). Therefore, the existing literature is not clear on whether the benefits of using icon arrays to present probability information can be achieved by their sole usage or in concord with other means.

Moreover, the assessment of gist knowledge in the previous health communication studies allowed participants to review the provided probability when they were asked to answer the gist questions (e.g., Hawley et al., 2008, Tait et al., 2010). Nevertheless, the valuation of presented formats should also consider whether they can assist individuals in storing general knowledge effectively. This is because short-term memory is referred to as the initial stage of information processing that can indicate how individuals process raw information and encode the obtained knowledge and, in turn, make a decision (Birnberg and Shields, 1984, Kida et al., 1998, Grossman and Welker, 2011, Ding et al., 2017). Furthermore, whilst some icon arrays studies included a y-axis numerical scale (also known as referent scale) in icon arrays, some did not (see Appendix B.2. for examples). It has been reported that numerical scales are important for individuals to identify the referents of different regions in icon arrays and the referents of specific numerical values in graphic displays (Feldman-Stewart et al., 2007, Zikmund-Fisher et al., 2008). Unfortunately, whether including numerical scales in icon arrays will assist the accuracy of information understanding has been largely neglected by the previous research.



(*Source from: Kreuzmair et al., 2017*)

Figure 2.1 Example of icon arrays

2.2.2 Numeracy, Comprehension and Formats

Evidence shows that individuals' numeracy has crucial influences on their financial activities and decisions made (e.g., Gerardi et al., 2010, Costa et al., 2020, Sunderaraman et al., 2020). For instance, Lusardi and Mitchell (2011a) found that investors who were unable to calculate a 2% interest rate are less likely to make and manage retirement plans successfully. Furthermore, individuals' numeracy is positively associated with the likelihood of their engagement in financial investment, such as in stocks or retirement plans (Christelis et al., 2010, Almenberg and Widmark, 2011, Lusardi and Mitchell, 2011b). This seems plausible; since individuals with lower numeracy (hereafter referred to as "lower numerates") have less ability and confidence in accurately comprehending finance-related information, so they find it more challenging to manage their finances properly and are more likely to unwittingly expose themselves to financial risk. Therefore, lower numerates need a means to access and process financial information, augment their confidence in doing so, and thereby facilitate their financial comprehension from such means.

The vulnerability of lower numerates is observed in health communication studies. It has been demonstrated that lower numerates are more influenced by probability formats, whereas those with higher numeracy (hereafter referred to as "higher numerates") are less influenced or even unaffected by probability formats (Lipkus and Peters, 2009, Traczyk and Fulawka, 2016, Garcia-Retamero et al., 2019). Individuals' numeracy also affects how they process the presented format and obtain knowledge from it (Peters et al., 2006). Specific to icon arrays, lower numerates tend to compare the relative areas between highlighted and non-highlighted icons, while higher numerates tend to count icons (Hess et al., 2011, Kreuzmair et al., 2016, Kreuzmair et al., 2017). Importantly, some studies disputed that graphs are not always equally helpful for everyone (e.g., Okan et al., 2012). It extrapolates that lower numerates may experience higher cognitive burden to understand financial information because, apart from the difficulties inherent in doing so, they need additional effort to grasp the uncommon icon arrays format first. Therefore, it is necessary to explore whether these recommended icon arrays formats are beneficial for individuals with lower numeracy in their achieving an understanding of financial probabilities.

2.2.3 Perceptions of Formats used to Present Financial Probability Information

It is valuable to examine how individuals perceive format helpfulness and their own confidence in their information understanding. Health communication studies have revealed that when people recognise presented information as trusted and helpful, their self-efficacy is increased, and thereby their uptake of that information too, leading to increased participation in more optimal decision-making (Schapira et al., 2006, Hawley et al., 2008). Other similar studies have claimed that individuals might be less engaged with information if they dislike the presented formats (Stone et al., 2017, Okan et al., 2018). Importantly, some health communication studies have documented that individuals' preferred formats were inconsistent with their objective performance in understanding information (Feldman-Stewart et al., 2000, Hildon et al., 2012, McCaffery et al., 2012, Micallef et al., 2012). Thus, it is worth exploring how individuals make judgements between icon-based and number-based formats to impart financial probability information. This could also provide for a more precise understanding of which format is more suitable and thereby recommended for use across the financial domain.

2.2.4 Rationale of the Study and Hypotheses

The aim of the study was to investigate the efficacy of different presentation formats in helping individuals understand information on financial probability. To this end, I designed a study on the probability of loss from three hypothetical financial investments. The study presented participants with financial information using one of four probability formats: percentage, frequency, icon arrays and icon arrays with numerical scales. It assessed participants' extent of gist and verbatim comprehension and their evaluations of the information provided. The study manipulated the (1) probability formats (i.e., number-based vs icon-based) and (2) design features in icon arrays (i.e., icon arrays vs icon arrays with numerical scales). Based on the earlier discussions, the study investigated three research hypotheses concerning different types of presentation format used in communicating financial probability information.

1 In line with extant findings, this study hypothesised that icon-based formats (i.e., icon-only and icon-scale conditions) will facilitate greater gist comprehension of

the probability of loss from financial investments, compared with number-based formats (i.e., percentage and frequency conditions). However, number-based formats are expected to facilitate greater verbatim comprehension of the probability of loss from financial investments than icon-based formats do.

2 The second aim of this study was to explore the extent to which higher and lower numerates understand financial probability under different presentation format conditions. Given that icon arrays have been infrequently used in the financial domain, it is hypothesised that number-based information will more effectively help lower numerate individuals to understand the probability information of loss from financial investments than icon-based information will. In contrast, higher numerates are expected to have consistent comprehension performance across different probability formats.

3 As discussed, number-based formats are more familiar to the general public. The third hypothesis was that number-based information will result in higher confidence in information comprehension, less difficulty in undertaking comprehension assessment tasks, and higher ratings of format helpfulness in facilitating the comprehension of financial probability than icon-based information will.

2.3. Methodology

2.3.1 Participants

All participants were recruited from Prolific Academic (www.prolific.ac), an online research-focused platform that provides access to an online pool of participants. Research has consistently documented that participants from this source produce better response and completion rates, and also provide higher-quality data than those from other platforms (e.g., Amazon Mechanical Turk, CrowdFlower; see Peer et al., 2017, Adams et al., 2020). As suggested, its participants are more attentive, naïve, honest, and diversified by education, income, age, and geographical location, among other variables. On the other hand, the response time tends to be slower in Prolific (cf.

MTurk), which requires a longer time to collect sufficient data. This might because Prolific has a smaller population (Palan and Schitter, 2018). Prolific itself also highlights that its participants are slightly younger in age and tend to have undertaken higher education (Prolific Team, 2018). Thus, the platform provides pre-screening filters to ensure the recruited participants are eligible to participate in the study.

To be eligible to participate in this study, they had to be UK residents, 18 years old or older, have English as their first language, and have an average Prolific approval rating equal to or greater than 98% from all of their previous Prolific studies. A total of 414 participants were recruited. Each one received £1.15 for their participation. In the survey, an instructional manipulation check (IMC) was placed in the middle of the survey to detect inattentive participants (Oppenheimer et al., 2009). A total of 122 participants failed the IMC and were therefore excluded from the sample. An additional seven participants were excluded for providing invalid answers or insufficient data or exceeding the response time threshold of 30 minutes. Therefore, the final sample comprised 285 participants. In total, the questionnaire took an average of 11 minutes per participant. Table 2.1 provides the demographic characteristics of all the participants.

Table 2.1. Description of the sample under each format condition

	Percentage	Nature Frequency	Icon-only	Icon- Scale	Population (total)
Group Size	68 (23.9 %)	75 (26.3%)	72 (25.3%)	70 (24.6 %)	285
Gender					
Male	32 (47.1%)	36 (48.0%)	36 (50.0%)	35 (50.0%)	139 (48.8%)
Female	36 (52.9%)	39 (52.0%)	36 (50.0%)	35 (50.0%)	146 (51.2%)
Education					
Lower educated	36 (52.9%)	32 (42.7%)	38 (52.8%)	31 (44.3%)	137 (48.1%)
Higher educated	32 (47.1%)	43 (57.3%)	34 (47.2%)	39 (55.7%)	148 (51.9%)
Experience in Financial Investment					
Yes	22 (32.4%)	21 (28.0%)	12 (16.7%)	25 (35.7%)	80 (28.1%)
No	46 (67.6%)	54 (72.0%)	60 (83.3%)	45 (64.3%)	205 (71.9%)
Age (average age = 39.5)					
18-30	20 (27.0%)	16 (21.6%)	19 (25.7%)	19 (25.7%)	74 (26.0%)
31-40	21 (23.9%)	25 (28.4%)	24 (27.3%)	18 (20.5%)	88 (30.9%)
41-50	11 (18.0%)	14 (23.0%)	18 (29.5%)	18 (29.5%)	61 (21.4%)
51-60	11 (26.2%)	13 (31.0%)	6 (14.3%)	12 (28.6%)	42 (14.7%)
61-75	5 (25.0%)	7 (35.0%)	5 (25.0%)	3 (15.0%)	20 (7.0%)

Note: All the variables show no statistically significant difference between the four formats' conditions.

[a] *Lower education < Bachelor's degree (= No schooling completed - Vocational/technical qualification), Higher educatsion ≥ Bachelor's degree (Bachelor's degree - Professional degree).*

2.3.2 Design and Material

All respondents were asked to imagine that they have a certain amount of savings, which they plan to invest in the stock market. They were then asked to imagine that their financial advisor had selected three stocks (Stock A, Stock B or Stock C), each of which varied in risk, for them to choose from. The risk was defined in the scenario; that is, in the chance of losing a portion of the value they invested in the stock in the short term. For each stock, the information describes the estimated risk of losing at least a quarter of their initial investment if the worst economic conditions occur in any given year. That is, Stock A, B and C had a 36%, 48% and 24%[3] probability of losing at least a quarter of the investment in a given year, respectively.

I used a between-subjects design in which the participants were randomly assigned to one of four conditions. In each condition, the format used to describe the probability of loss for Stocks A, B and C differed. The four formats were (1) percentages (e.g., 36% chance), (2) frequencies (e.g., 36 in 100 chance), (3) icon-only, and (4) icon-scale. The icon arrays consisted of 10×10 icons and were filled from the bottom up with black human figures to represent the number of people who lost at least a quarter of their investment, and grey human figures to represent the number who lost less than a quarter of their investment. While the icon-only format featured no numerical data, the icon-scale format included numbers increasing by 10 (e.g., 0, 10, 20… 100) to correspond with each row of 10 icons. As discussed in Section 2.1, the numerical scale is a key referent that might affect graph interpretation; thus, I included both icon-only (Figure 2.2) and icon-scale (Figure 2.3) conditions in this study to explore whether the inclusion of scales in icons arrays influences comprehension levels. All the icon arrays formats were created by a well-established website, iconarray.com. The full instructions, scenario information and format conditions are in Appendix B.3. Appendix B.4.

[3] The range of risk probabilities was based on the work of Dolan et al. (2012). They suggested that icon arrays are more effective in communicating the outcome range between 0.01 and 0.5. To ensure consistency, the denominator was 100 for all conditions. Previous studies have documented that it is easier to engage with and understand the magnitude of risk probability when the denominator is 100 or, similarly, visualised 100 persons compared to larger denominators (Viscusi, 1992, Schapira et al., 2001). Moreover, to have a consistent comparison with Hawley et al.'s (2008) findings, the author designed the numerical difference between each Stock to be 8, which was the same as their design. Also, because Stock B was twice the size of Stock C, this design was expected to benefit both lower numerates and higher numerates to easily recognise the difference, regardless of graphic or numerical conditions.

includes all questions corresponding to the outcome measures, which were described above.

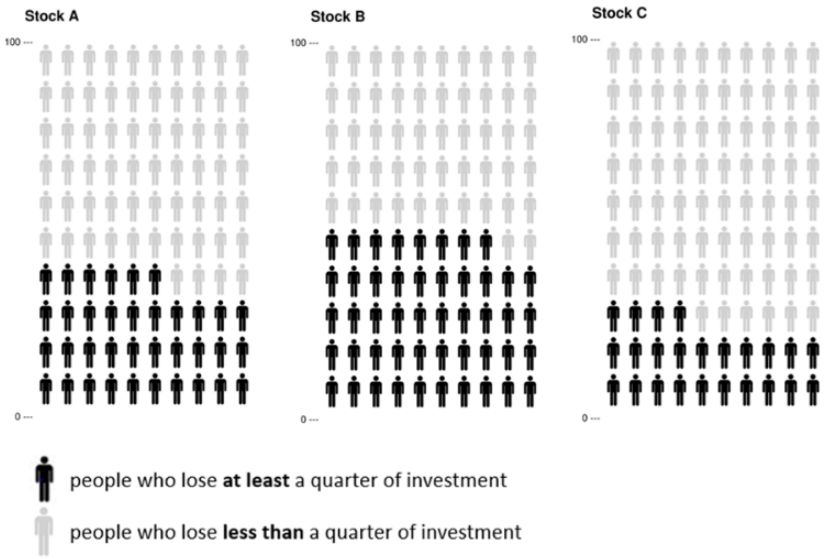


Figure 2.2 Icon-only condition

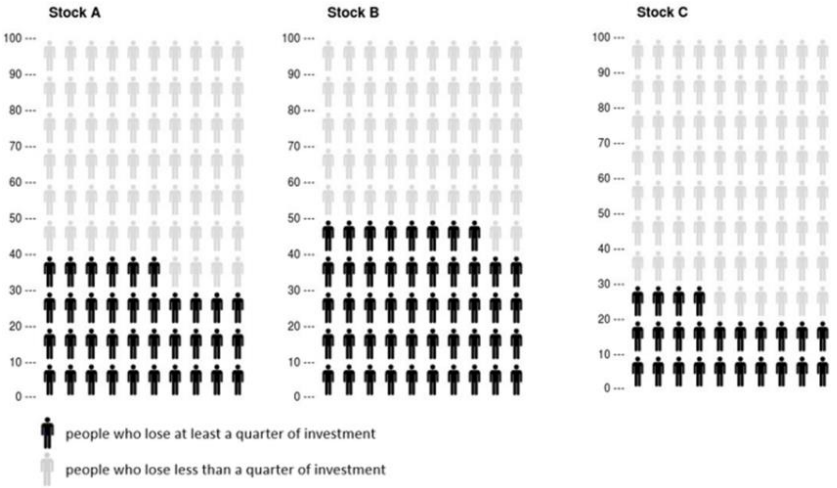


Figure 2.3 Icon-scale condition

2.3.3 Outcome Measures

2.3.3.1 Comprehension of Risk Probability

The primary assessment was the comprehension of the probability of loss across three financial stock holdings. This was comprised of both gist and verbatim knowledge as indicators in the assessment, demonstrated via the number of correctly answered questions.

Four questions were used to measure participants' gist knowledge in identifying some basic comparison information about three stocks' associated risk. For example, one question asked, "*Which stock has the lowest risk*?" with the response options "*Stock A, Stock B or Stock C*". Since it is important to assess the difficulty participants experienced to encode and recall gist knowledge, they were not allowed to review the previously provided risk probability until the next assessment of verbatim knowledge. However, the instruction page specified that participants needed to pay close attention to the information presented because it may be no longer visible.

Three questions were used to assess how precisely participants had understood the probability of any financial loss arising from holding the three stocks. These questions evaluated participants' ability to perform mathematical operations based on the presented information. For instance, one question was, "*What is the difference in the likelihood of risk between Stock A and Stock C?*" and the response options in the percentage condition were "*A: 0%, B: 12%, C: 25%, D: 24%"*.

2.3.3.2 Respondent Perceptions of the Information Provided

The study used four items to measure participants' perceptions of information provided – namely, their performance confidence, the question difficulty, their information understanding, and the format helpfulness.

The four questions were: (1) "*Using the scale, please indicate how confident you felt when answering the above questions about stock risk information from Q1 to Q8*"; (2) "*Using the scale below, please indicate the extent to which you found the numerical questions in section II above from Q1 to Q8 easy/difficult to answer*"; (3) "*Using the scale below, please indicate the extent to which you found it easy/difficult to understand*

the information about Stocks A, B and C that you viewed at the beginning of the questionnaire"; (4) "*Using the scale below, please indicate the extent to which you believe that the way the information was presented would help you understand the risks associated with other financial investments in the future*". The evaluation scale for these questions used a 1-10 scale, with 1 being the lowest favourable rating and 10 the highest favourable rating. For example, 1 was very unconfident and 10 was very confident.

2.3.3.3 Measurement of Numeracy and Sociodemographic Characteristics

As per Garcia-Retamero and Hoffrage (2013), this study assessed each participant's numeracy using the 11 items developed by Lipkus et al. (2001) and Schwartz et al. (1997). Five sociodemographic questions asked the participants to indicate their age, gender, education level, financial investment experience, and income.

2.3.4 Data Analyses Overview

To examine the research questions, multiple linear regressions were conducted to assess the effect of the independent variables (i.e., the four different probability formats) on the dependent variables (i.e., the level of comprehension and perceptions of presented information). The icon-scale condition served as the reference category in the regressions. In all regression tests, education, age, financial experience, numeracy (except Hypothesis 2 testing) and gender were control variables because extant studies found that these factors might influence the performance of individuals in comprehending numerical information to some extent (Powell and Ansic, 1997, Bernheim, 1998, Hyde, 1990, Agnew et al., 2008, Bateman et al., 2014, Hastings et al., 2011, Lusardi and Tufano, 2015). It further employed post hoc analyses with Least Significant Difference (LSD) to access all pairwise format comparisons of dependent variables. For Hypothesis 2, the median numeracy score was used to define the higher and lower numeracy groups (Schwartz et al., 1997, Lipkus et al., 2001, Hawley et al., 2008). It follows that the further multiple regressions separately assessed the effectiveness of each presentation format for just the higher and lower numeracy participants, independently. Meanwhile, the mean number of gist and verbatim knowledge questions that were answered correctly for each format between higher and lower numerates were compared using Independent *t*-tests.

2.4. Results

2.4.1 The Performance of Gist and Verbatim Knowledge (Hypothesis 1)

The results of the regression analyses to test Hypothesis 1 are shown in Table 2.2. For gist knowledge, the finding is unexpected. Participants in the icon-scale condition had significantly lower gist knowledge than participants in either the percentage (β = 0.470, t = 2.530, p = 0.012) or frequency conditions (β = 0.448, t = 2.457, p = 0.015). There was no significant difference in gist comprehension between icon-only and icon-scale conditions (β = 0.267, t = 1.438, p = 0.152). In addition, the Post hoc analyses did not identify any statistical difference between icon-only, percentage and frequency in gist comprehension (the lowest statistical values: M_{est} = 0.238, SE = 0.184, p = 0.197). For verbatim knowledge, the finding is also of interest. Participants in the icon-scale condition had significantly less verbatim knowledge than participants in all three other formats (percentage: β = 0.414, t = 4.243, p = 0.000; frequency: β = 0.316, t = 3.310, p = 0.001; icon-only: β = 0.236, t = 2.423, p = 0.016). The Post hoc analyses only revealed that the percentage format resulted in marginally significant better verbatim knowledge than the icon-only condition (M_{est} = 0.194, SE = 0.102, p = 0.058).

Furthermore, the regression analyses observed that participants' numeracy had a significant positive relationship with both gist and verbatim comprehension (gist: β = 0.139, t = 3.169, p = 0.002; verbatim: β = 0.092, t = 4.015, p = 0.000), suggesting that participants with higher numeracy ability had better comprehension of the financial information provided. Despite the regression analysis, Table 2.3 reports the mean number of gist and verbatim knowledge questions that were answered correctly in each format. It portrays a general picture that participants in the percentage format (cf. icon-only, icon-scale and frequency) required less time to achieve better comprehension of both types of financial knowledge. Additionally, although participants in the icon-scale condition spent less time processing and answering the questions than those in the icon-only condition did, the icon-only condition imparted better knowledge of financial probability information.

In sum, Hypothesis 1 is partially accepted. Contrary to my expectations, the icon-based format did not assist the participants in gaining better gist knowledge of financial information. Meanwhile, in line with expectations, the number-based formats did

facilitate their achieving better verbatim knowledge of financial information. In fact, participants in the icon-scale condition had the least adequate understanding of the financial probabilities. In relative terms, the percentage format was more effective at helping the participants understand the financial probability information than the other three formats were.

Table 2.2. Results of multiple regressions

Dependent Variables	**Gist Knowledge**		**Verbatim Knowledge**		**Performance Confidence**		**Questions Difficulty**		**Information Understand**		**Information format Helpfulness**	
Independent Variables	*Coeff (Std. Error)*	*t (p)*	*Coefficient (Std. Error)*	*t (p)*	*Coefficient (Std. Error)*	*t (p)*	*Coefficient (Std. Error)*	*t (p)*	*Coefficient (Std. Error)*	*t (p)*	*Coefficient (Std. Error)*	*t (p)*
Percentage	.470 (.186)	2.530* (.012)	.414. (.097)	4.243*** (.000)	.671 (.370)	1.815† (.071)	.370 (.344)	1.075 (.283)	.835 (.338)	2.470* (.014)	-.214 (.406)	-.527 (.599)
Frequency	.448 (.182)	2.457* (.015)	.316 (.096)	3.310** (.001)	.441 (.363)	1.215 (.225)	.043 (.337)	.126 (.900)	.466 (.331)	1.406 (.161)	-.050 (.398)	-.125 (.901)
Icon-Only	.267 (.186)	1.438 (.152)	.236 (.097)	2.423* (.016)	.332 (.370)	.898 (.370)	.786 (.344)	2.286* (.023)	-.100 (.338)	-.297 (.767)	-.305 (.406)	-.751 (.453)
Icon- Scale	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*	*Refer*
Sum of Numeracy Score	.139 (.044)	3.169** (.002)	.092 (.023)	4.015*** (.000)	.158 (.087)	1.814† (.071)	.120 (.081)	1.479 (.140)	.092 (.080)	1.161 (.247)	-.124 (.096)	-1.297 (.196)
Age	-.004 (.006)	-.657 (.512)	-.001 (.003)	-.212 (.832)	.003 (.011)	.232 (.817)	-.003 (.010)	-.259 (.796)	.004 (.010)	.413 (.680)	.008 (.012)	.703 (.483)
Education	.031 (.048)	.638 (.524)	.079 (.025)	3.137** (.002)	-.080 (.096)	-.835 (.405)	.014 (.089)	.154 (.878)	.091 (.088)	1.036 (.301)	-.091 (.105)	-.864 (.389)
Experience	-.113 (.163)	-.692 (.490)	-.009 (.085)	-.110 (.913)	-1.335 (.324)	-4.118*** (.000)	-1.460 (.301)	-4.843*** (.000)	-1.011 (.296)	-3.414** (.001)	-.422 (.356)	-1.186 (.237)
Gender	-.046 (.135)	-.342 (.732)	.071 (.071)	1.005 (.316)	-.478 (.269)	-1.777 (.077)	-.437 (.250)	-1.748† (.082)	-.226 (.246)	-.920 (.358)	.403 (.295)	1.366 (.173)
R (R^2)	.296 (.061)		.415 (.148)		.362 (.106)		.389 (.099)		.172 (.002)		.296 (.061)	

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 285 participants.*

[a] *Dummy variable for the formats, icon-label format served as the reference category.*

[b] *Dummy variable for financial experience, coded 1 = no financial experience and 0 = had financial experience.*

[c] *Dummy variable for gender, coded 1 = female and 0 = male.*

[d] *Numeracy, age and education were at original values (continuous variables).*

Table 2.3. Participant's mean number of gist and verbatim knowledge questions that were answered correctly and subjective perceptions under each format condition

Format conditions	Gist Knowledge (mean score of correct: range 0-4)	Verbatim Knowledge (mean score of correct: range 0-3)	Performance Confidence (the rating range 1-10)	Questions Difficulty (the rating range 1-10)	Information Understanding (the rating range 1-10)	Format Usefulness (the rating range 1-10)	Response Time (seconds)
Percentage	3.28	2.75	7.12	6.93	7.85	6.78	625.32
Frequency	3.29	2.69	6.87	6.57	7.49	6.88	650.43
Icon-Only	3.06	2.56	6.60	7.13	6.75	6.63	680.51
Icon-Scale	2.83	2.36	6.50	6.63	7.09	6.97	653.99
Overall	3.12	2.59	6.77	6.81	7.29	6.81	652.91

Note: Data are presented as a mean based on participants' corresponding scale. A total of 285 participants.

[a] *The higher the score of the comprehension knowledge indicates a better information understanding.*

[b] *The higher the rating of subjective perceptions indicates more positive evaluation (where 10 = maximum response. e.g., very confident, very easy to understand,etc.).*

2.4.2 The Performance of Higher and Lower Numerates (Hypothesis 2)

To learn more about the influence of probability presentation formats on higher and lower numerates, I used the median numeracy score of 9 as the cut-off value to split the participants into higher (> 9) and lower (≤ 9) numerate groups. The former and latter included 150 and 135 participants, respectively.

Statistically, the regression analyses of the effectiveness of each presentation format for just the higher and just the lower numerate participants are reported in Table 2.4 and Table 2.5, respectively. The results demonstrated that for higher numerate participants, there was no significant difference in gist knowledge between the icon-scale condition and the other three conditions (percentage: $\beta = 0.303$, $t = 1.185$, $p = 0.238$; frequency: $\beta = 0.369$, $t = 1.572$, $p = 0.118$; icon-only: $\beta = 0.313$, $t = 1.202$, $p = 0.231$). However, verbatim knowledge was significantly lower among higher numerates in the icon-scale condition compared to the other three conditions (percentage: $\beta = 0.466$, $t = 4.216$, $p = 0.000$; frequency: $\beta = 0.406$, $t = 3.999$, $p = 0.001$; and icon-only: $\beta = 0.384$, $t = 3.416$, $p = 0.001$). Among the lower numerate participants, the gist knowledge performance was marginally better for lower numerates when they were presented with the number-based conditions than in the icon-scale condition. As shown in Table 2.5, there were marginally significant differences between the percentage and icon-scale formats ($\beta = 0.539$, $t = 1.941$, $p = 0.055$), and the frequency and icon-scale formats ($\beta = 0.552$, $t = 1.899$, $p = 0.060$). Furthermore, the only condition in which lower numerates' verbatim knowledge was significantly higher than in the icon-scale condition was in the percentage condition (percentage: $\beta = 0.354$, $t = 2.094$, $p = 0.038$; frequency: $\beta = 0.211$, $t = 1.194$, $p = 0.235$; and icon-only: $\beta = 0.123$, $t = 0.747$, $p = 0.456$). The Post hoc tests showed that no additional significant difference was found between the icon-only, percentage and frequency formats in both gist and verbatim comprehension between higher and lower numerates.

Furthermore, Table 2.6 shows the mean value of each outcome variable, stratified by numeracy level, for each presentation format. The data revealed that participants with higher numeracy acquired better financial knowledge than those with lower numeracy in all format conditions. Statistically, Independent *t*-tests found that in the icon-only condition, higher numerates had significantly higher comprehension of both types of

knowledge than lower numerates had (gist: $t = 2.545$, $p = 0.013$; verbatim: $t = 2.402$, $p = 0.020$). In the frequency condition, higher numerates had a marginally significant better comprehension of gist knowledge and a significantly better verbatim knowledge than lower numerates had (gist: $t = 1.433$, $p = 0.085$; verbatim: $t = 2630$, $p = 0.012$). In terms of the percentage format, there was only a marginally significant difference in verbatim comprehension between higher and lower numerates (gist: $t = 1.724$, $p = 0.090$). Although in the icon-scale condition there was no statistically significant difference in information comprehension between higher and lower numerates, both groups had the least understanding in this format.

Therefore, these results further supported the proposition that the icon-scale format was the least effective for imparting both gist and verbatim financial knowledge to both higher and lower numerates. Specifically, the performance of lower numerates was consistent with Hypothesis 2; that number-based formats assisted them in understanding financial probabilities better than icon-based formats do, particularly the percentage format. For higher numerate individuals, although they achieved less accurate comprehension of verbatim knowledge from icon-based formats, there was no significant difference in obtaining gist knowledge between these formats.

Table 2.4. Multiple regression of information comprehension for the higher numeracy group

	Gist Knowledge		**Verbatim Knowledge**	
	Coefficient *(Std. Error)*	*t* *(p)*	*Coefficient* *(Std. Error)*	*t* *(p)*
Percentage	.303 (.256)	1.185 (.238)	.466 (.111)	4.216*** (.000)
Frequency	.369 (.235)	1.572 (.118)	.406 (.102)	3.999*** (.000)
Icon-Only	.313 (.260)	1.202 (.231)	.384 (.113)	3.416** (.001)
Icon-Scale	Refer	Refer	Refer	Refer
Age	.004 (.007)	.479 (.633)	-.003 (.003	-1.046 (.297)
Education	-.050 (069)	-.729 (.467)	.075 (.030)	2.533* (.012)
Experience	.125 (.200)	.623 (.534)	-.030 (.086)	-.347 (.729)
Gender	-.143 (.181)	-.793 (.429)	.181 (.078)	2.320* (.022)
R **(R^2)**	.180 (.015)		.433 (.147)	

*Note: †p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 150 higher numeracy participants*

[a] *Dummy variable for format, icon-label format served as the reference category.*

[b] *Dummy variable for financial experience, coded 1 = no financial experience and 0 = had financial experience.*

[c] *Dummy variable for gender, coded 1 = female and 0 = male.*

[d] *Age and education were at original values (continuous variables).*

Table 2.5. Multiple regression of information comprehension for the lower numeracy group

	Gist Knowledge		**Verbatim Knowledge**	
	Coefficient *(Std. Error)*	*t* *(p)*	*Coefficient* *(Std. Error)*	*t* *(p)*
Percentage	.539 (.278)	1.941† (.055)	.354 (.169)	2.094* (.038)
Frequency	.552 (.291)	1.899† (.060)	.211 (.177)	1.194 (.235)
Icon-Only	.223 (.271)	.825 (.411)	.123 (.165)	.747 (.456)
Icon-Label	Refer	Refer	Refer	Refer
Age	-.011 (.008)	-1.282 (.202)	.002 (.005)	.322 (.748)
Education	.087 (.071)	1.222 (.224)	.120 (.043)	2.765** (.007)
Experience	-.524 (.287)	-1.826† (.070)	-.132 (.127)	-1.044 (.298)
Gender	-.024 (.208)	-.113 (.910)	-.096 (.174)	-.549 (.584)
R **(R^2)**	.317 (.051)		.333 (.062)	

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 135 lower numeracy participants*

[a] *Dummy variable for format, icon-label format served as the reference category.*

[b] *Dummy variable for financial experience, coded 1 = no financial experience and 0 = had financial experience.*

[c] *Dummy variable for gender, coded 1 = female and 0 = male.*

[d] *Age and education were at original values (continuous variables).*

Table 2.6. Participant's mean score comparison between lower and higher numeracy groups regarding gist and verbatim knowledge questions that were answered correctly

	Gist Knowledge (mean score of correct: range 0-4)			**Verbatim Knowledge (mean score of correct: range 0-3)**		
Format condition	Higher	Lower	*t-test* of high vs low *(p)*	Higher	Lower	*t-test* of high vs low *(p)*
Percentage	3.39	3.17	$t = .940$, (.351)	2.85	2.66	$t = 1.724$† (.090)
Frequency	3.43	3.07	$t = 1.433$† (.085)	2.83	2.48	$t = 2.630$* (.012)
Icon-Only	3.42	2.74	$t = 2.545$* (.013)	2.76	2.38	$t = 2.402$* (.020)
Icon-Scale	3.05	2.56	$t = 1.518$ (.135)	2.42	2.28	$t = .853$ (.397)
Overall	3.33	2.88	$t = 3.398$** (.001)	2.71	2.45	$t = 3.569$*** (.000)

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001.*

[a] *The number of higher numerates: 150 participants; the number of lower numerates: 135 participants.*

[b] *Lower numeracy = 0-9, higher numeracy = 10-11 on the objective numeracy scale.*

[c] *The higher the score in knowledge indicates better information comprehension.*

2.4.3 The Assessment of Information Evaluations (Hypothesis 3)

The regression analyses of participants' evaluations from each format are summarised in Table 2.2. The results of the evaluations of "information understanding" and "performance confidence" were in line with the objective performance of gist and verbatim knowledge understanding. That is, the percentage condition received a significantly higher rating in the "information understanding" evaluation than the icon-scale condition received (β = 0.835, t = 2.470, p = 0.014). Post hoc analyses further revealed that the percentage condition received a higher "information understanding" evaluation than the icon-only condition did (M_{est} = 1.103, SE = 0.348, p = 0.002). In addition, participants in the percentage condition had marginally significant higher confidence than those in the icon-scale condition only (β = 0.671, t = 1.815, p = 0.071). Interestingly, for the evaluation of "question difficulty", the picture was rather different. The only condition in which the evaluation of "question difficulty" was perceived to be significantly less difficult to understand than in the icon-scale condition was in the icon-only condition (β = 1.147, t = 2.445, p = 0.016). However, there was no significant difference in the "format helpfulness" evaluation between the different conditions.

In sum, participants in the percentage format condition (cf. the icon arrays conditions) were more confident in their information comprehension and perceived the information as easier to understand. However, participants in the icon-only condition perceived the questions to be less difficult than the participants in the other three formats did.

2.5. Discussion

This is the first study to examine the efficacy of icon arrays formats in communicating financial probability information to lay individuals. Although health communication studies have suggested that the icon arrays format is an effective format for communicating probabilistic information to the public, I found limited evidence to support this suggestion. In fact, the results of this study showed that icon-based formats were less effective than number-based formats at helping individuals understand financial probability information, regardless of their numeracy skills. Specifically, icon arrays with numerical scales produced less gist and verbatim knowledge in the recipients. I tentatively conclude that icon arrays alone do not necessarily help either higher or lower numerates to have better comprehension of financial probability information, whereas percentages appear to be a relatively superior approach for this.

2.5.1 Financial Probability Formats and Comprehension

The results of the gist comprehension demonstrated that icon arrays alone did not assist participants in having and recalling better gist knowledge than the numerical formats did. These results differed from some previous health communication studies. For instance, both Hawley et al. (2008) and Tait et al. (2010) found that icon arrays were better than either text (i.e., including percentage), or table (i.e., frequency) formats in helping participants draw health-related gist knowledge. On the other hand, the performance in drawing verbatim knowledge was consistent with other scholars who have shown that number-based formats are more useful to obtain precise numerical information (Waters et al., 2006, Feldman-Stewart et al., 2007). For instance, Hawley et al. (2008) observed that tables produced better verbatim knowledge in the recipients than the icon-scale format did. This finding supports the assertion that precise numerical knowledge can be extracted more simply from numerical formats than from counting

each icon and array in icon arrays (Gaissmaier et al., 2012). There are a number of reasons to explain why icon arrays used alone in presenting financial information were unable to facilitate individuals in understanding financial probability.

First, the inconsistent findings around gist comprehension could be due to the approach of assessing participants' gist knowledge being distinct from those of previous health communication studies. As highlighted earlier, this study did not allow participants to review the probability information provided when they were responding to the gist questions. Since short-term memory can indicate the effectiveness of an individual's ability to process and encode new information (Ding et al., 2017), the results of gist comprehension in this study suggest that icon arrays (cf. number-based formats) appeared less effective at helping recipients encode financial information and store the financial gist knowledge in their memories. It is plausible that this is because icon arrays are new to conveying financial information and individuals may therefore lack the specific experience and related intuition in processing financial information from them; the icon arrays may also contain various conventional features (e.g., titles or keys for explaining the human icons) that may result in excessive distraction and effectively degrade memory retrieval capacity (Ding et al., 2017). In contrast, number-based formats are commonly used in the financial domain, so individuals might be more familiar with them and thereby find it easier to extract and recall the essential information the formats portray.

Second, regarding the comparison between icon-scale and icon-only formats, the results revealed that participants in the icon-only condition had better comprehension performance than those in the icon-scale condition, especially in verbatim comprehension. In other words, the numerical scale in icon arrays was more likely to hinder the information comprehension of financial probability for both types of knowledge. These results are not only consistent with those of Feldman-Stewart et al.

(2007), who found that icon arrays with numerical scales have higher error rates of gist knowledge than those without them, but also extend their findings by showing that they hinder verbatim comprehension. A possible explanation is that some individuals often do not properly incorporate information from conventional features into their interpretations (Huestegge and Philipp, 2011, Okan et al., 2012, Okan et al., 2018). In addition, applying dual-process theory, this result may be engaged with two different means of cognitive processing: System 1 and System 2. The former is a rapid and automatic system with simplification strategies to reduce cognitive effort, and the latter is a slow and deliberative system being more analytical to interpret information (Speier, 2006, Lipkus and Peters, 2009). In this case, an additional numerical scale in the icon-scale condition may have appeared as an aid that encouraged participants to apply mental shortcuts when reading the numbers roughly, and subconsciously spend less time rather than straining to count icons and arrays in the graph. In other words, the appearance of the numerical scale seems to invoke System 1 processing away from System 2 processing. Thus, the attention of the participants in this condition might have been degrade in reading the numerical scale for extracting quantitative information, and thus more prone to systematic errors (Zeelenberg et al., 2007, Evans, 2008, Jones, 2015, Zhang et al., 2018). In contrast, without the numerical scale, the icon-only condition may stimulate in participants a need for more effort to consciously quantify icons and arrays, as more analytical System 2 processing, and obtain accurate knowledge.

2.5.2 Numeracy and Comprehension

This study found that the use of icon arrays alone to represent financial data is unable to facilitate lower numerates to generate greater gist and verbatim knowledge. In fact, lower numerates benefited more from the percentage presentation in understanding financial information. Beyond the abovementioned reasons, another possible explanation should not be ruled out. Given lower numerates' lesser ability to interpret

statistical data, they are more likely to experience stress when they access new financial information. Based on several psychology studies, it can be extrapolated that the cognitive and metacognitive burden of obtaining financial knowledge can affect encoding and storage capacity (de Quervain et al., 1998, Kuhlmann et al., 2005, Traczyk et al., 2018). Moreover, the performance of generating verbatim knowledge in lower numerates was compatible with the findings reported by Hess et al. (2011) and Kreuzmair et al. (2016). Both identified that lower numerates had difficulty in achieving precision with numerical data. Moreover, previous research has revealed that graphic literacy correlates with numerical literacy (Galesic and Garcia-Retamero, 2011). For example, Gaissmaier et al. (2012) confirmed such a positive link in their participants, with lower graphic literates having better gist and verbatim knowledge when health-related information was presented in a numbers-only condition. Thus, the comprehension performance of the lower numerates in my study, to some extent, was in line with the results of Gaissmaier et al. (2012).

For higher numerates, the gist comprehension results support the previous finding that higher numerates (cf. lower numerates) are less susceptible to the influence of presentation formats than lower numerates are (Lipkus and Peters, 2009, Reyna et al., 2009). However, higher numerates had less understanding of verbatim knowledge in the icon-based formats, especially the icon-scale condition. This result was in line with Hawley et al. (2008) in that their higher numerates generated worse verbatim knowledge in the icon-scale format. It is thus reasonable to suppose that higher numerates may focus more on the numerical data depicted in the icon arrays (Peters, 2008, Hess et al., 2011, Kreuzmair et al., 2016). Yet, although the numerical scale may attract higher numerates' attention, the number labels might reduce their attention to extract the exact number of icons and/or rows attentively. In contrast, since there was no numerical scale in the icon-only condition, the higher numerates may have more

likely applied their default strategy to count icons and arrays, with ultimately better comprehension than for the icon-scale condition (Kreuzmair et al., 2016). Furthermore, the results of the comprehension performance assessment between higher and lower numerates were consistent with previous studies suggesting lower numerates to be consistently disadvantaged in accessing and understanding numeracy-related information. Therefore, it is imperative for researchers to resolve to find suitable presentation formats that boost lower numerates' ability to access better financial knowledge and make more informed decisions.

2.5.3 Perceptions of Information and Formats

In this study, participants were more confident and felt the information was easier to understand in the percentage condition than in the icon arrays conditions. These findings were consistent with the participants' comprehension objective (i.e., gist and verbatim knowledge). It is possible that they are generally more familiar with the percentage format in communicating financial information and so would have higher confidence in their understanding of information than the participants with the icon-based formats would.

Another interesting finding is that participants in the icon-only condition judged the comprehension tasks to be less difficult to answer than those in the other three conditions did. It is plausible that the icon-only format did not include any numerical data so participants would have perceived the tasks as less mathematical or finance-related. This implies that the icon arrays format seems to make numerical tasks easier to answer, but it does not mean recipients can be helped to better understand probability information from such a format. In other words, when the format makes the recipients feel the task is less numerical, they may expend less cognitive effort in processing the information provided. This is consistent with the suggestion that the formats rated

helpful are not necessarily those contributing to enhanced performance in understanding information (Feldman-Stewart et al., 2000, McCaffery et al., 2012). As Barnes et al. (2016) identified, participants preferring graphic formats did not have better risk comprehension overall.

2.6. Limitations and Future Research

As with all studies, this study was conducted under controlled conditions to limit the influence of additional variables that could be addressed in future research. First, this study focuses on comparing the efficacy of financial communication between using icon-based and number-based formats. Future studies could investigate circumstances where icon arrays are used in conjunction with numerical formats to present financial information. Second, in finance, other graphic formats such as bar or line charts are more commonly utilised than icon arrays. As this study speculates, how prevalent a format is across a domain might affect the extent of information comprehension. It could be fruitful to discover and compare the efficacy of other commonly used graphic formats to convey financial probability information.

Third, due to questionnaire limitations, it is difficult to collect accurate data on exactly how participants process information under different format conditions. More research and theoretical developments are needed. It may be worthwhile to examine (1) why icon arrays are ineffective in communicating financial information, and (2) whether the scarcity of icon arrays usage in finance does itself limit their efficacy. Therefore, implementing a qualitative study in a more naturalistic context may lead to more in-depth insights.

2.7. Conclusion

The current study extended prior health communication research in several notable ways. First, it investigated the efficacy of icon arrays formats (cf. number-based formats) in finance. Second, while some health communication studies recommend using the icon arrays format to communicate probability information, there are two unclear guidelines regarding their application. Therefore, this study examined the efficacy of icon arrays in presenting information alone instead of as supplementary to numerical formats. The findings suggest that using icon-based formats alone does not help either higher or lower numerates in acquiring better comprehension of financial information, compared with using either percentage or frequency formats. Ironically, adding numerical scales on the y-axis in icon arrays actually compromised individuals' comprehension. Moreover, the gist comprehension results in this study imply that participants were less intuitive in processing, encoding and recalling financial information from icon arrays formats than they were from numerical formats.

This study has contributed to the financial communication literature strands, highlighting the importance of building effective communication with individuals, having identified the influence of different probability information formats on their comprehension. Its findings provide a starting point for future research efforts hoping to explore the influence of different formats to impart financial information. To conclude, one size cannot fit all. The recommendation from health communication studies about icon arrays is less applicable in the financial domain.

Chapter Three

How Well Do Commonly Used Presentation Formats Facilitate the Comprehension of Complicated Financial Information: Mortgage Products?

How well do commonly used presentation formats facilitate the comprehension of complicated financial information: mortgage products?

ABSTRACT

Academics and financial regulators have recently drawn attention to the importance of identifying how to help lay individuals better understand mortgage products. While accumulative evidence demonstrates that presentation formats can affect an individual's ability to acquire accurate information, no studies have directly examined the extent to which different presentation formats can help mortgage novices (i.e., individuals with no history of securing a mortgage) to understand complex mortgage products. To address this issue, I conducted a study in which 183 mortgage novices were randomly allocated to review information about two mortgage products presented using one of three formats: text-only, graph-only, and text-and-graphs. The study measured the participants' extent of mortgage comprehension, debt literacy, "present preference" (defined as the tendency to overvalue current benefits at the expense of long-term rewards), and perceived importance of mortgage characteristics (e.g., the outstanding balance). Contrary to expectations, the results revealed that presenting both textual and graphic formats to iterate the same mortgage information impeded participant's comprehension, regardless of their debt literacy. Consistent with cognitive load theory, this finding suggests that when intricate financial information is reiterated using multiple formats, it may overwhelm an individual's cognitive processing capacity and lead to reduced comprehension of that information. By comparison, I found that for individuals with lower debt literacy, a text-only format led to higher comprehension than a graph-only format. However, for individuals with higher debt literacy, the graph-only format led to higher comprehension than the text-only format. This indicates that the extent to which graphic presentation formats facilitate comprehension of complex

financial information is affected by an audience's related prior knowledge. The study also found an interaction between presentation format and "present preference" on the perceived importance of mortgage characteristics. Collectively, the results clearly indicate that the design and implementation of graphic displays in financial communications needs to be carefully considered.

3.1 Introduction

Choosing mortgage products is a significant financial decision in most homeowners' lifetimes. Unlike other financial investments, mortgage products are infrequently purchased, and such decisions have long-lasting influences on borrowers' financial resources. Meanwhile, the mortgage market is a crucial component of a country's and even the world economy. For example, the value of regulated residential mortgages in the UK is worth at least £1 trillion in 2016 (Financial Conduct Authority [FCA], 2018). The value of mortgage debt has contributed to over 80% of total UK household liabilities (FCA, 2019).The danger of people taking inappropriate mortgage products is a major concern for financial authorities because it could contribute to the outbreak of a financial crisis, such as the 2007-2008 sub-prime mortgage credit crunch (Cocco, 2013, Agarwal et al., 2014b). Mortgage decision-making is thus crucial for economies, financial markets, lenders and individual borrowers alike.

In the mortgage market, there are two classified products that differ in the ways and amounts of repaying interest and the loan principal over the mortgage term. One is a traditional principal-repayment mortgage: each monthly payment includes interest accrued for the outstanding loan and a small amount of repayment of the principal. The other is an interest-only mortgage: the monthly payment is only interest due on the loan principal throughout the mortgage term, and the total loan principal is repaid at maturity. The selection of mortgage repayment choices involves a trade-off between present and future constraints, as well as the probability of default risk between principal-driven and payment-driven decision-making (Campbell and Cocco, 2003, Amromin et al., 2018). Borrowers are expected to not only understand the nature of the two products, but also recognise the associated financial consequences, both short-term and long-term, that should be consistent with their financial circumstances (Timmons et al., 2019). For instance, variability in the repayment amount in each period will constrain their consumption, as well as affordability, which is relative to their income.

Unfortunately, evidence shows that most borrowers do not have an adequate understanding of mortgage products, despite this being crucial to selecting appropriate products (Bucks and Pence, 2008, Lacko and Pappalardo, 2010). Borrowers can misinterpret the benefits and risks of each product and consequently make unsuitable

mortgage choices. This can cause borrowers to experience higher interest costs, higher default risk or even loss of home (Cocco, 2010, Raghubir and Das, 2010, Gathergood and Weber, 2017a).

Previous studies have found that borrowers' financial or debt literacy and the degree of "present-bias" they have are associated with optimal decision-making around mortgages (Hullgren and Söderberg, 2013, Cox et al., 2015, Guiso et al., 2018, Larsen et al., 2019, Xiao and Porto, 2019). O'Donoghue and Rabin (1999) refer to "present-bias" (or earlier in this paper, known as "present preference") as an individual's tendency to give disproportionately stronger weight to current benefits than to future ones. The higher the present preference of borrowers, the more likely they would take mortgage products with lower initial payments, and the less likely they would consider future default risk (Atlas et al., 2017, Gathergood and Weber, 2017a). This means that individuals' present preference could affect the weighing between the short-term and long-term benefits of each mortgage. Moreover, borrowers with lower financial literacy will tend to have more difficulty in understanding the inherent consequences of each mortgage and a higher likelihood of taking inappropriate mortgages (Gathergood and Weber, 2017). Although extant studies have alerted us to the imperative of enhancing individual borrowers' mortgage-related comprehension, surprisingly no study has explored either the role of presentation formats in the phases of enabling mortgage comprehension, or the relationships with these two varying factors, an individual's debt literacy and present preference.

It has been suggested that presentation formats can affect people's comprehension and the quality of their decision-making (e.g., Fraser-Mackenzie et al., 2015, Dambacher et al., 2016). The efficacy of different presentation formats varies under different conditions. Written texts are the traditional format to present financial information. Graphs are the main alternative to texts that allow numerical information to be more concise and can summarise key data into single patterns (Cairo, 2012, Lipkus, 2007). For instance, a time-series chart can display the long-term financial changes to a mortgage. However, the comparative efficacy among different types of formats communication is inconclusive. Some studies indicate that graph comprehension is not universally intuitive and that graphic features can unduly distort individuals'

evaluations of information provided (Carpenter and Shah, 1998, Marlow and Dabbish, 2014).

However, in today's information age, multiple formats are usually presented. Paivio (1990) has suggested that providing both graphic and textual presentations is more beneficial for an individual's learning than just offering one of these formats alone. It seems reasonable to expect that providing mortgage-related information in both graphic and textual format would assist borrowers in developing their understanding through corroborating across both visual and verbatim sources. On the other hand, several studies have found that the apparent value of multiple formats may be overestimated because audiences can experience information overload and increased cognitive effort, which may be required to process and assimilate larger quantities and types of data (e.g., Mayer and Moreno, 2003, Clark and Feldon, 2005). In addition, there has been scant investigation into the efficacy of different formats in promoting individuals' understanding when the communicated financial information is complicated. Therefore, there are some unanswered questions concerning which types of presentation formats – such as graphs, texts, or graphs and texts together – can facilitate the comprehension of intricate financial information, such as that associated with mortgage products.

The present study fills these gaps by assessing the effectiveness of different presentation formats (text-only vs. graph-only vs. a combination of text and graph) in facilitating a better understanding of principal-repayment and interest-only mortgages among individuals with no prior experience of securing a mortgage. The study also examined the interactions between presentation formats and individuals' cognitive characteristics, namely debt literacy and present bias.

The remainder of this paper is structured as follows. Section 3.2 reviews the relevant literature and presents the research questions, while Section 3.3 explains the design of the experiment, measurements and analysis. Section 3.4 presents the findings, and Section 3.5 discusses the results and their implications. Section 3.6 reviews the research limitations and directions for future research, before Section 3.7, which concludes.

3.2 Literature Review

3.2.1 The Importance of Mortgage Comprehension

There is a specific concern that borrowers have limited understanding of interest-only mortgages (e.g., Fishbein and Woodall, 2006, Seay et al., 2017). These mortgages are expected to create more opportunities to income-constrained individuals to achieve homeownership by potentially enabling greater liquidity for consumption or other investments with higher returns. However, evidence shows that interest-only borrowers tend to focus more on the benefits of lower up-front costs at the expense of are ineffective to managing their financial resources over the mortgage term. For instance, Larsen et al. (2019) found that compared to principal-repayment borrowers, interest-only borrowers did not tend to use the extra liquidity to increase their savings or invest in other financial assets but instead became more indebted. Likewise, the UK Financial Conduct Authority pointed out that, although they restricted the interest-only lending activity following the 2007-2008 recession, a sizeable proportion of interest-only borrowers did not have sufficient repayment plans to cover their loan principal at maturity. Furthermore, borrowers should be aware that interest-only mortgages involve more uncertainty because the financial investments that they use for repaying the lump sum debt at maturity are likely to have uncertain performance. For example, when a stock market correction like the 2000 crash effectively wipes out significant value in assets held by many interest-only borrowers, leaving them with insufficient funds to repay their loans (Cocco, 2013). It is clear that borrowers who lack a comprehensive understanding of the consequences of mortgage decisions could misinterpret the risks and benefits involved. Therefore, it is important to assist them to engage with and assimilate accurate mortgage-related knowledge in a straightforward and effective manner.

An important study by Lacko and Pappalardo (2010) investigated the extent of borrowers' comprehension of mortgage disclosures. They found that many borrowers did not understand the mortgage terms until after they secured their mortgages. More importantly, their findings demonstrated that borrowers' limited cognitive ability and the complexity of mortgage products were not the causes of the poor understanding of mortgage disclosures. In fact, it was owing to the ineffective presentation design of the

disclosures. However, which types of presentation formats can enhance borrowers' mortgage knowledge most effectively has not been investigated in the research to date. While the manner of relying mortgage-related information is the initial stage in facilitating mortgage comprehension and arguably the most crucial (FCA, 2019), there is no study that has directly investigated the influence of different types of presentation format on mortgage comprehension at this information acquisition stage.

A growing body of research has identified that borrowers' financial or debt literacy is associated with the quality of mortgage choice and success in financial management (e.g., Lusardi and Mitchelli, 2007, Disney and Gathergood, 2011). The lower the financial literacy of the borrowers, the more likely they would hold interest-only mortgages and have a higher default rate (Moore, 2003, Gathergood and Weber, 2017a, Balasubramnian and Sargent, 2020). For example, Seay et al. (2017) found that lower debt-literate households were lured into excessive consumption instead of reducing their mortgage debt, since they had limited awareness of the lower initial payments being at the expense of larger subsequent periodic repayments. In addition, borrowers with lower debt literacy are more susceptible to predatory lending practices (Agarwal et al., 2014a, Ho and Pennington-Cross, 2006, Agarwal et al., 2017). Conklin (2015) found that lower debt-literate borrowers who had taken advice from mortgage brokers were more likely to have suboptimal mortgages. These findings reinforce an urgent call to identify a mortgage presentation format that can particularly help lower debt-literate borrowers generate more accurate mortgage knowledge for better mortgage decision-making themselves, rather than relying solely on mortgage advisors. Notably, although there are increased regulatory interventions to assist public financial literacy, their effectiveness has not been conclusive (O'Connell, 2009, Fernandes et al., 2014). For instance, Zokaityte (2018) concluded that the levels of individuals' financial literacy have remained consistently low in some countries even though considerable financial education schemes have been implemented, such as in the UK, Australia and USA.

3.2.2 Information Presentation Formats

A growing body of research has documented that presentation formats can affect comprehension, cognitive effort in processing and ultimately decision-making (e.g., Ghani et al., 2009, Roggeveen et al., 2015, Dambacher et al., 2016, Ceravolo et al.,

2019). Graphs and written texts are two frequently used formats in finance. The ways they present information are fundamentally different and have particular features even though they provide the same information. Written texts are the conventional way to impart information because education systems are heavily driven by text formats (Hannus and Hyönä, 1999, Schmidt-Weigand et al., 2010). In contrast, graphic presentations have ability to engage individuals' attention or draw focus onto specific information that might be overlooked in text formats (Lipkus and Hollands, 1999, Lipkus, 2007, Yang, 2020). Graphs can also summarise numerical data and reproduce them in concrete visual-spatial forms (Tversky, 2001, Gattis, 2002, Cairo, 2012). Seay et al. (2017) have recommended a presentation approach with side-by-side comparisons of mortgage-related information to highlight both short-term and long-term consequences, to enhance borrowers' understanding. Thus, it seems plausible that well-designed graphs can make mortgage information more vivid, enabling individuals to visualise financial distinctions or compare change across time, for instance by using two time-series charts to demonstrate the financial changes across the mortgage term for each mortgage. Likewise, additional bar charts could be used to present monthly repayments for both mortgages, which would allow viewers to more easily compare the short-term risk for each product.

On the other hand, some studies dispute the value of graphic displays for enhancing information communication. Graph comprehension is not always straightforward and its required processes may be too strenuous and come with requisite abilities to be able to make inferences (Shah and Carpenter, 1995, Freedman and Shah, 2002, Okan et al., 2012). Individuals ideally should be able to identify the visual features from graphics, such as direction, and then integrate and infer these into conceptual relations, by themselves (Carpenter and Shah, 1998). Unfortunately, a wealth of evidence demonstrates that individuals tend to allocate insufficient attention to graphic details, failing to make accurate interpretations (Okan et al., 2016, Okan et al., 2018). Moreover, individuals with lower debt literacy may be impeded from obtaining a sound understanding of mortgages from graphic presentations. For example, results from a study that used line charts to display mortality rates for two drugs over a 50-year period showed that individuals with less numeracy had difficulties in comprehending these graphic displays than individuals with greater numeracy, according to (Zikmund-Fisher

et al., 2007). Similarly, Keller and Junghans (2017) found that compared to higher numerate individuals, those with lower numeracy had lower comprehension of complex graphs presenting the number of surviving patients from two treatment options in a given time period. This study explained that higher numerates were more able to focus their attention on task-relevant information in complex graphs than lower numerates could. Hence, it seems logical that because mortgage products are complex with characteristics that include debt-related detail, graphs depicting such information might present more comprehension challenges to individuals with lower debt literacy. Importantly, it is apparent that graphic displays are frequently used in the finance domain to impart financial-related information (see Appendix C.1. for an example) yet the efficacy of using graphs alone to present complex financial information appears to have received little attention in the literature. In particular, whether the effectiveness of graphic displays is associated with borrower debt literacy remains unknown.

Given that graphs and texts are dissimilar in how they present information, attention has been focused on the efficacy of using more than one representation. Paivio (1990)'s dual coding theory asserts that a combination of text and graphs (i.e., multiple-format presentations) can better enhance individuals' understanding of the information provided than presenting either texts or graphs alone. Following Paivio's effort, scholars have suggested that two types of congruent formats can complement and strengthen each other and provide flexibility in catering to individuals with varying abilities of either verbal or visual skill (e.g., Mayer, 2009). In contrast, there are studies in which multiple-format presentations did not prove to be more beneficial for better information understanding than text presentations alone were (e.g., Clark and Feldon, 2005, Rasch and Schnotz, 2009, Renkl and Scheiter, 2017). They argued that if one presentation format is intelligible to individuals trying to understand information, it is unnecessary to provide another unless there are new benefits in doing so (Sweller, 2005, De Jong, 2010). Building on cognitive load theory, multiple-format presentations might exceed individuals' information-processing capacity. However, the studies that advocated dual coding theory did not address whether the extent of information complexity might constrain the efficacy of using multiple formats. The concern is that because mortgage-related information is complicated, representing the same information in divergent formats may "over-distribute" the information, creating

greater challenge for audiences. Therefore, questions remain unanswered over whether the complexities of mortgage products can be communicated better in written texts, graphic formats or using both formats combined.

3.2.3 Present Bias and Perception:

A further focus in recent research has been the relationship between presentation formats and behavioural biases, with evidence showing inconsistent decision behaviours when financial information is presented using different information formats. To illustrate, studies by both Raghubir and Das (2010) and Duclos (2015) showed that investors often made impaired financial decisions when information was presented via graphs because they attempted to simplify the decision process by only focusing on certain data highlighted in the graphs. Likewise, Bateman et al. (2014) found that individuals are more likely to have higher risky retirement savings accounts when the investment information is displayed using graphs rather than texts. These findings raise a suspicion that employing graphs to present mortgage information might evoke borrowers' propensity to demonstrate the abovementioned notion of present bias, which may affect the evaluation of information content and, in turn, decision behaviours.

This is because the two mortgage repayment products involve a trade-off between present and future resources and previous studies have found that borrowers' present bias is strongly interrelated to mortgages choice (Atlas et al., 2017). For instance, Gathergood and Weber (2017a) identified present-biased borrowers to be more attracted to interest-only mortgages, suggesting that the lower monthly repayments might receive more attention than the long-term outstanding balance. Agarwal et al. (2014b) also found that interest-only borrowers with this present bias are more likely to default on their mortgage repayments, regardless of whether they are experienced or naïve borrowers. To illustrate, the default rate of experienced borrowers with present bias was higher than those with consistent time preference. Thus, since graphs can make certain details or aspects appear more salient than they deserve, it is reasonable to assume that more vivid information used may trigger or aggravate borrowers' present bias, and therein affect their assessment of mortgage-related information, like monthly repayments and outstanding balances. More myopic individuals may weight more on monthly repayments when they see the information presented in a graph than in a text.

These studies collectively signal that exploring such graphic influence empirically may help finance sector practitioners use such insights to better communicate mortgage products.

3.2.4 The Rationale of the Study and Hypotheses:

The aim of this study was to examine the potential of different presentation formats to help naïve borrowers understand mortgage-related information. Therefore, I conducted a study considering two types of mortgage product: principal-repayment and interest-only mortgages. The study assessed participants' levels of mortgage comprehension and their evaluation of mortgage-related information when it was presented in different format conditions, namely graph-only, text-only or combined-format. Based on the knowledge gaps identified in the above literature review, I derived three research hypotheses concerning how variations in presentation format can influence the comprehension and evaluation of mortgage-related information:

(1) The first aim was to examine the effectiveness of different formats in promoting a better understanding of two mortgages. Applying dual coding theory, this study hypothesised that combined-format [c.f. graph-only or text-only formats] will facilitate greater comprehension of mortgage products.

(2) The second aim of this study was to examine the relationships between debt literacy, mortgage comprehension and presentation formats. Prior studies indicate that lower numerates have greater difficulty in acquiring information from graphs than higher numerates do. Hence, it is expected that the graph-only format [c.f. texts-only format or combined-format] will be less likely to help individuals with lower debt literacy [c.f. individuals with higher debt literacy] in understanding mortgage products.

(3) The third aim was to investigate whether individuals' present bias will moderate the influence of presentation formats on the perceived importance of particular mortgage-related information, namely three characteristics: "outstanding balance", "monthly repayment" and "total interest cost". Since the information in graphs is vivid, this study expects that the graph-only format [c.f. text-only

or combined-format] will aggravate individuals who have intrinsic present bias and thereby induce a higher perceived importance of monthly repayments and total interest costs, but a lower perceived importance of outstanding balance.

3.3 Methodology

3.3.1 Participants

All participants were recruited via Prolific (www.prolific.ac), an online research platform within which participants provide high-quality responses than those from platforms of Amazon Mechanical Turk or CrowdFlower (Peer et al., 2017, Adams et al., 2020). In addition, while most Prolific's participants are younger in age and more educated, it offers pre-screening filters to researchers to reduce the potential selection bias. To be eligible to participate in this study, participants had to be UK residents, between the ages of 18 and 65, have English as their first language, and have a minimum Prolific approval rating of 98% from all of their previous Prolific studies. Moreover, it was crucial to minimise the likelihood of participants having mortgage-related experience and knowledge, which could affect their responses to the study materials. To achieve this, the study (a) specifically requested participants who had no current or prior experience of having a mortgage and (b) used a screening question to identify respondents who had already held a mortgage. Participants who stated they had held a mortgage were not allowed to proceed with the study. A total of 278 participants were recruited, 89 of which were excluded because they failed an Instructional Manipulation Check (Oppenheimer et al., 2009) and 6 of which were excluded for exceeding a response time of 25 minutes. Therefore, the final sample comprised 183 participants and the questionnaire took an average of 11.6 minutes per participant. Each participant received £1.40 for their participation.

3.3.2 Design and Material

All respondents were asked to imagine that they had just started a new job with a net annual salary of £34,200 (i.e., £2,850 monthly) and had no savings and lived alone. They were then asked to imagine that they planned to take out a mortgage of £250,000 to buy their first house and repay the mortgage themselves over a term of 25 years.

Their mortgage advisor stated that they had to choose between two types of mortgage repayment option: principal-repayment or interest-only. Both options were assumed to have the same fixed-interest rate of 4%. For each repayment option, the information presented to the participants included the monthly repayment amount, the outstanding balance at the very start and end of the mortgage term, as well as the total interest repaid.

This study employed a between-subjects design in which the participants were randomly assigned to one of three conditions: (1) text-only, (2) graph-only, and (3) combined-format. The graphic material consisted of four-bar charts, which provided the same information as the textual material. Specifically, there were two time-series column charts displaying each mortgage's financial shifts of the outstanding balance along with yearly repayments at the very start until the end of the mortgage term (see Figure 3.1 and Figure 3.2). The other two were relatively simple bar charts that displayed (a) the comparison of monthly repayments, and (b) the comparison of total repayments which is segmented by the proportions of total interest repayment and original mortgage debt (see Figure 3.3 and Figure 3.4). "Simple" refers to the condition that recipients obtain a small amount of information, whereas "complex" refers to where there is a need to make inferences (Keller and Junghans, 2017). The reason for using bar charts is because they are familiar to the public (Jones, 2015). In addition, the graphs used the colour red to represent debt and green to represent repayments reducing the debt, given that red and green are prominently used in finance in Western countries to represent losses and gains (Kliger and Gilad, 2012). For the combined-format condition, graphs were placed above the text. This was to prevent the possibility that participants might read the text and neglect to use the graph on the basis (rightly or wrongly) that it did not appear to provide anything new. Moreover, the information used *plain* language rather than financial *jargon* to standardise accessibility and ensure a focused on assessing the impact of presentation formats. For instance, the "outstanding balance" was written as "amount you owe on your mortgage at end of the year". Appendix C.2. provides the mortgage scenario information given to participants in all conditions. Appendix C.3. includes all questions asked in each of the outcome measures described at above.

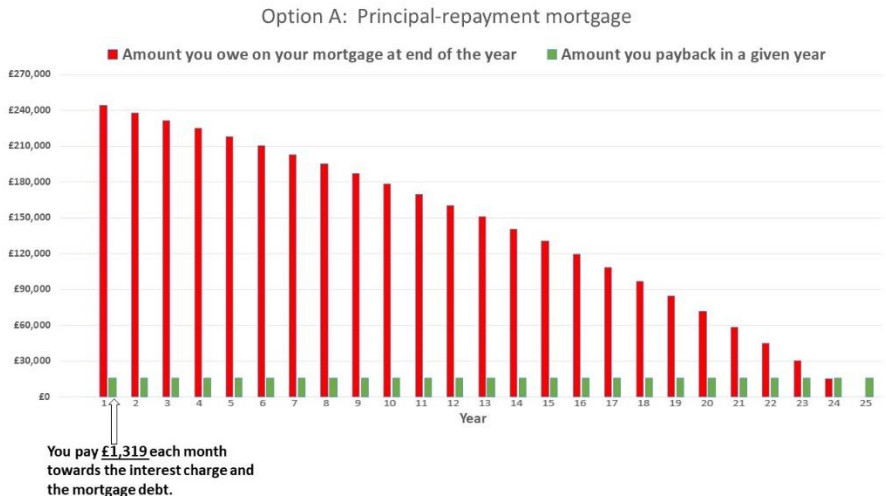


Figure 3.1 Time-series chart of principle-repayment mortgage

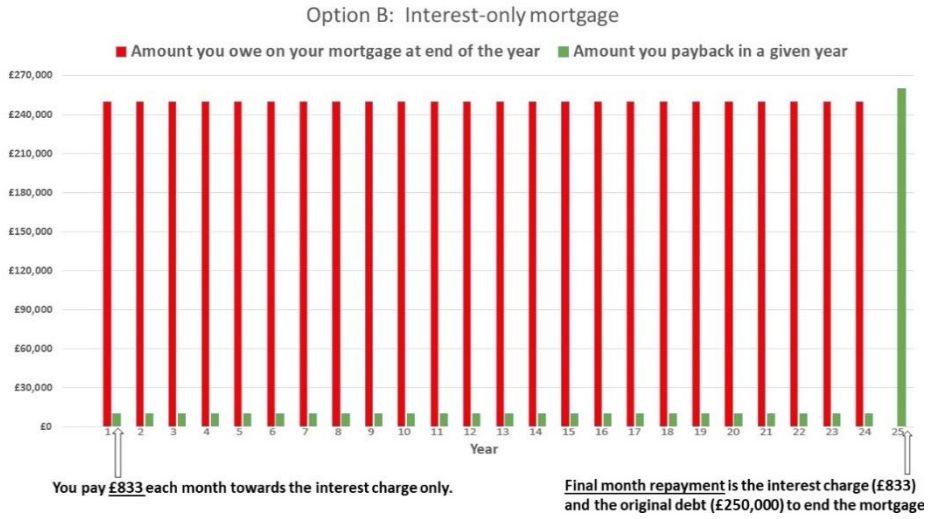


Figure 3.2 Time-series chart of interest-only mortgage

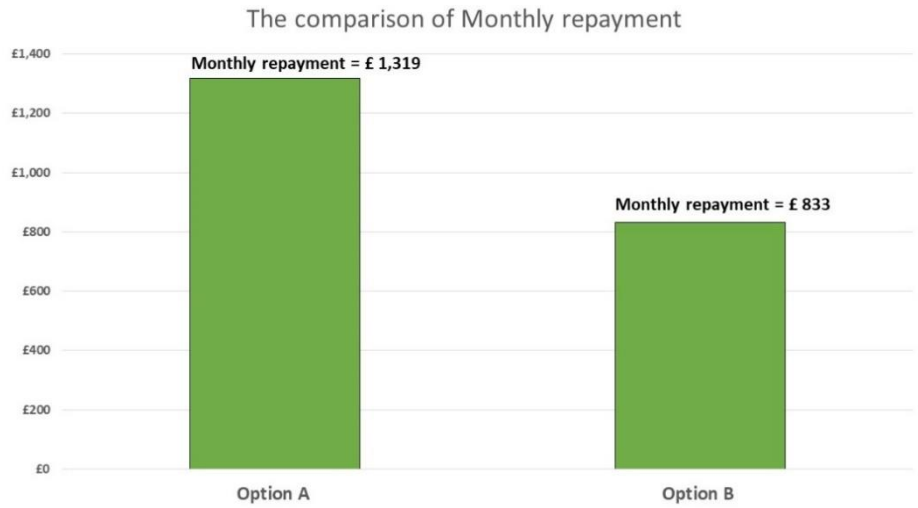


Figure 3.3 Simple bar chart of monthly repayment

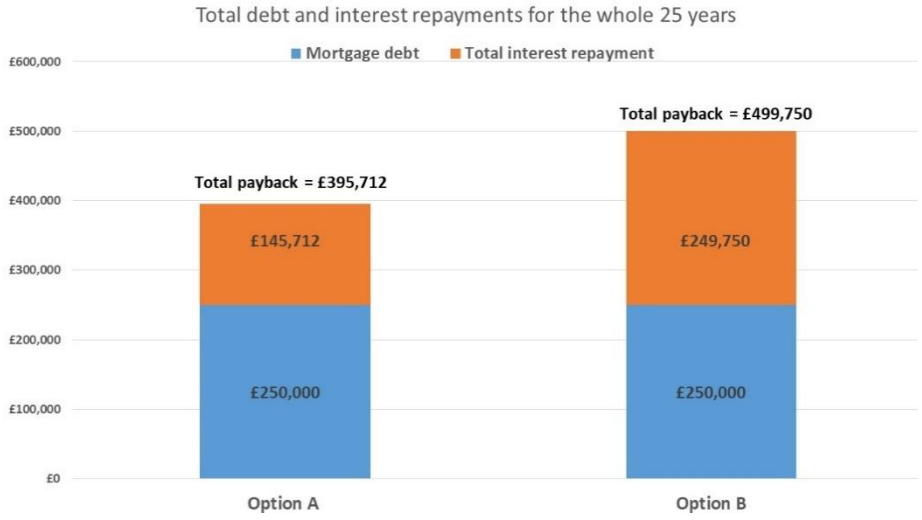


Figure 3.4 Bar chart of total debt and interest repayment for the whole 25 years

3.3.3 Outcome Measures

Comprehension of the mortgage products

The primary aim was to measure the comprehension of information about two mortgage products. This was assessed via the number of correctly answered questions on the differences between the two products. In total, there were five comprehension questions, such as "*Which one of the two repayment types would enable you to start paying back the mortgage debt (i.e., £250,000) sooner?*". Other questions assessed the comprehension of two products' financial implications, such as "*During the 25-year term, which one of the two repayment types would provide you with greater flexible cash flow for other financial investment activities?".* One question evaluated the understanding of how the products might be more or less suitable to certain financial circumstances: "*Which one of the two repayment types would be better suited to someone who currently has a very unstable monthly income, but who is likely to inherit over £250,000 in cash in approximately 25 years from now?".*

These comprehension questions were placed at the top of each page and specified that the information provided about the mortgages was at the bottom of the page for reference purposes. Participants were also asked to choose between the two repayment types, according to their preference.

Debt literacy

The assessment of participants' debt literacy used three items, "compound interest", "time-value of money" and "understanding of payment methods". These measures were developed and utilised by Lusardi and Tufano (2015) and have been extensively employed in research to explore influence in financial decision-making (e.g., Van Ooijen and van Rooij, 2016).

Evaluation of mortgage characteristics

Participants were asked three questions to evaluate the perceived importance of the outstanding balance amount, the monthly repayment amount, and the amount of total interest costs, respectively. These measurements used a 10-point scale (1 = not important at all; 10 = very important), for example: *"Please use the scale below to indicate how important the amount you would owe during the mortgage term was to*

you when choosing between the two mortgage repayment options."

Behavioural characteristics

Given the prevalence of present preference in mortgage decision-making, the study assessed participants' potential present bias using a short statement followed by a five-point Likert-scale with responses ranging from "agree strongly" to "'disagree strongly": "*I am impulsive and tend to buy things even when I can't really afford them*". This question has previously been used to examine the influence of present bias on mortgage choice (Gathergood and Weber, 2017a).

Moreover, risk attitude has been found to influence financial decisions and the judgement of information (Campbell and Cocco, 2003, Cox et al., 2015). Hence, participants' risk attitude was collected as one of the control variables when investigating participants' evaluations on the importance of mortgage characteristics. The measurement of their attitude to financial risk was taken from the Domain-Specific Risk-Taking scale (Blais and Weber, 2006). The scale consisted of five statements and participants used a 7-point scale (ranging from 1 = extremely unlikely to 7 = extremely likely) to indicate the likelihood that they would engage in a described activity. For instance, one statement was "*Betting a day's income at the horse races*".

Sociodemographic characteristics

Five sociodemographic questions asked participants to indicate their age, gender, education level and any other debt experience had. Table 3.1 provides the demographic characteristics of all the participants.

Table 3.1. Description of the sample under each format condition

	Text-only	Graph–only	Combined-format	Full sample
Group Size	58 (31.7%)	62(33.9%)	63 (34.4%)	183
Gender				
Male	30 (51.7%)	23 (37.1%)	20 (31.7%)	73 (39.9%)
Female	28 (48.3%)	39 (62.9%)	43 (68.3%)	110 (60.1%)
Education				
Lower educated	26 (44.8%)	34 (54.8%)	27 (42.9%)	87 (47.5%)
Higher educated	32 (55.2%)	28 (45.2%)	36 (57.1%)	96 (52.5%)
Other types of debt experience				
No other debt experience	5 (8.60%)	9 (14.50%)	4 (6.30%)	18 (9.80%)
Had other debt experience	53 (91.40%)	53 (85.50%)	59 (93.70%)	165 (90.20%)
Age（average age = 33.5）				
18-30	32 (36.0%)	28 (31.5%)	29 (32.6%)	89 (48.6%)
31-40	10 (18.5%)	20 (37.0%)	24 (44.4%)	54 (29.5%s)
41-50	8 (44.4%)	5 (27.8%)	5 (27.8%)	18 (9.8%)
51-65	8 (36.4%)	9 (40.9%)	5 (22.7%)	22 (12.0%)

Note: All the variables show no statistically significant difference between the three formats conditions

[a] *Lower education < Bachelor's degree (= No GCSE or higher education schooling completed – vocational/technical qualification), Higher education ≥ Bachelor's degree (Bachelor's degree – professional degree).*

3.3.4 Data Analysis Overview

To examine the first two research questions, this study conducted multiple linear regressions to investigate the effect of the independent variables (i.e., the three mortgage-information formats) on the dependent variables (i.e., the levels of comprehension). The combined-format condition served as the reference category in the regressions. In all regressions, education, age, gender, time spent on information comprehension, and the number of other debt experiences were control variables. Post hoc analyses with Least Significant Difference were undertaken to assess all pairwise format comparisons of dependent variables. To analyse the relationship between formats and debt literacy levels on information comprehension, the median debt literacy score was used to define higher and lower debt literacy groups. The study then conducted multiple regressions to assess the effectiveness of each presentation format for the higher debt literates and lower debt literates separately.

Addressing the third research question, the study first conducted an ANOVA to examine

whether there was any significant difference in the perceived importance among three mortgage characteristics when participants made their mortgage choices. The three mortgage characteristics were the independent variables, and perceived importance was the dependent variables. Post-hoc analyses using the Bonferroni procedure were employed to assess all pairwise comparisons of the perceived importance of the three mortgage characteristics. The study, then, used the SPSS macro PROCESS (Model 1) to test the moderation effects with information format as the independent variables, the perceived importance of the three mortgage characteristics as the dependent variables and the degree of present bias as the moderator. Specifically, a pick-a-point approach was used to probe the interactions for comparing the effect of different format conditions on the perceived importance of mortgage characteristics at three different levels of present bias (i.e., -1SD, 0SD and +1SD of the present bias). In all moderation tests, participants' debt experience, debt literacy, risk attitude and the mortgage information comprehension level were the control variables.

3.4. Results

3.4.1 Comprehension of Mortgage Information (Hypothesis 1)

Table 3.2 presents the results of the regression analyses which examined the comparative efficacy of three presentation format conditions to improve mortgage comprehension. The results revealed that participants in the combined-format condition had significantly lower mortgage understanding than participants in either the text-only condition (β = 0.366, t = 2.562, p = 0.011), or the graph-only condition (β = 0.284, t = 2.063, p = 0.041). However, no significant difference was identified between text-only and graph-only conditions (M_{est} = 0.081, SE = 0.140, p = 0.565). Table 3.3 reports the mean value of comprehension questions answered correctly in each format. It provides an overall picture that participants in the text-only condition generated a relatively greater understanding of mortgage knowledge and used less time on information processing and comprehension, as compared to the graph-only and combined-format conditions.

These results were contrary to Hypothesis 1. Presenting the same mortgage information using both texts and graphs together did not help participants understand the

information any better than presenting texts or graphs alone did. Instead, participants in the combined-format condition acquired the least accurate knowledge of the mortgages.

Table 3.2. Summary of multiple regression of mortgages comprehension in different presentation formats

	B	*Std. Error*	*t*	*Sig.*
Text-only*	.366	.143	2.562	.011
Graph-only*	.284	.138	2.063	.041
Combined-format	Reference	Reference	Reference	Reference
Sum of Debt literacy Score	.094	.074	1.279	.202
Age†	.010	.006	1.741	.084
Education**	.172	.059	2.904	.004
Gender*	-.245	.121	-2.026	.044
Time-spending on comprehension & questions*	-.174	.068	-2.571	.011
Debt experience (non-mortgage)	.075	.072	1.051	.295
R^2= .169				

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 183 participants.*

[a]*Dummy variable for the formats, Combined-format served as the reference category.*

[b] *Dummy variable for gender, coded 0 = female and 1= male.*

[c] *Debt literacy, the number of times of other debt experiences (non-mortgage), time-spending on comprehension questions, age and education were at an original value (continuous variables).*

Table 3.3. Participants mean score for comprehension and perceptions under each format condition

Format condition	**Overall knowledge (comprehension)**	**Perceptions of the importance of each mortgage characteristic** (the rating range 1-10)			**Time-spending on comprehension & questions**
	(mean score of correct: range 0-5)	**Outstanding balance**	**Monthly repayment**	**Total interest payment**	(in minutes)
Text-only	4.64	7.93	6.91	8.64	1.26
Graph–only	4.50	8.02	6.92	8.48	1.61
Combined-format	4.30	7.86	6.76	8.43	1.54
Overall	4.48	7.93	6.86	8.51	1.53

[a] *The higher the score of the comprehension knowledge indicates better information understanding.*

[b] *The higher the number for subjective perception indicates the perceived importance was higher (where 10 = maximum response. i.e., very important.).*

3.4.2 Comprehension among Individuals with Higher and Lower Debt Literacy (Hypothesis 2)

To investigate the extent to which individuals with higher and lower debt literacy understand the mortgages in different format conditions, the study divided the sample into higher and lower debt literacy groups using the median debt literacy score of 1 as the cut-off value. The lower (≤ 1) debt literacy group comprised 122 participants, and the higher (>1) debt literacy group comprised 61 participants.

The analyses of the effectiveness of each presentation format for the lower and higher debt literacy groups separately are reported in Tables 3.4 and 3.5, respectively. The results in Table 3.4 illustrates that for individuals with lower debt literacy, the only condition in which mortgage comprehension was significantly higher than in the combined-format condition was in the text-only condition (β = 0.475, t = 2.690, p = 0.008). By comparison, individuals with higher debt literacy, as seen in Table 3.5, had marginally significant better mortgage comprehension in the graph-only condition than in the combined-format conditions (β = 0.524, t = 1.829, p = 0.073). That is, for both debt literacy groups, the combined-format was associated with the lowest levels of comprehension. No additional significant difference in mortgage comprehension was found between text-only, graph-only and combined-format formats for the higher and lower debt literacy groups (the lowest statistical values: β = 0.201, t = 1.23, p = 0.22).

Table 3.6 presents the overall mean value of comprehension questions answered correctly in each format, stratified by the degree of debt literacy. Independent *t*-tests only found that individuals with higher debt literacy had significantly higher comprehension than the lower debt literates in the graph-only condition (t = 2.916, p = 0.005). Although no other statistically significant differences in the comprehension performance were found between higher and lower debt literacy groups in the other three format conditions, there were two points which were noteworthy. First, for individuals with lower debt literacy, comprehension was found to improve and took less time to understand when the information was presented in the text-only condition. Second, there was no significant difference in mortgage comprehension between higher and lower debt literacy groups in the text-only condition. This suggests that in relative terms, the text-only condition seems useful in reducing comprehension performance difference between the groups, as well as enhancing mortgage understanding in both.

Collectively, these results partially supported Hypothesis 2. The formats that included graphic displays did not facilitate the lower debt literacy group to have better mortgage understanding. In fact, the text-only format (cf. graph-only or combined-format) facilitates greater comprehension for the lower debt literacy group. In comparison, participants with higher debt literacy appear to have better ability in obtaining accurate mortgage knowledge from the graph-only condition.

Table 3.4. Multiple regression of mortgage comprehension for the lower debt literate group

	B	*Std. Error*	*t*	*Sig.*
Text-only**	.475	.177	2.690	.008
Graph –only	.201	.163	1.234	.220
Combined-format	Reference	Reference	Reference	Reference
Age	.008	.007	1.154	.251
Education**	.206	.067	3.083	.003
Gender*	-.329	.146	-2.252	.026
Time-spending on comprehension & questions	-.145	.085	-1.704	.091
Debt experience (non-mortgage)	.091	.082	1.115	.267
R^2= .211				

*Notes: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 122 lower debt literacy participants.*

[a] *Dummy variable of the formats, combined-format served as the reference category.*
[b] *Dummy variable for gender, coded 0 = female and 1= male.*
[c] *The number of times of other debt experiences (non-mortgage), time-spending on comprehension questions, age, and education were at an original value (continuous variables).*

Table 3.5. Multiple regression of mortgage comprehension for the higher debt literate group

	B	*Std. Error*	*t*	*Sig.*
Text-only	.227	.269	.842	.404
Graph –only†	.524	.287	1.829	.073
Combined-format	Reference	Reference	Reference	Reference
Age	.014	.010	1.458	.151
Education	.136	.135	1.012	.316
Gender	.024	.214	.113	.910
Time-spending on comprehension & questions †	-.213	.117	-1.827	.073
Debt experience (non-mortgage)	-.043	.158	-.276	.784
R^2= .127				

*Notes: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 61 higher debt literacy participants.*

[a] *Dummy variable of the formats, combined-format served as the reference category.*
[b] *Dummy variable for gender, coded 0 = female and 1= male.*
[c] *The number of times of other debt experiences (non-mortgage), time-spending on comprehension questions, age, and education were at an original value (continuous variables)*

Table 3.6. Participants mean score comparison between lower and higher debt literacy groups under each dependent variable

Format condition	Overall knowledge (comprehension)			Time-spending on comprehension & questions		
	(mean score of correct: range 0-5)			(in minutes)		
	Higher	Lower	*t-test* (high vs low)	Higher	Lower	*t-test* (high vs low)
Text-only	4.54	4.72	t = -.950, p = .346	1.57	1.32	t = 1.139, p = .260
Graph-only	4.84	4.35	t = 2.916**, p = .005	1.58	1.64	t = -.222, p =.825
Combined-format	4.44	4.26	t = .689, p = .493	1.20	1.65	t = -1.894†, p = .063
Overall	4.61	4.41	t = 1.553, p = .122	1.47	1.56	t = .615, p = .539

*Notes: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. The number of lower debt literates:122 participants; the number of higher debt literates: 61 participants.*

3.4.3 Evaluations of Mortgage Characteristics and Moderation Effects (Hypothesis 3)

The results of the ANOVA analysis that compared participants' perceived importance of the three mortgage characteristics illustrated a main significant difference, F (2, 546) = 31.459, p < .0005, η^2 = 0.103. This indicated that the three mortgage characteristics were weighted differently in terms of their relative importance. The Post Hoc Bonferroni analysis, as shown in Table 3.7, revealed that the total interest cost was perceived as significantly more important than the other two mortgage characteristics (outstanding balance: M_{est} = -0.579, SE = 0.211, p = 0.019; monthly repayment: M_{est} = -1.650, SE = 0.211, p = 0.000). Furthermore, outstanding balance was perceived to be more important than monthly repayment (M_{est} = 1.071, SE = 0.211, p = 0.000).

Tables 3.8 and 3.9 present the analyses of moderation effects, to determine the extent to which present bias might moderate the relationship between the presentation formats and the perceived importance of mortgage characteristics. Concerning the perceived importance of outstanding balance, as indicated in Table 3.8, the results identified a greater interaction effect between present bias and the text-only condition relative to the effect between present bias and the combined-format condition (b = 0.5699, t = 2.0307, p = 0.0438). The pairwise inferential tests showed in Table 3.9 specified this moderation effect occurred when the present bias was at a higher level. That is, among participants with higher present bias, the outstanding balance was perceived to be

marginally more important in the text-only condition than in the combined-format condition (b = 1.0339, t = 1.7277, p = 0.0858). However, for participants with a relatively low or moderate level of present bias, no statistically significant difference was found in the perceived importance of the outstanding balance across the three format conditions. Furthermore, no significant present bias effect was found between graph-only and combined-format conditions in this analysis (b = 0.3214, t = 1.0218, p = 0.3083). These relative conditional effects are depicted in Figure 3.5 which shows an interesting pattern: among participants with higher present bias, the graphic display conditions (i.e., graph-only and combined-format) were associated with lower perceived importance of the outstanding balance than the text-only condition when participants were considering mortgage selection decisions.

Regarding the perceived importance of total interest cost, the study observed that present bias moderated the effect of participants in the graph-only condition, compared to those in the combined condition (b = 0.5903, t = 2.2788, p = 0.0239). Specifically, the moderation effect occurred when present bias was either at a high or low level, but not at a moderate level, as shown in Table 3.9. Among participants with higher present bias, the evaluation of the total interest cost was perceived as more important in the graph-only condition than in the combined condition (b = 0.9674, t = 1.7276, p = 0.0858). In contrast, participants with lower present bias in the combined-format condition perceived the total interest cost to be more important than those in the graph-only condition did (b = -0.8036, t = -1.7695, p = 0.0786). These relative effects are shown in Figure 3.6 which demonstrates an additional interesting pattern: the perceived importance of the total interest cost appeared relatively consistent in the text-only condition regardless of the degree of present bias.

For the perceived importance of monthly repayment, the analyses did not statistically identify a moderation effect of present bias on the relationship between presentation formats and the perceived importance of monthly repayment (present-bias*graph-only: b = 0.2167, t = 0.7020, p = 0.4836; present-bias*text-only: b = -0.1650, t = -0.5993, p = 0.5498). Moreover, Figure 3.7 depicts the influence of the present bias level on how the importance of the monthly repayment was perceived across the variations in presentation format. This figure suggests a pattern that among participants with higher

present bias, the monthly repayment was perceived as more important in the graph-only (cf. text-only) condition.

In sum, these results were partially in line with Hypothesis 3 that the level of present bias moderates the effect of presentation format on the perceived importance of mortgage-related information. Specifically, graphic (cf. textual) formats were more likely to evoke the participants who have higher present preference, which appeared to be reflected in their perceiving the current mortgage concern of monthly repayments as relatively important, and the long-term mortgage concern of outstanding balance as less important.

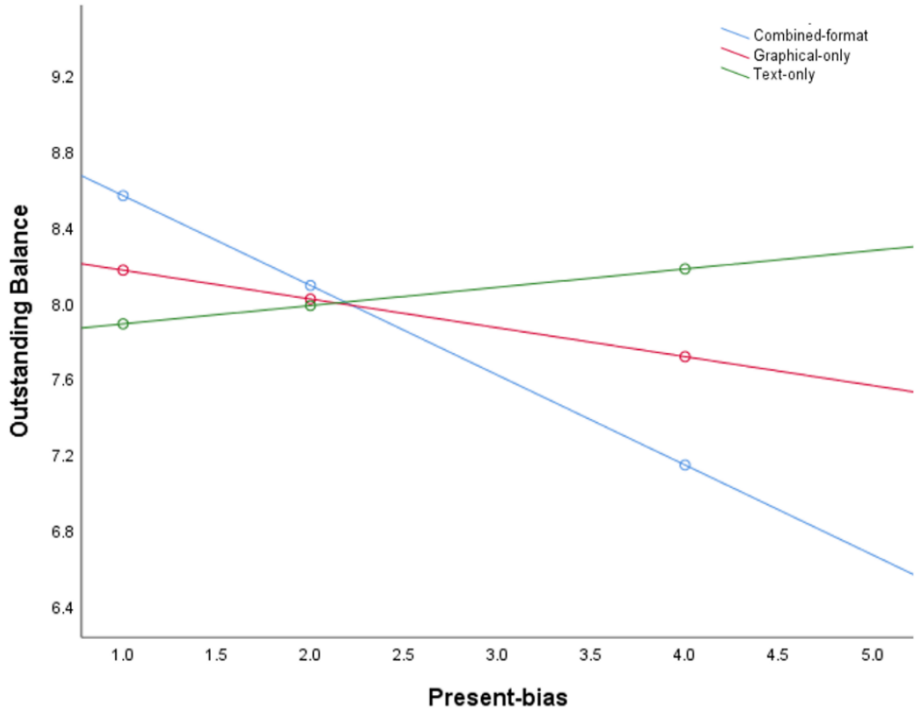


Figure 3.5 Moderation effects of present bias on the relationship between information formats and the perceived importance of the outstanding balance

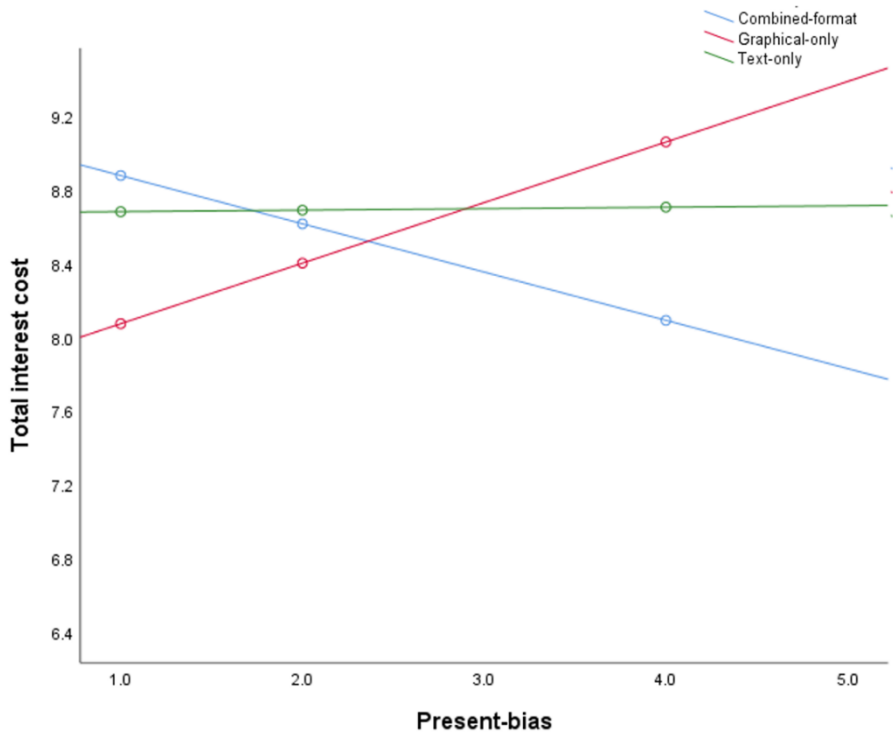


Figure 3.6 Moderation effects of present bias on the relationship between information formats and the perceived importance of total interest cost

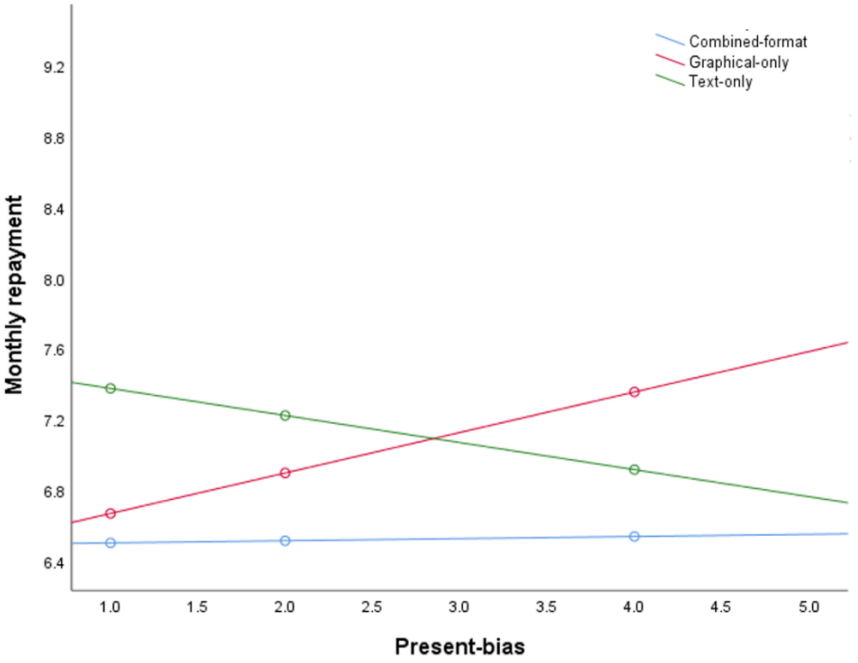


Figure 3.7 Moderation effects of present bias on the relationship between information formats and the perceived importance of monthly repayment.

Table 3.7. Post hoc analyses for the evaluations of three mortgage characteristics.

Dependent Variable: three evaluated mortgage characteristics						
Variable (I)	**Variable (J)**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Outstanding balance	Monthly repayment	1.071***	.211	.000	.56	1.58
	Total interest cost	-.579*	.211	.019	-1.09	-.07
Monthly repayment	Total interest cost	-1.650***	.211	.000	-2.16	-1.14

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 183 participants.*

Table 3.8. The analysis of moderation effect for the perceptions of three mortgage characteristics

	Outstanding balance				Total interest cost				Monthly repayment			
	coeff	*se*	*t*	*p*	*coeff*	*se*	*t*	*p*	*coeff*	*se*	*t*	*p*
Present-bias * graph-only	.3214	.3145	1.0218	.3083	.5903	.2591	2.2788*	.0239	.2167	.3087	.7020	.4836
Present-bias * text –only	.5699	.2806	2.0307*	.0438	.2699	.2311	1.1675	.2446	-.1650	.2754	-.5993	.5498
Debt literacy	-.3696	.2013	-1.8361†	.0681	-.2783	.1658	-1.6785†	.0951	-.8429	.1976	-4.2668***	.0000
Debt experience	.2312	.1902	1.2157	.2257	-.1348	.1567	-.8602	.3909	.3493	.1867	1.8714†	.0630
Comprehension	.1880	.2029	.9263	.3556	.2104	.1671	1.2587	.2098	-.3242	.1991	-1.6282	.1053
Risk-attitude	-.0488	.1506	-.3242	.7462	-.2571	.1240	-2.0728*	.0397	-.1099	.1478	-.7437	.4581
R^2	.0545				.0893				.1472			

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 183 participants.*

[a] *Debt literacy, the number of times of other debt experiences (non-mortgage), the score of comprehension performance, and the score of risk attitude were at an original value (continuous variables)*

Table 3.9. Pairwise inferential tests for the perceptions of mortgage characteristics at lower, moderate and higher moderator value

Moderator value	Perceived importance for each mortgage factor											
Present-bias (PB)	**Outstanding balance**				**Total interest cost**				**Monthly repayment**			
	Effect	*se*	*t*	*p*	*Effect*	*se*	*t*	*p*	*Effect*	*se*	*t*	*p*
Lower level												
Graph-only	-.3931	.5514	-.7128	.4769	-.8036	.4542	-1.7695†	.0786	.1663	.5411	.3074	.7589
Text-only	-.6757	.5607	-1.2052	.2298	-.1961	.4618	-.4245	.6717	.8726	.5503	1.5858	.1146
Moderate level												
Graph-only	-.0717	.3986	-.1798	.8575	-.2133	.3283	-.6496	.5168	.3830	.3912	.9790	.3289
Text-only	-.1059	.4141	-.2557	.7985	.0738	.3410	.2164	.8289	.7075	.4064	1.7412†	.0834
Higher level												
Graph-only	.5711	.6799	.8400	.4021	.9674	.5600	1.7276†	.0858	.8163	.6672	1.2236	.2228
Text-only	1.0339	.5984	1.7277†	.0858	.6135	.4929	1.2447	.2149	.3775	.5873	.6427	.5213

*Note: † p <0.10, *p <0.05, ** p <0.01, ***p <0.001. A total of 183 participants.*

[a] *The different levels of present bias were at: -1SD, 0SD, and +1SD of the present bias.*

3.5 Discussion

3.5.1 Mortgage Presentation Formats and Comprehension

The findings from this study demonstrated that simply presenting texts and graphs together (i.e., in the combined-format) to echo the same mortgage information did not bring about a better understanding for mortgage novices. In fact, the study found that the combined formats imparted the least mortgage knowledge in participant comprehension than the formats of texts alone or graphs alone. Notably, although this study did not statistically find significant differences in comprehension between the text-only and graph-only formats, participants with the text-only format spent less time to understand the information than participants with the graph-only format did. With respect to information-process efficiency, the text-only format was more effective in promoting better mortgage comprehension. This observation indirectly supports the argument that graph comprehension needs more time and effort to help people construct accurate meaning and understand information. There are several reasons that may explain this study's findings and could provide useful insights into the communication of complicated financial information.

First, the results suggest that the presentation of the combined formats probably exceeded participants' information-processing capacity and, ultimately, may have induced a degree of cognitive overload. That is, the combined formats not only required viewers to process information from both texts and graphs individually but, more importantly, to expend additional effort and time to compare and verify across them and then integrate both sources to achieve better comprehension. Surprisingly therefore, this study observed that participants in the combined-format condition spent the least amount of time on information processing. This implies that they may indeed have become overloaded by the quantity of information (i.e., four graphs and two written paragraphs) and so they became more selective about which information to attend to

(Bawden, 2001, Eppler and Mengis, 2008). Schick et al. (1990) proposed a similar argument, which suggested that when accounting information exceeds individuals' actual processing capacity, they attend only to the information perceived to be most relevant, potentially leading to increased processing errors and poor judgement. Other relevant literature investigating information processing has also claimed similar phenomena and suggested that individuals' processing capacity limitations as reasons for being selective in allocating their attention (Birnberg and Shields, 1984, Hirshleifer and Teoh, 2003).

Second, as highlighted in Section 3.2.2, the studies supporting dual coding theory did not specifically address the condition of intricacy in communicated information. Accordingly, the results of this study suggest that when information is complicated, presenting across multiple formats may produce the perception of redundancy of format(s), so the additional complexity from creating excessive formats can result in some withdrawal and, therein, impeded information comprehension. In contrast, the results of the text-only and graph-only conditions reinforced the suggestion that without duplicated information across different presentations formats, participants dedicated more cognitive resources to process the information more elaborately and generated better comprehension (Mayer and Moreno, 2003, De Jong, 2010). This is consistent with a study by Rasch and Schnotz (2009), which failed to find students assimilated knowledge from combined formats (i.e., both text and pictures) better than from texts alone.

Third, to achieve complementary benefit from the combined formats, individuals would need to effectively integrate the information from each. However, my findings suggest that this probably does not happen. In this study, the texts and graphs in the combined-format condition were presented separately in sequence; the material was presented as four graphs first followed by written texts. According to the split-attention effect, the separation between two types of formats could interfere in participant performance. This notion suggests that formats with separate diagrams and text can hinder

information learning because recipients are expected to search for and match text content with relevant parts of the diagram (Chandler and Sweller, 1992, Jarodzka et al., 2015, Sithole, 2016). Research has revealed that searching and matching unnecessarily overloads a recipient's limited capacity and does not contribute to the information understanding process (Chandler and Sweller, 1991, Sithole et al., 2017). Consistent with previous research, individuals can find it very difficult to understand information when texts and graphs are not integrated effectively in a presentation (Morrison et al., 2014). Indeed, because the mortgage information was complex and voluminous, participants probably would have needed to make multiple physical and mental transitions, assimilating and evaluating among the text and graphs. Hence, it is plausible that they were momentarily challenged, demotivated or distracted from acquiring information fully and accurately in the combined-format condition. There is scope for further research into the structural organisation of text and graph layouts that may affect information processing and comprehension in financial communication.

Drawing upon the abovementioned insights, the findings elicit important considerations when utilising multiple formats to communicate complicated financial information. To have effective presentation formats, it is necessary to consider (a) the number of formats, (b) the potential danger of redundant format(s), and (c) the combination layout. In other words, it is important to bear in mind individuals' information assimilation capacity. This issue has been spotlighted in accounting studies, suggesting that when preparing accounting information, individuals' attention and processing capacity should be considered (Braun, 2000, Hirshleifer and Teoh, 2003). Unfortunately, these considerations have received little attention in the financial communication domain.

3.5.2 Debt Literacy, Information Formats and Comprehension

Stratifying the comprehension analysis into lower and higher debt literacy groups, the same pattern emerged that the combined-format was the least effective in promoting mortgage comprehension for either group. Importantly, the study observed two notable

results. One is that the lower debt literates benefited the most from the text-only format, which helped them achieve a similar mortgage information comprehension level to that of the higher debt literates. In contrast, the higher debt literacy group generated better mortgage understanding from the graph-only format. These findings reveal how graphic displays may facilitate comprehension through activating or associating with individuals' prior debt-related knowledge. It is important to consider why participants who were lower in debt literacy did not benefit more from the graphic displays. This study suggests two possible reasons: (i) the greater cognitive demands of graphic formats and (ii) the number of inter-related graphs required to communicate intricate mortgage-related information.

First, graph comprehension processes are more complex and require participants to make inferences and construct the mortgage knowledge by themselves. Hence, those with lower debt literacy would find it more challenging to do so, particularly between the inter-related mortgage characteristics needed to build accurate mortgage knowledge from the graphs. Some studies have suggested that bar charts enable data distributions to be more easily identified but inferences from the patterns more difficult (Lurie and Mason, 2007, Jääskeläinen and Roitto, 2016).

In contrast, textual formats directly state the relationships of the inter-related mortgage characteristics; thus, it is reasonable to assume that texts reduce the likelihood of lower debt literate participants making incorrect inferences, thereby promoting better mortgage comprehension. Higher debt literacy groups have better knowledge of debt; thus, they would have greater ability to locate and isolate key information and make accurate inferences from the presented graphs. Thus, they seem in a better position than the lower debt literacy group to benefit from graphic formats in extracting accurate information to build better mortgage knowledge. These findings support those of previous research, suggesting that compared to lower numerate individuals, higher numerates more easily concentrate their attention on the graph's features to discern the most appropriate representation for a given task, which enables them to extract

information faster and more accurately (Hawley et al., 2008, Keller et al., 2009). A study by Stern et al. (2003) also found that, compared with those holding higher economics knowledge, participants with lower economics knowledge are prevented from constructing accurate relationships among economic variables from line charts.

Second, another notable and feasible speculation is that the number of graphs may create more difficulties for the lower debt literacy group than the other group to understand mortgage information. Each graph in the graph-only condition was essential and conveyed different mortgage product characteristics, which are highly inter-related and cover various debt-related matters, such as total interest cost and monthly repayments. Thus, participants needed to effectively build connections and construct relationships among these graphs to achieve a comprehensive understanding of each mortgage. However, such integration processes would demand more cognitive resources and create more challenge for the lower debt literacy group. Future studies may wish to consider more precise exploration into how individuals obtain and construct complex knowledge when information is presented across several graphs.

Overall, to compare the comprehension performance between lower and higher debt literacy groups, this study contributes a better understanding of each format's efficacy in imparting complicated financial information and shows how this can be associated with an individual's background and knowledge. Notably, individuals are rarely perfect processors of graphs. The process of graphic comprehension and the inter-relationships among graphs are likely to induce increased burden on individuals with lower debt literacy trying to understand mortgage information.

3.5.3 Present-Bias, Information Formats and Perceptions

This study observed that individuals' present preference moderated the influence of presentation formats on perceptions of the importance of mortgage product characteristics. Specifically, among participants with higher present preference, graphic

displays induced perceptions of outstanding balance as less important, but rendered perceptions of monthly repayments and total interest cost as more important, as compared to the text-only format. This indicates that for individuals with higher present preference, their perceptions of information provided are more likely to be swayed by this preference in the graphic formats than in the textual formats. This finding is compatible with those of Duclos (2015) who demonstrated that when information is graphically rather than numerically displayed, respondents were more likely to disproportionately weight the value of recent stock information and neglect earlier information. Linciano et al. (2018) also suggested that individual features (e.g., risk tolerance, personal traits) triggered higher risk perceptions from visually presented information but lower risk perceptions from verbally presented information. A possible explanation is that graphic displays may make some information become salient and thereby attract and hold recipients' attention to a larger extent than textual formats might. Perhaps it is the vivid nature of information in graphs that makes it more likely to receive greater weight relative to other information, through triggering more present-biased individuals to respond to their propensity and moderate their information perceptions. In contrast, the mortgage information was more evenly presented in the text-only format. Therefore, the graphic information on monthly repayments could trigger awareness of current benefits, and such a characteristic may receive a greater weight by present-biased participants. Likewise, the time-series charts depicted the long-term financial circumstances of mortgagees, which could alleviate present-biased participants' concerns, as long-term patterns tend to evoke an erroneous interpretation of future consequences "being far away from now" so more subject to randomly changing circumstances and thereby less important. These findings address the influence of visual impact in graphic communication of financial information, which deserves more investigation in future research.

Furthermore, this study extends the existing literature by shedding light on the comparison of the perceived relative importance among three mortgage characteristics.

Regardless of presentation format, the results revealed that total interest cost was perceived as more important than the other two characteristics, with outstanding balance next, before monthly repayments. This implies that total repayment cost would be the priority in mortgage choice decisions. Accordingly, the majority of participants (95%) selected the principal-repayment mortgage since the interest-only mortgage had significantly higher total interest cost (26% higher) than the former (see Appendix C.4.). There is further scope for future studies to test evaluations of these mortgage characteristics via a larger sample size (e.g., from the platforms of the UK ofsficial "Wealth and Assets Survey", or a cross-sectional survey of UK households the "YouGov Debt Tracker"). Also, future research can employ qualitative research tools for a deeper probe into a more insightful understanding of how communication formats affect mortgage decisions.

3.6 Limitations and Future Direction

The present study has some limitations that could open avenues for future research. First, since this was the first study to explore the influence of different presentation formats in communicating mortgage information, the questions and materials samples were relatively less complicated than real-world scenarios. For example, the interest rate was assumed constant in this study. Future studies could examine the same circumstances but with varying future interest rates and could also employ more difficult comprehension questions. Second, as the current study implies, the "overloaded" formats and the potential split-attention effect between texts and graphs are fruitful areas for future research. It is worthwhile to conduct a qualitative study to obtain in-depth insights on how individuals understand mortgage information when presented in multiple formats. For instance, to identify which parts of the information or formats are redundant or confusing and why. In addition, it could be valuable to explore specifically what difficulties or errors in graphs may hinder individuals with lower debt literacy from understanding mortgages.

3.7 Conclusion

Given the importance of promoting effective communication of mortgage-related information, to date, this study addressed this need and examined the efficacy of different formats in facilitating comprehension for mortgage novices. Overall, the study found that simply combining graphs and texts is the least beneficial format in communicating mortgage information, regardless of individuals' debt literacy. Importantly, for individuals with lower debt literacy, the results suggest that textual formats are better than graphic or multiple formats to facilitate mortgage comprehension. This finding strengthens the suggestion that the benefits of employing graphs to impart financial information are constrained by individuals' relevant prior knowledge. Meanwhile, this study raises an important concern that graphic displays (cf. texts) may evoke an individual's propensity towards present preference, essentially promoting current monthly repayments to be seen as more important.

Finally, this study provides valuable broad implications for current financial communication standards. At both practitioner and policy level, this study suggests that when practitioners aim to effectively communicate financial products with intrinsic complexity, extra care should be taken in deciding the amount of information provided and the format design particularly in configuring or choosing between texts and graphs. Meanwhile, the mortgage sector should consider the influence of communication formats on mortgage novices' comprehension. This study has evidenced that simply employing additional graphic presentations when needing to publicly communicate complex financial information should be approached with caution. To conclude, this study tentatively suggests that the old adage "less is more" appears reasonable when communicating intrinsically challenging financial information.

Chapter Four

How Can Graphic Displays More Effectively Communicate Financial Information?

How can graphic displays more effectively communicate financial information?

ABSTRACT

The efficacy of using graphic displays to communicate numerical information has received substantially more attention in health and educational domains than in the financial domain. This is surprising given the frequency with which graphic displays are used in the finance sector. Furthermore, the few studies that have examined this issue have uncovered some surprising results. For example, research shows that lay individuals who view text-based formats tend to develop better comprehension of financial information than those who view graphic formats, such as bar charts. However, none of these studies has specifically explored why an individual's comprehension of financial information may be hindered by graphic display formats or how such formats could be designed to improve comprehension. To address this knowledge gap, 40 participants were recruited and asked to process financial information presented using two types of graphic display (i.e., financial probability of stock risk using icon arrays, and mortgage information using text and bar charts). Think-aloud and think-after methods were employed to collect data on participant's comprehension levels, cognitive processes and judgements. Verbal protocol analysis revealed that graphic formats were more useful to communicate gist information (essence) than verbatim information (precise detail). That is, graphic formats more effectively helped participants make comparisons between different types and sets of financial data and identify key information quickly. However, in terms of generating deeper insights into financial knowledge, the results showed that further graph interpretation was required by participants and that this required effort and was most effective when supported by written text. Furthermore, the participants emphasised that text was their preferred format for receiving financial information. Specifically, they reasoned that textual formats provide more precise information and are more straightforward to interpret. By

contrast, they reported that the integration and interpretation required to understand graphic formats increases the likelihood of making errors. In addition, this study found that, although arresting colours are helpful in the information identification process, they could reduce participants' attention in integrating other graphic details and elicit disproportionate weighting or even emotional responses towards the represented information, relative to other information. Red bars were viewed as an alarm signal and received considerably more attention than green bars. Black icons (cf. grey icons) in icon arrays increased the salience of the higher risk class that contributed to a higher awareness of the class.

4.1. Introduction

To engage with financial information and develop sound financial knowledge are crucial for individuals' decision-making. Unfortunately, most people do not understand or utilise financial information effectively, and as a result, make inappropriate financial choices (Disney and Gathergood, 2011, Lusardi, 2012, Chin and Bruine de Bruin, 2019). For example, evidence shows that although considerable mortgage-related information is available to the public, many borrowers in the UK do not fully understand mortgages and remain unaware of the short-term and long-term consequences of different types of mortgage (Miles, 2004). Some borrowers underestimate debt costs and take unsuitable mortgages, especially those with lower financial knowledge. One reason might be that the nature of financial information is complicated and technical, so laypeople have difficulties in understanding and making informed financial decisions (Miles, 2004, Bucks and Pence, 2008). As a result, financial information should be presented in a comprehensible manner to promote active information processing and accurate understanding for the public. If individuals have difficulty engaging with, interpreting and understanding information provided, the value of such published financial information is diminished, and the efforts proven futile.

Graphic displays have been adopted in various domains such as health, accounting, education, and finance, to impart numerical knowledge to the public. Some research fields (e.g., in health and climate hazard communication) have claimed that graphic displays can facilitate information understanding (Ancker et al., 2006, Tait et al., 2010, Sadiku et al., 2016). One suggested benefit is that graphs can more easily highlight specific information, which can usefully trigger individuals' attention mechanisms toward prominent aspects or detail that may be neglected and undetected in textual formats (Oestermeier and Hesse, 2000, Chua et al., 2006, Lipkus, 2007). In addition, graphs can transform numerical data into vivid visual-spatial forms that allow individuals to view relations more directly, with less mathematical computation (Lipkus and Hollands, 1999, Cairo, 2012, Yang, 2020). For example, it is common to use bar graphs to identify value difference via different bar heights, and line charts to depict trends through time via presented patterns (Tan and Benbasat, 1990).

Nevertheless, some studies have argued that other important factors, such as content communicated, the degree of information complexity or communication goals, could affect the efficacy of presentation formats in communication of information to the public (e.g., Ghani et al., 2009, Visschers et al., 2009). First, different presentation formats are assumed to have

specific advantages and disadvantages for different purposes. As Strobel et al. (2016) suggested, a certain type of graph may facilitate information processing in some situations but not in others. Recently, compared to other graphic formats such as bar or pie charts, icon arrays have been largely recommended as an effective means to communicate the probability of health-related information (Ancker et al., 2006, Garcia-Retamero et al., 2012, Kreuzmair et al., 2016). Claims around icon arrays' effectiveness are several. Icon arrays are reported to categorise proportional information into discrete visual classes. Thus, individuals can compare and disentangle different classes via the relative areas and then recognise the part-to-whole relationship from the overall data provided (Lipkus, 2007, Garcia-Retamero and Galesic, 2009, Garcia-Retamero et al., 2010, Okan et al., 2012). In other words, individuals can identify the global meaning from the provided content (i.e., gist knowledge) without focusing too much on the numbers behind the graph (Feldman-Stewart et al., 2007, Reyna et al., 2009, Kreuzmair et al., 2016). Meanwhile, icon arrays can be more precisely read than bar or pie charts because individuals can count each icon and array to obtain precise numerical values (i.e., verbatim knowledge: Zikmund-Fisher et al., 2008, Fagerlin et al., 2011).

On the other hand, there are also contrary claims. The results of icon arrays to promote the understanding of verbatim knowledge are inconsistent in the health-related studies (e.g., Kreuzmair et al., 2016). To illustrate, Hawley et al. (2008) found that icon arrays conferred lower levels of verbatim knowledge than tables and bar charts did. In contrast, Tait et al. (2010) found that icon arrays were better than texts and tables in facilitating both types of knowledge. However, there are limited studies investigating either the underlying reasons for such inconsistent results, or how individuals actually correctly read numbers from icon arrays – in other words their ability to obtain verbatim information. More recent financial research has demonstrated that icon arrays are not effective at helping people understand financial probability information (Zhang et al., unpublished a). They found that percentage and frequency formats imparted better financial comprehension than icon arrays, especially in obtaining precise numerical information. In addition, they reported that adding numerical scales on y-axis in icon arrays can compromise the information comprehension even more. The authors extrapolated that since the presentation of icon arrays is rarely used to impart financial probability information, individuals may experience more challenges to understand the financial information. Therefore, it is worthwhile to further explore why icon arrays are ineffective to impart financial information, and indeed whether the frequency of icon arrays usage in the finance domain will limit their efficacy. These explorations may provide some in-

depth insights into what factors should be recognised when financial practitioners intend to use icon arrays to communicate in the financial domain.

Second, the public is increasingly exposed to large amounts of intricate financial information with various elements, often presented in multiple formats, such as graph with supporting textual narrative, within one message. Providing various formats is promoted by dual coding theory (Paivio, 1990), which asserts that using graphic and textual presentations together can improve individuals' learning more than text-only or graph-only presentations can. The explanation is that when people process two congruent formats, the two sets of information generated from each can corroborate and strengthen each other, producing better understanding overall (Tait et al., 2010).

However, studies based on cognitive load theory argue that presenting multiple formats to iterate the same content might exceed individuals' information processing capacities so have a negative impact on their comprehension (Clark and Feldon, 2005). Furthermore, some studies also suggest that multiple formats can create more tasks for individuals since they have to build relationships between multiple sources in order to achieve a coherent mental representation (Seufert, 2003, Sithole et al., 2017). For example, Rasch and Schnotz (2009) found that, compared to text-only presentations, those that include both graphs and texts did not seem to promote students' understanding of the information provided. Likewise, a recent study investigated the efficacy of presenting both graphs and texts (cf. using graphs only and texts only) to communicate mortgage information and found that multiple formats did not assist participants in having better mortgage comprehension (Zhang et al., unpublishedb). Notably, they found that even when they used commonly viewed bar charts to impart the mortgage-related information, participants with lower debt literacy had better mortgage comprehension in the text-only format than in the graph-only format.

Furthermore, evidence shows that to achieve a comprehensive understanding of information from a single graphic display, individuals have to participate in complex cognitive processes requiring considerable effort (Carpenter and Shah, 1998). Based on the cognitive model of graph comprehension, adequate comprehension of graphs should emerge from three process stages (Lohse, 1993, Carpenter and Shah, 1998). The first is pattern-recognition, wherein recipients identify visual patterns and principal features, such as bars with different heights. The second consists of interpretive processes, wherein recipients translate the identified patterns and construct them into conceptual relations of both qualitative and quantitative

meaning. For example, the sizes of spatial features may vary, implying different quantities or performances of the variables represented in the y-axis and x-axis. The third consists of integrative processes, wherein recipients infer information from conventional features – such as axes labels, numerical values on scales, or legends – in the graphs and associate them with the identified visual pattern and relations. Such processes indicate that recipients not only need to identify the visual features but also have to construct accurate meaning and make sound judgements from the graphs. As Carpenter and Shah (1998) suggested, in the real world, graph comprehension goes beyond visual presentations to make inferences. As we can see, the benefits of graphic displays in enhancing comprehension of complicated financial information is questionable since this may increase individuals' cognitive burden and create more challenges, especially when imparting new financial knowledge to finance-naïve individuals. Curiously, it remains unclear why presenting both graphs and texts is the least effective format to facilitate the assimilation of complex financial information, such as that associated with mortgage-related information. Perhaps certain factors or features in graphs can be detrimental to graph comprehension and understanding financial information. Therefore, it is worthwhile to address these under-explored questions, to gain a precise understanding on how to improve such formats (i.e., icon arrays, bar charts and combined formats) and thereby select appropriate formats – supported by evidence – to assist laypeople in understanding financial information better.

Last but not least, recent studies have found some inconsistent decision-making behaviours when financial information was presented in different formats. For instance, both Raghubir and Das (2010) and Duclos (2015) found that investors often make impaired financial decisions because they seem to simplify their choices by focusing on specific data points in graphs. Bateman et al. (2014) also reported that individuals are more likely to have more risky retirement investments when the associated information is displayed in graphs rather than texts. Surprisingly, empirical research into the precise attributes in graphs that affect individuals' attention and information evaluation processes are scarce in the financial domain. Furthermore, there is limited knowledge of how individuals react to and evaluate different types of format for communicating financial information. Health communication studies have found that the degree to which patients trust the format in which information is delivered affects the uptake of that information and whether it is then used in their medical decisions (Schapira et al., 2006, Hawley et al., 2008). Thus, knowing individuals' evaluations of presentation formats can

provide valuable suggestions for the finance industry, especially those seeking to build trustworthy financial communication channels with the public.

The objective of this study:

Consequently, the aims of this study were to (1) understand why icon arrays do not facilitate the understanding of financial probability information, (2) examine how individuals deal with complicated mortgage information when it is presented in both textual and bar chart formats, and (3) explore how individuals evaluate various types of presentation formats in financial contexts.

To achieve the above goals, a qualitative study was undertaken using one-to-one interviews to collect the data. Given that the overall aim of this study was to explore how individuals engage, react, extract, process, perceive, comprehend and evaluate financial information when it is presented in different formats, interviewing is considered the most appropriate instrument to provide deeper insights into what participants think and how they read the presented information (King and Horrocks, 2010). There is scant research of this particular nature so not much is known about it (Sekaran and Bougie, 2010). The present study, therefore, has the following objectives:

1. To examine whether the congruence between financial information content and format familiarity of icon arrays affects the comprehension of financial probability information.
2. To identify how the provision of both graphs and texts influences the processing and comprehension of financial information.
3. To identify the attributes in graphs that inhibit or facilitate the comprehension of financial information.
4. To identify individuals' evaluations of the efficacy of various presentation formats (namely icon arrays, bar charts and texts) for communicating financial information.

The rest of this chapter is structured as follows: Section 4.2 explains the design of the interviews, procedure and verbal protocol analysis. Section 4.3 presents the findings, while Section 4.4 discusses the main results and their implications. Finally, Section 4.5 exposes the limitations and Section 4.6 is the conclusion.

4.2. Methodology

4.2.1 Participants

This study conducted 40 one-to-one interviews. Thus, a total of 40 university students (21 females and 19 males) were recruited from a large UK university to participate in this study, and each participant received a £12 Amazon voucher. To be eligible to participate, they had to be UK residents, have English as their first language, and have no current or prior experience of having a mortgage. The last condition was to minimise the likelihood of mortgage-related experience influencing participants' responses to the materials. The average age of the participants was 23 years (SD = 3.39), and their academic backgrounds were diverse, spanning Music, English, Economics, Medicine and Engineering.[4] Table 4.1 provides the demographic characteristics of all participants. Each interview took an average of 56 minutes.

Table 4.1 Demographic characteristics of participants

Variables	Categories	Number
Gender	Male	19
	Female	21
Education Level	Undergraduates	30
	PhD and Master	10
Academic Major Backgrounds	Medicine	7
	Physics, Economics, Engineering	18
	Laws, Language, Music	15

4.2.2 Research Design and Procedure

The design of the interview was a combined structure. A think-aloud approach was employed first, followed by a think-after approach, and finally, a short questionnaire for each interview. The think-aloud approach was central to this study and used first. That is, participants verbalised their thinking and reactions whilst they were reading financial information. The

[4] Given the participants were from different academic backgrounds, it is plausible that those with quantitative backgrounds (e.g., Economic) might have different ways of processing and obtaining financial knowledge than those with qualitative backgrounds (e.g., Music). However, to examine the influence of academic backgrounds on financial information understanding was not this study's objective; thus, this study's results presented a comprehensive picture of how non-financial experienced individuals react and process financial related information under different presentation formats. The effect of academic backgrounds is one potentially fruitful area for future studies.

verbal expressions directly provided their initial reactions and thinking processes (Jaspers et al., 2004), and in this way, their cognitive processes were less likely to be affected by the interviewer (Ericsson and Simon, 1998). This think-aloud approach has been widely applied in different research domains. For example, risk-related research uses this method to explore the thinking associated with trust judegments in risk management (Earle, 2004). In information-seeking research, Xie and Cool (1998) used the think-aloud method to identify problems confronted by information searchers when using online search engines for accessing databases. Peebles and Ali (2009) used the same approach to investigate differences in graph comprehension between bar and line charts.

In the think-after method, participants were asked questions based on their think-aloud responses. This method was used in the second stage of the interview. It was done in order to clarify and explore each participant's thinking, making it explicit. Evidence from past studies shows that some participants only articulate verbatim information in the stimulus materials rather than articulating their thoughts, feelings and cognitive processes (Bowers and Snyder, 1990). In other words, these sequential interview steps provide powerful opportunities to interact with participants relevantly and to explore the genuine reasons they had particular thoughts or responses (van Teijlingen and Forrest, 2004). It is believed that combining think-aloud and think-after methods can provide abundant data with insights into participants' interactive information behaviour.

Procedure

All participants were allowed time to initially read a standard information sheet and they signed a consent form. After the agreement, they were given debriefing information describing the nature of the interview, including the think-aloud stage to ensure they have understood it correctly. They were also reassured that the study was not a test, and any queries that they might have about the procedure were explained at this stage. After that, participants were randomly assigned to one of the information scenarios to start with (see Section 4.2.4 for the materials). Firstly, they read the background information sheet and were informed they were prohibited from revisiting it. Then they received the corresponding materials that they were asked to understand. Participants were encouraged to read the information as they normally would and feel free to express any thoughts by speaking aloud. Once participants began to think aloud, they were not interrupted unless they went silent for a while and were invited to continue talking throughout the process. When they had understood the materials as much as

possible, they informed me and then proceeded to the think-after stage. After completing one scenario, they continued to the next scenario with the same procedure. In the think-after stage, the common question asked was "*Why did you feel/think [x]?*" in response to participants' reactions in the think-aloud stage. For instance, if participants showed clear signs of confusion, I would ask "*Why did you feel confused when you read this page*? *Could you explain a bit more?*". At the interview conclusion, participants were required to complete a short questionnaire, which collected descriptive data, such as their demographic characteristics.

4.2.3 Material

Two sets of financial information materials were presented to the participants for them to assess the efficacy of icon arrays and multiple formats for communicating financial information, respectively. One material set was about financial probability, namely stock risk, presented by the icon arrays format only. The other material presented two types of mortgage using bar charts and written texts.

Stock scenario

Three variations of icon arrays displays were used to present information on the probability of losing money in a given year from investing in one of three stocks, labelled Stock A, Stock B, and Stock C. A background information sheet (not think-aloud material) asked all respondents to imagine they had a certain amount of savings, which they planned to invest in the stock market. They were then asked to imagine that their financial advisor had selected three different stocks for them to choose from, and each stock varied in its associated probability of losing money in the short term, in other words each carried different financial risk. See Appendix D.1. for the material.

The second information sheet was think-aloud material. It included (a) a graph title: "*The graphs below show the chance of each stock losing at least a quarter of the value of the investment in a given year*"; (b) three icon arrays diagrams that illustrated the probability of Stocks A, B, and C losing at least a quarter of the investment in a given year at 36%, 48% and 24%, respectively; (c) the key explaining the representations of black and grey human icons. Specifically, the black ones represented the number of people who lost at least a quarter of the value of their investment, and the grey ones represented those who lost less than a quarter. The icon arrays consisted of 10×10 icons and were filled from the bottom up with black human

icons and grey human icons. The diagrams included a numerical scale on the y-axis with increments of ten (0, 10, 20 … 100) to correspond with each row of ten icons. The icon arrays in this study were designed by Zhang et al. (unpublisheda), created from a well-established website, iconarray.com (for reference, the icon arrays are included again in Figure 4.1).

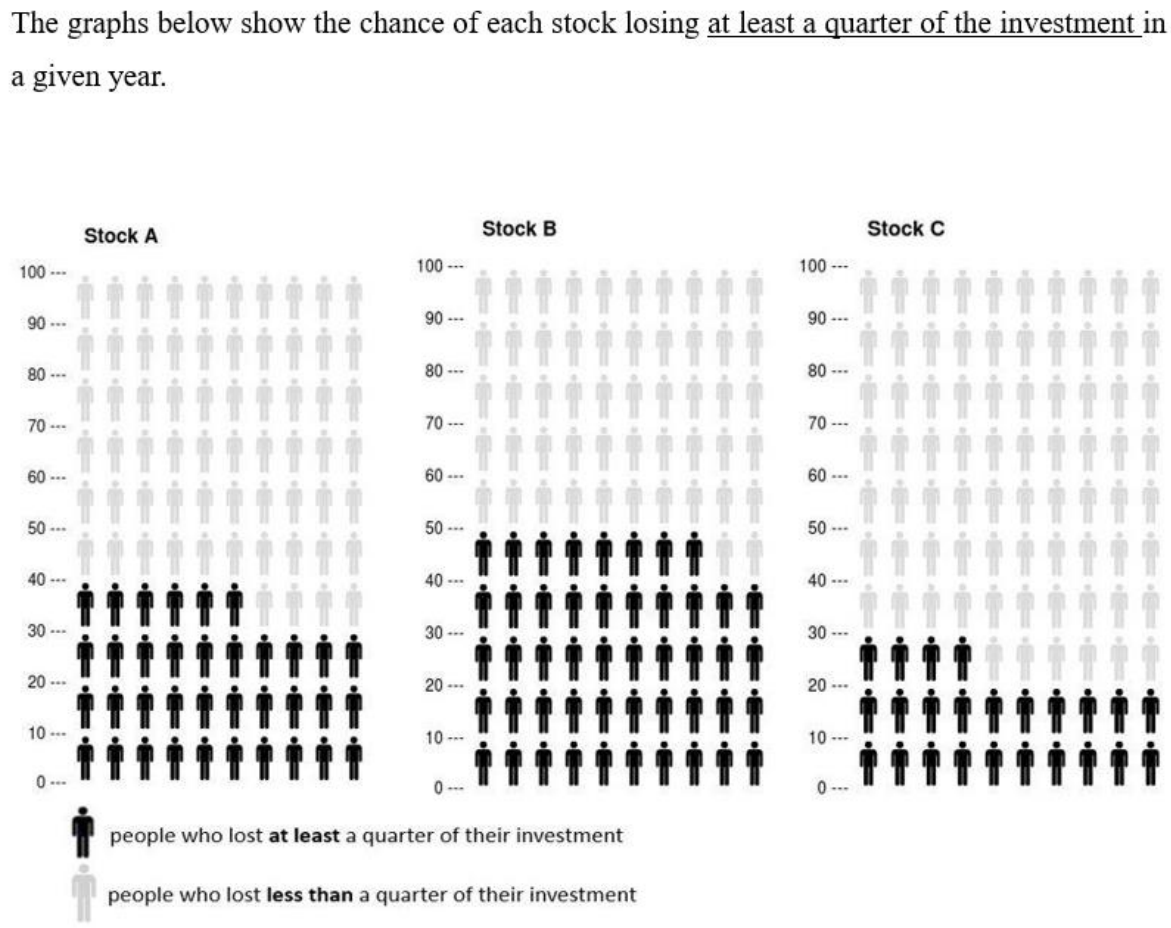


Figure 4.1 The icon arrays displays

Mortgage scenario

One background information page was provided (not think-aloud material) which asked all respondents to imagine that they have just started a new job with an annual net salary of £34,200[5] (i.e., £2,850 each month), they had no savings and lived alone. They were then asked to imagine they planned to take out a mortgage of £250,000 to buy their first house and repay it themselves over a term of 25 years. Their mortgage advisor stated that they had to choose between two mortgage repayment options: principal-repayment or interest-only[6]. Both options were assumed to have the same fixed interest rate of 4% (see background information in Appendix D.2.).

For the think-aloud materials, there were three information sheets imparting the above two mortgage products. One information sheet presented all the textual information, in two blocks of writing. It was structured by the mortgage name with the related information to follow, such as the monthly repayment amount, the outstanding balance at the very start and end of the mortgage term, and the total interest to be repaid.

The graphic material was presented on the other two information sheets, which consisted of four-bar charts communicating the same information as the written texts.

[5]The reason for choosing a net salary of £34,200 was to ensure the monthly repayments for a principle-mortgage would be affordable (see footnote 2). Even participants who took a principle-mortgage would have their daily expenses reasonably covered after their monthly repayments. Thus, there was a clear trade-off between these two mortgages for participants to make judgements on. Of note, based on data between 2012 and 2014 from WAS (the Wealth and Assets Survey, which is the largest UK survey of household finances, interviewing approximately 30,000 households per annum, undertaken by the Office for National Statistics), among mortgage holders, the most recently available average household income is £46,400.

[6] In the mortgage market, there are two classified products, distinguished by how repayments of interest and loan principal are made over the mortgage term. One is a traditional principal-repayment mortgage: each monthly repayment includes the interest accrued for the outstanding loan and a small amount of repayment of the principal (Cocco, 2013). The other is an interest-only mortgage: its monthly repayment is only the interest on the loan principal throughout the mortgage term, with the loan principal itself repaid in one sum at maturity (Cocco, 2010).

One page displayed (a) the comparison of monthly repayments, and (b) the comparison of total repayments, which was segmented by the proportions of total interest repayment and original mortgage debt. The graphs on this page were relatively simple bar charts. The other page contained time-series column charts that displayed the changes in the outstanding balance, along with yearly repayment sums at the very start until the end of the 25-year mortgage term. Since the literature suggests that red and green are the primary colours used in the finance industry in Western countries to represent losses and gains (Kliger and Gilad, 2012), this study used these colours to represent debt and repayment, respectively, in these graphs. It is worth mentioning that the three mortgage information sheets were laid out in random order on a desk for the participants, so they were free to read the sheets in any order they wished.

All the materials and graphs used in this study's think-aloud procedure and the related background information was originally designed and examined in previous studies by Zhang et al. (unpublisheda,b). For reference, the texts and graphs are included again below in Figure 4.2. All the information was presented on A4 paper sheets and all the graphs were colour printed.

Mortgage scenario in text format

Information about mortgage options:

Option A: principal-repayment mortgage.

The monthly payment will be £1,319. A part of this monthly payment goes towards paying off the mortgage debt, and the other part of the payment goes towards paying off the interest.

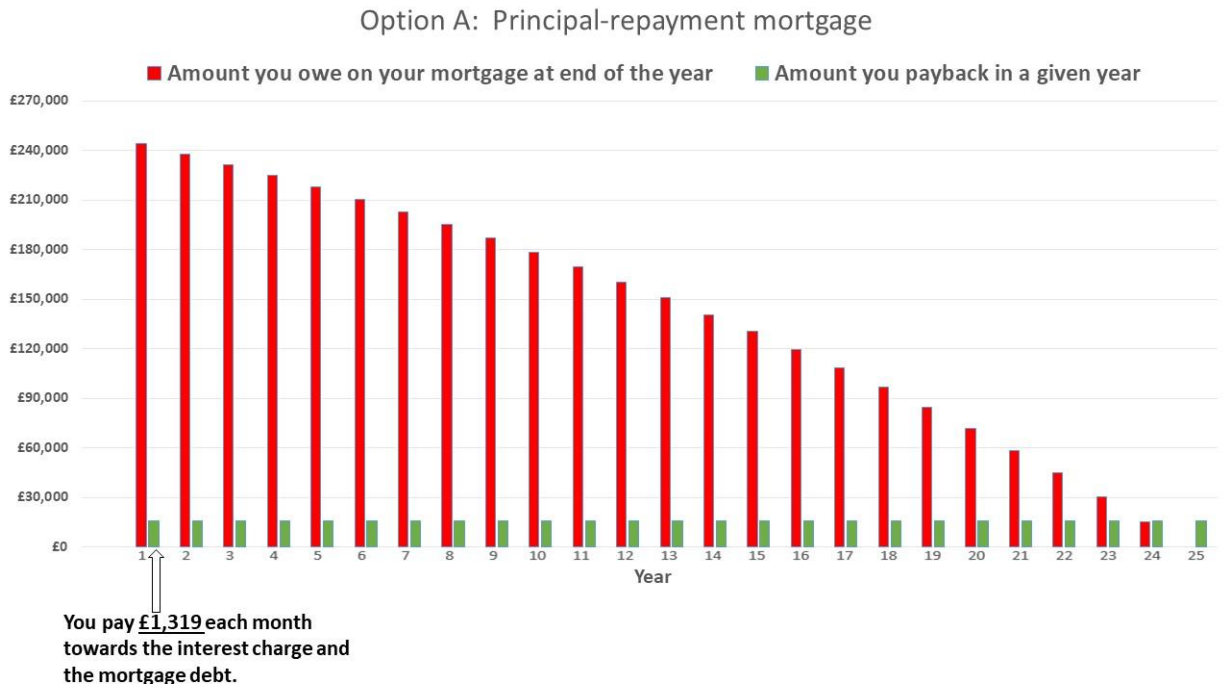
The amount you borrow on your mortgage at the very start of the mortgage term (Year 0) will be £250,000. With each monthly payment that you make, this amount of debt will gradually be reduced. In year 25, after your final payment, your mortgage debt will be £0. Over the whole 25 years, you will have to pay back the £250,000 mortgage, plus £145,712 in interest payments. Hence, the total amount that you will pay back will be £395,712.

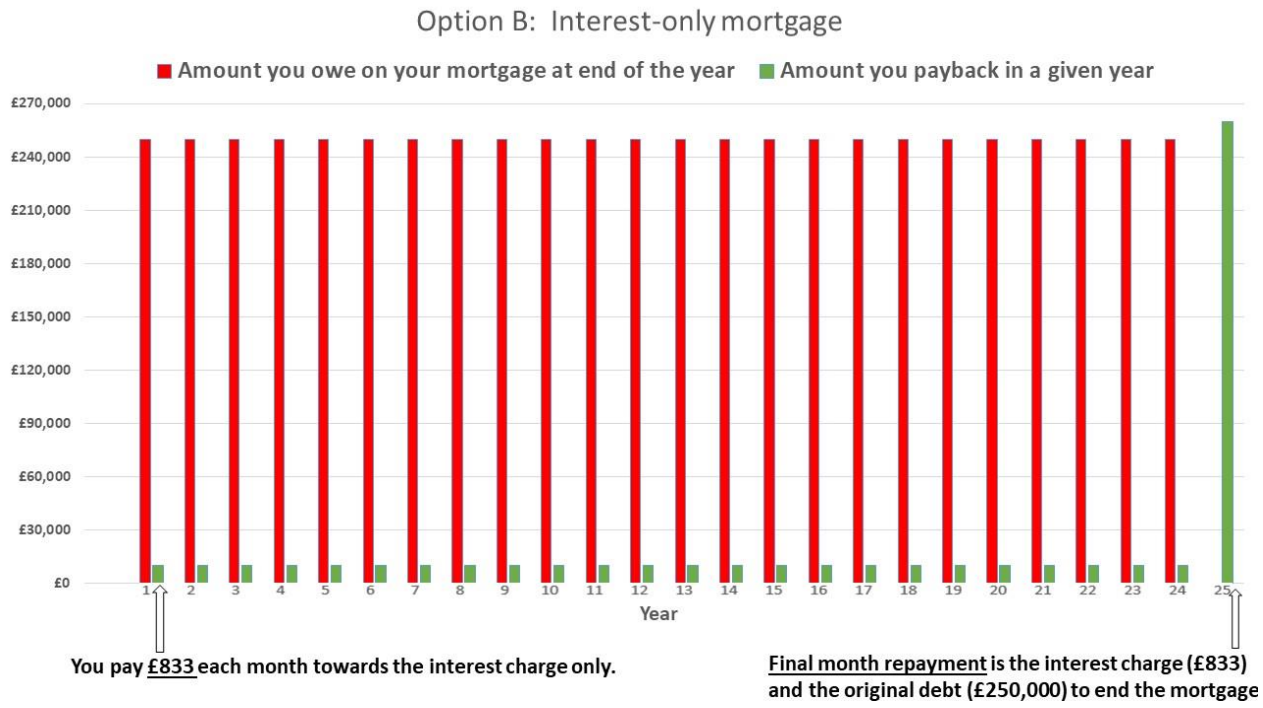
Option B: interest-only mortgage.

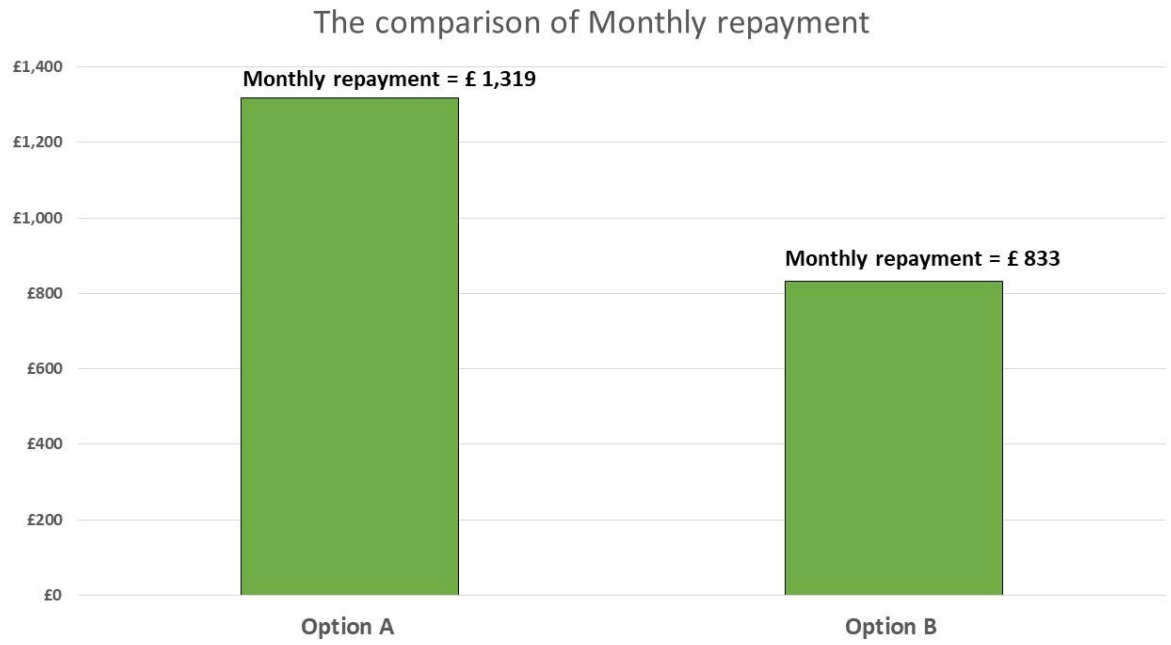
The monthly payment will be £833. All of this monthly payment goes towards paying off the interest, and none of the payment goes towards paying off the mortgage debt.

The amount you borrow at the very start of the mortgage term (Year 0) will be £250,000. This amount of mortgage debt will remain the same throughout the 25-year mortgage term. Therefore, at the end of year 25, you will have to repay all of the £250,000 mortgage debt at once. Over the whole 25 years, you will have to pay back the £250,000 mortgage, plus £249,750 in interest payments. Hence, the total amount that you will pay back will be £499,750.

Mortgage scenario in graphic displays







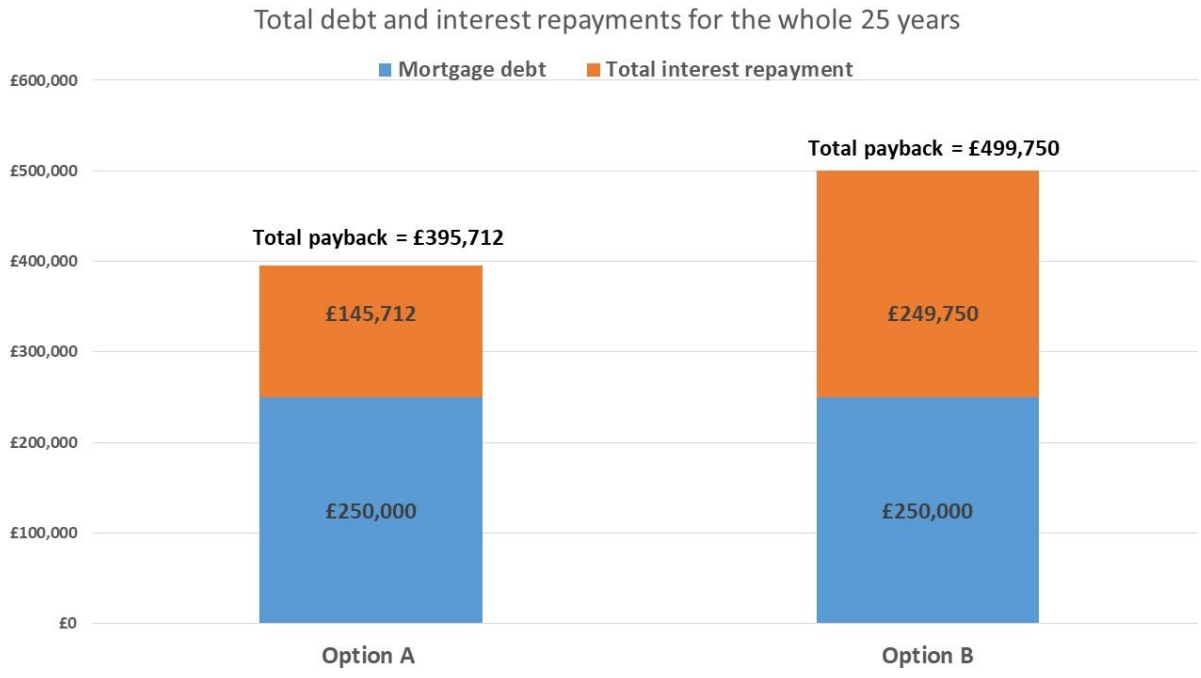


Figure 4.2 The displays of the texts and four graphs in the mortgage scenario

Questionnaire and other descriptive data collection

As mentioned, the study employed a short questionnaire to collect participants' demographic characteristics (i.e., their age, gender and education level) and to assess their familiarity and experience with icon arrays[7]. The question used for the latter was "*How many times have you seen information presented in this format (icon arrays) before?*" and response choices were "*never, once or twice, three to five times, around ten times, more than twenty times and very familiar with this presentation format*". If participants had seen icon arrays before, they were asked to report what kind of information had been imparted from them.

In the think-after procedure, four structured questions were also asked to capture participants' perceptions of the presentation formats for communicating specific financial information. In the stock scenario, the questions were: (1) "*Do you think it is necessary to add precise percentage values in the icon arrays displays?*"; (2) "*From your experience in this study, would you prefer to have this graphic display (icon arrays), or numerical formats such as percentages, or it does not matter which formats are used to communicate this type of financial information?*". In the mortgage scenario, the questions were: (3) "*From your experience in this study, between textual and graphic presentations, which format would you recommend to help individuals with little financial experience understand financial information? Please tell me why?*"; (4) "*Between texts and graphs, which presentation format helps you the most to understand the mortgages and why?*".

[7] It also measured participants' debt literacy since evidence from past studies shows that recipients' prior related knowledge can affect graph comprehension (Stern et al., 2003, Zhang et al., unpublishedb). Debt literacy was measured using three items: awareness of "compound interest", "time-value of money" and "understanding of payment methods". These measures have been extensively employed across different countries to explore their influence on financial decisions (e.g., Van Ooijen and van Rooij, 2016).

Meanwhile, notes were taken to record participants' behaviours during their think-aloud process. Specific behaviours included whether participants were active in obtaining precise probability values from the icon arrays and how they obtained them, for example counting icons and arrays or reading the numbers from the numerical scale. This recording directly helped to indicate whether the icon arrays encourage participants to process and extract accurate verbatim information. Likewise, how participants read the texts in the mortgage scenario was also reported, for instance whether they read the texts word for word, or skim-read them, or failed to finish them. The above assessments were undertaken in order to obtain more valuable insights into participants' information processing behaviours and their evaluation of presentation formats.

4.2.4 Analysis Method of Qualitative data

In analysing the collected data, the recording for each participant was verbatim transcribed. Content analysis was employed to identify and develop categories from the data, systematically. After categorising, I quantified the characteristics recorded in the qualitative data to address each research question, in line with the approach used by (Joffe and Yardley, 2004). The data coding was performed by the software Nvivo. This process was conducted by several stages and was segmented by scenarios. Initially, the coding categories were inductively focused because no qualitative study has explored how such financial information is understood. Specifically, inductive coding was congruent with the principles of content analysis when there is no standardised classification or existing coding scheme (Neuendorf, 2017). Each participant was treated as a fundamental unit of analysis, and 20 transcripts were randomly selected to establish a preliminary set of codes first. At this stage, reading and re-reading of the transcripts enabled the identification and definition of the codes that emerged from the data. Then, a rudimentary coding scheme was developed and subsequently examined by the remaining 20 transcripts. A final coding scheme was established for generic

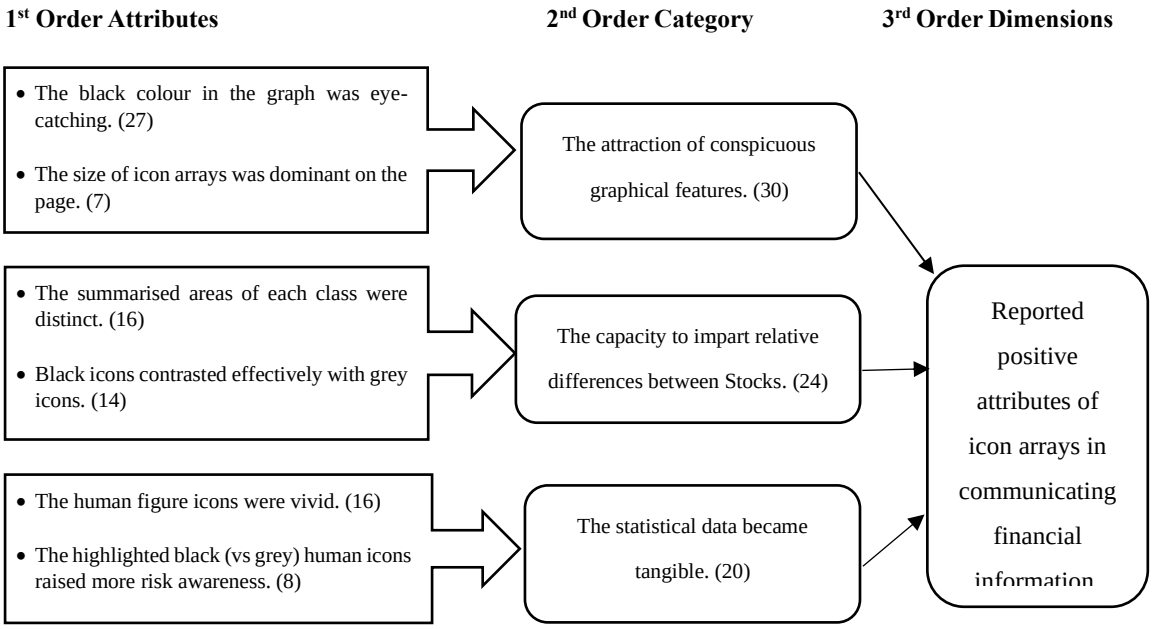
application across all the data. After this, code categorisation was carried out. This was to observe similar meanings that were compiled into the overarching categories through classifying and integrating coded units of the data (Saldaña, 2015). The coding process was performed three times, with each cycle starting with the raw data, before comparing and organising the findings. Constant comparison of the data with the code definitions assured stability of the code meanings.

4.3. Results

For each set of obtained results, a corresponding table was developed to portray the proportions of each category and sub-category articulated by the participants, along with coding explanations, and some exact quotes.

4.3.1 Stock Scenario

This study identified three dimensions from the stock scenario: positive attributes, limitations and subjective evaluations of using icon arrays to communicate financial information. Figure 4.3 presents the overall structure of the icon arrays results.



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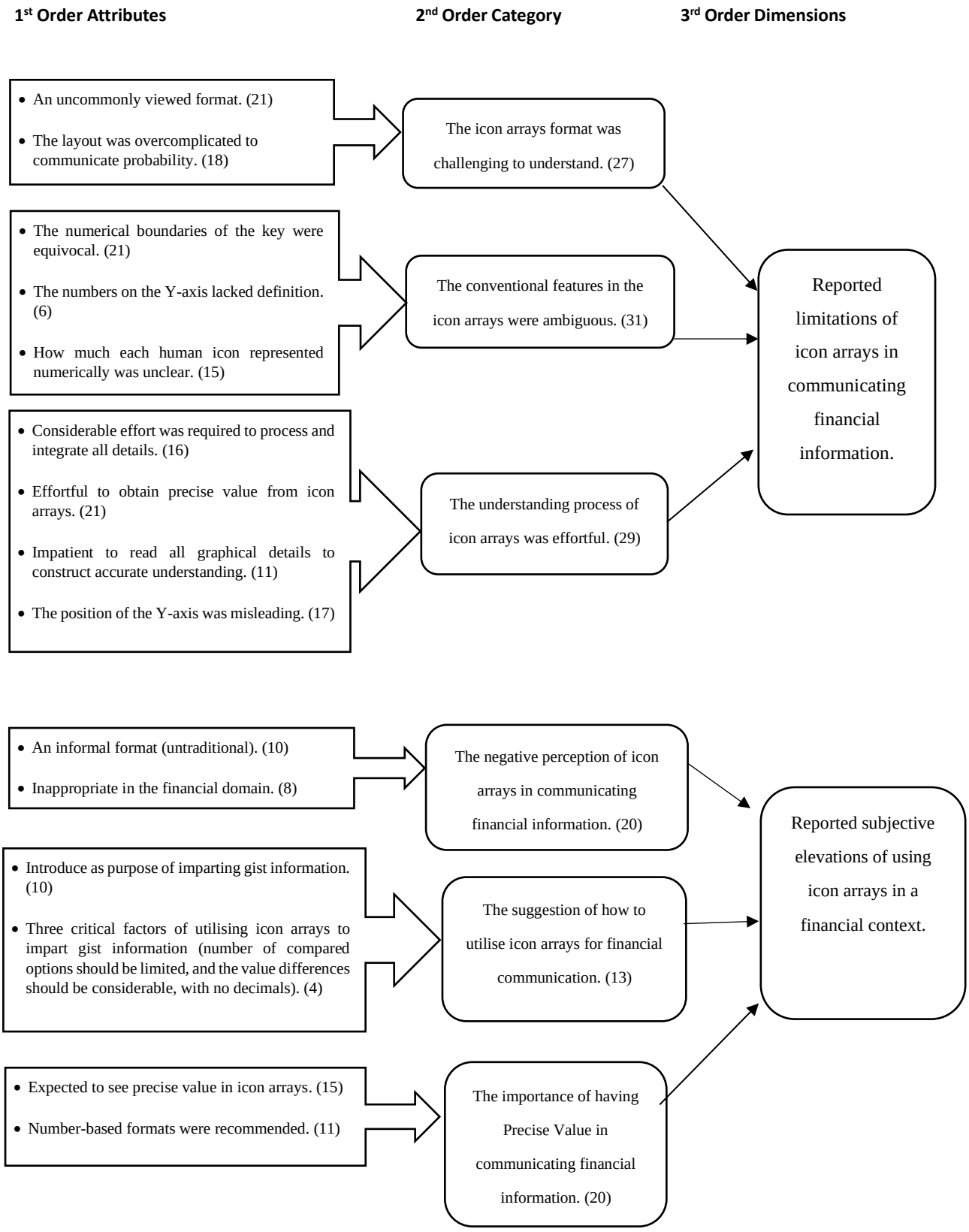


Figure 4.3 Structure of participants' responses following content analysis for the stock scenario presented using icon arrays

Dimension 1: Positive Attributes of Icon Arrays

The data revealed three categories of how icon arrays assisted participants in understanding the risk probability of stocks (see Table 4.2). Firstly, a substantial proportion (30/40) of the participants indicated that they were more attracted by the black human icons than other graphic features like the title, key or grey human icons, when they initially read the information sheet. As clear in the examples in Table 4.2, the black colour, with its summarised area represented, leads most participants to focus on the highlighted class, the black human icons. This resulted in Stock B standing out since its display had more of them than the other two. Most reasoned that the icon arrays diagrams covered a large area of the page and the black colour drew most of their attention.

Secondly, the majority (24/40) perceived that the three icon arrays allowed them to identify the relative differences among the three stocks easily. The data explained that the contrasting colour between black and grey disentangled different classes and allowed participants to compare the categorised areas without any calculations. One example quote is illustrated below:

> "*It's allowing a really obvious comparison. This one, even though you know, say, whatever, that number is bigger than 30, these alongside it really visualises that height. I feel the height is good at visualising significance.*" (Participant 21)

Thirdly, half the participants stated that the use of icon arrays to present financial risk made the statistical data more vivid and closer to their lives. Many of them expressed that because of the icons being human figures, they were more likely to imagine themselves in a similar situation as the displayed humans. Meanwhile, a few participants stressed that they would avoid investing in Stock B because the highlighted class of black human icons grabbed their attention and induced anxiety.

In sum, these findings supported the idea that icon arrays guide participants to notice the prominent class and allow them to identify the relative differences between options effectively. Particularly, the data revealed that the colour attribute of black versus grey in icon arrays evoked pattern recognition. In addition, using human icons made financial data become vivid**.** However, these positive attributes of icon arrays were more likely to facilitate the comprehension of gist than verbatim information, as will be discussed in Dimension 2.

Dimension 2: Limitations of Icon Arrays

Table 4.3 summarises the observed limitations of icon arrays for communicating financial probability information. Initially, more than half the participants (27/40) reported that the layout of human icon arrays was strange, confusing or unfamiliar. They further stated that they found it challenging to process and understand the message initially without considerable cognitive effort. In addition, some commented that icon arrays made the financial information overcomplicated and suggested using other more frequently viewed graphs, such as bar or pie charts.

Second, the majority (31/40) appeared somehow confused about the meanings of conventional features in the icon arrays. In fact, 15 participants questioned the quantity each human icon represented, for instance just one person or perhaps ten or a thousand persons. Six participants questioned whether the numbers on the y-axis scale represented percentages or a hundred investors only. Half the participants also questioned the numerical boundaries of the key (i.e., the representation of the grey and black human icons) and some queried whether the grey human figures, which represented those who lose "less than" a quarter of their investment, also included those who lost nothing or those who made a profit. For example:

> "*It's a bit confusing. Like what is this axis? Is this percentage? So this might be a percentage of people, they take on like the modelling around a hundred people. I guess … but not sure.*" (Participant 29)

"*People who invest in that lost less than a quarter as they still could have lost some, or they also might have made a profit.*" (Participant 34)

The third limitation was that icon arrays comprehension requires effort (29/40). Just under half the participants (16/40) demonstrated that they read each graphic feature attentively and then integrated them to infer the relations among the three stocks. Meanwhile, the data revealed that eleven participants misunderstood the information because they did not dedicate enough effort to reading the graphic features and thus made an incorrect inference. A typical quotation:

"*It's clearly stock B from here is the least bad, the fewest amount of grey, with C being the worst.*" (Participant 14)

Furthermore, roughly half of the participants (21/40) expressed that it was time-consuming and arduous to extract a precise probability value for each stock's risk from the icon arrays. Importantly, the data revealed that participants did not appear to count each icon and array attentively to obtain quantitative information, as was claimed by previous studies. It was interesting, however, to note that some participants performed calculations when they sought to obtain precise values in digits. For instance, they counted the number of grey human icons (i.e., non-highlighted) for example 4 and then subtracted this from 10 (i.e., the number of icons in each row) to get 6. This information processing indicated that, in fact, icon arrays engagement is not necessarily free of mathematics, as some studies claimed. For the reading of arrays, some of them counted each closely, but others just read the numbers on the y-axis. Participants went on to comment that icon arrays are easily miscounted and more likely to elicit human error. More importantly, this study identified one design issue in the icon arrays used. Seventeen participants pointed out that the position of the numbers on the y-axis could be misinterpreted and lead them to infer the wrong percentage. They suggested that the

numbers on the y-axis should be placed in the middle of the human icon figures of each array rather than at the bottom of the human icons. An example of such a comment is:

> "*I look at numbers there, and I realised that could be a bit ambiguous. I don't know whether thirty is below or above.*" (Participant 30)

Collectively, these findings illustrate that (1) format familiarity affects information understanding, (2) the icon arrays design should be carefully reviewed to ensure layout and content mitigate any ambiguities, (3) comprehension of icon arrays can require considerable effort by readers, and (4) icon arrays may not necessarily impart verbatim information effectively.

Dimension 3: Subjective Elevations of Using Icon Arrays in a Financial Context

Three categories of participants' general evaluations of icon arrays in a finance context are defined and shown in Table 4.4. First, icon arrays were perceived as an unexpected format to use in communicating financial information (20/40). Some of them saw icon arrays as an informal format in doing so and as untruthful. A few participants, who study in the heath domain, expressed that icon arrays were unsuitable for communicating financial information in contrast with health-related information. As illustrated:

> *"Myself in medicine. So I think if it was a medical one, it would be kind of just a person's risk in a certain time period, for example, having a heart attack. In this one, it would be like 24 people out of a 100 will have a heart attack. And they're all kind of in the same situation. And then the equivalent that is not having the heart attack. I think that's more simple than people who have lost at least a quarter, or people who have lost less than a quarter. So, I think in medicine it's just a bit simpler."* (Participant 10)

> "*I feel like thirty-six percent conveys more kind of trustworthy rather than just thinking about thirty-six people."* (Participant 38)

The second category is participants' suggestions on how to utilise icon arrays to present financial information. Ten of them suggested that icon arrays format could be used for introductory purposes. Four of them stressed the reasons why icon arrays allowed them to easily visualise relative differences. They stated this was because the value differences between the stocks were sufficiently evident, the number of options to compare was not too high, and decimal values were not involved. In fact, these suggestions point towards critical factors to be considered in the design of icon arrays. More importantly, half the participants believed that having precise values is essential for financial investment information. Thus, some of them preferred number-based formats, such as percentages, because they believed exact numbers were straightforward, making them more confident and dispassionate in their comprehension.

> "*So it (icon arrays) was trying to be kind of more emotive. Rather than… if I was thinking about investments, I think I'd want it to be more actual figures rather than emotive*". (Participant 38)

In sum, these additional findings strengthened the idea that format familiarity, and the nature of the communicated content, have strong effects on recipients' perceptions of the credibility of information provided and format selections. Additionally, it appears to be important to present precise values in graphs used in financial communication.

Table 4.2. Reported positive attributes of icon arrays in communicating financial information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a.	The attraction of conspicuous graphic features [30]	Refers to the initial attraction when participants started to read the information.	▪ Black colour in the graph was eye-catching. [27] ▪ The size of icon arrays was dominant on the page. [7]	• "Definitely the black, the kind of bold colour (i.e. black colour) definitely gets my attention much more." (P6) • "First attention, I say the stock B, the amount, I think. The black is quite alarming. Um, so the first thing to catch my attention was the stock B, like the numbers of the black figures. Because that's the most of all of them." (P20) • "Initially, the graphs, of course, with the biggest thing on the page. And that's why I was first drawn to them". (P33)
b.	The capacity to impart relative differences between stocks [24]	Refers to the comments of how participants benefited from the icon arrays displays.	▪ The summarised areas of each class were distinct.[16] ▪ Black icons contrasted effectively with grey icons.[14]	• "I think it's quite easy to show that one stock is more risky than another. Just compare the size. Look at it in general, like without calculating. You can sort of see which one has a bigger ratio." (P8) • "It's allowing really obvious comparison. This one, even though you know, say whatever that number is bigger than 30, it's really visualised that height. I feel height is good at visualising significance." (P21) • "Probably the contrast between the two colours of people in the graphs, which kind of makes stock B standout, because it has the highest amount of the dark-coloured people kind of visual difference." (P38) • "The colours were useful, it's very illustrative that you can see light and dark, dark being the worst-case scenario." (P2)
c.	The statistical data became tangible [20]	Refers to thoughts of using icon arrays in communicating financial information.	▪ The human figure icons were vivid. [16] ▪ The highlighted black (vs grey) human icons raised more risk awareness. [8]	• "This, you may feel like that having physical image, brings you more to life, you can actually visualise it." (P21) • "I think the fact that these little people help a lot because like shows you the real people rather than just like numbers, makes it more personal." (P25) • "This one, you can actually see each one is a person. If you were to take this option, stock B, you could either be one of these people (black), or you could be one of these people (grey). So I think this makes it more humanised." (P3) • "It helps you sort of see that is happened to 24 per cent of people, um, makes it more personal. So if you invest your money into something, I think seeing the amount of people that lost money, you'd feel like touched your money rather than a percentage." (P20) • "I think the graphs give me a nice, especially emotionally use, like an emotional understanding of what's going to happen. Like these little people." (P30) • "Um, so I'd probably draw away from stock B. Because it has the most black people, yeah, a lot of black people, feel panic, you know." (P4) • "I'd say anxious, actually, slightly worried, yeah, anxious, worries. Because you can see here, the black people, mostly they're going to lose at least over a half." (P2)

Table 4.3. Reported limitations of icon arrays in communicating financial information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a.	The icon arrays were challenging to understand initially. [27]	Refers to the thoughts and reactions when participants initially processed the icon arrays presentation.	▪ An uncommonly viewed format. [21] ▪ The layout was overcomplicated to communicate probability. [18]	• "The info-graphics laid out kind of weirdly for me, because that's just not how my brain works in terms of like this… For me personally, it would make it harder for me to understand." (P19). • "I'm trying to understand information, I haven't seen anything like this before, so I'm quite confused most." (P22) • "So, it's quite strange how that people rather than just percentages. I think it would make more sense if it was in like a percentage terms. Um, that's kind of I suppose that the Y-axis is the percentages. They would make more sense for me for to just be a bar… find that quite strange." (P12) • "I just think it was a lot more difficult to get out than it needed to be. I think what they're showing was like or just 56 out of a 100, you know, just put it like that. I think that people are really unnecessary, to be honest." (P11) • "So that I mean, and in that sense, having the pictogram is perhaps not quite so advantageous because you only get the percentage, like the power of ten, you only get the tens column in the height and the one column is the wave. I mean, just visually, maybe for me, it would probably be better if it was just like a bar graph rather than a pictogram." (P28)
b.	The conventional features in icon arrays were ambiguous.[31]	Refers to the thoughts and reactions of uncertainties and queries when participants try to understand icon arrays presentation.	▪ The numerical boundaries of the key were equivocal.[21] ▪ The numbers on the Y-axis lacked definition. [6] ▪ How much each human icon represented numerically was unclear. [15]	• "People who invest in that lost less than a quarter as they still could have lost some, but they also might have made a profit." (P34) • "Because the key is quite vague. It (black human icon) could be anywhere from 25% to 100%, and then the grey figure, these people who lost less than a quarter, that could be 0% to 24%. Um, so everyone could have lost something. but or they could have not or made a gain." (P20) • "It's a bit confusing. Like what is this axis? Is this percentage? So this might be percentage of people, they take on like the modelling around a 100 people. I guess!" (P29) • "Uh, is this a percentage? Or is that just out of a hundred participants? I'm assuming it's a percentage." (P32) • "I didn't realise that one person was like 1%." (P12) • "I think this is quite hard to understand. Um, just with it being people, because I don't know how much each person is meant to represent. If meant to represent money, then again, I don't really know what a 100, for example represents." (P13)

c.	The understanding process of icon arrays was effortful. [29]	Refer to the process reactions when participants try to obtain deeper comprehension from icon arrays presentation.	▪ Considerable effort was required to process and integrate all details.[16] ▪ Effortful to obtain precise value from icon arrays. [21] ▪ Impatient to read all graphic details to construct accurate understanding. [11] ▪ The position of the Y-axis was misleading. [17]	▪ "I will say it's a bit kind of overwhelming, because there's a lot of variables you have to maintain in your head." (P36) ▪ "Here, you've got kind of the vertical information, which is coming from zero to a hundred and tens. But you also then have to kind of go horizontally and think about those things. It's a bit confusing. Because when you look at a graph, you expected to go up, not go up and across." (P40) ▪ "Because the way this is presented. Slightly confusing if you don't look at it more than once. And we just look at once slightly confusing. And then these little things (the key), you gotta then translate this onto the graph. You know, confusion." (P14) ▪ "It's clearly stock B from here is the least bad, the fewest amount of grey with the C being the worst." (P14) ▪ "36% of people lose at least a quarter of their investment, which means that is 64% gain." (P30) ▪ "It is hard for me to sort of see how many exactly, like how many people like with the percentage, even though is sort of visually represented, I sort of have to make sure where the line is." (P35) ▪ "Um, if you were looking to get specific figures, then maybe not so good because it would take a while to interpret it. And it seems like a very manual thing to interpret." (P6) ▪ "I look at numbers there, and I realised that could be bit ambiguous. I don't know whether 30 is below or above." (P30) ▪ "I mean, I wasn't sure initially whether the number on the Y-axis was referring to kind of the bottom of the person on the top of the person." (P38)

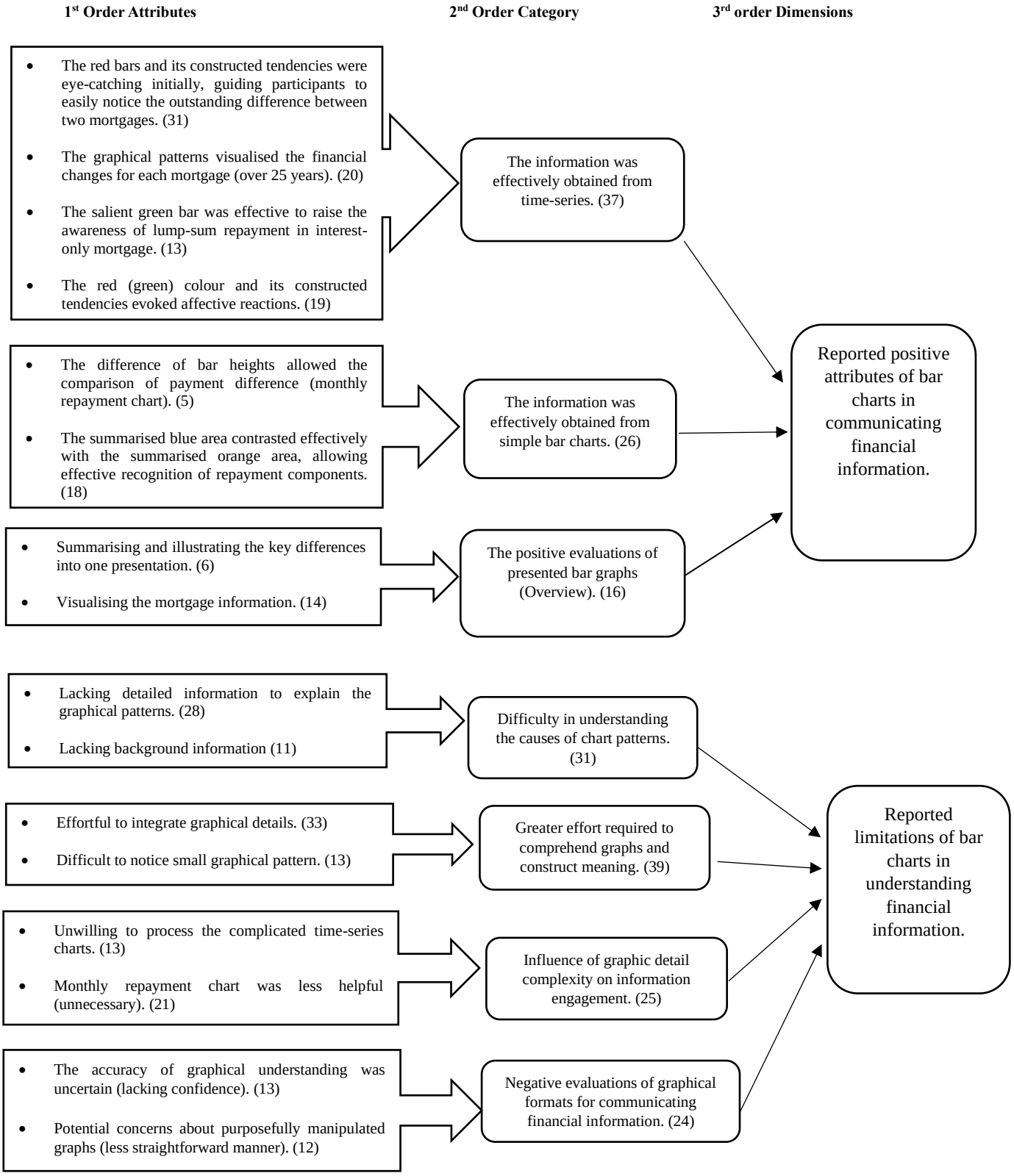
Notes: The reported positives and limitations of icon arrays reflect the comprehension process of how participants understood the displays and that how they obtained financial information from such displays.

Table 4.4. Reported subjective elevations of using icon arrays in a financial context

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a.	The negative perception of icon arrays in communicating financial information.[20]	Refers to participants' comments when they viewed the icon arrays in communicating financial information.	• Icon arrays were viewed as an informal format because they were untraditional.[12] • Icon arrays were perceived as inappropriate in the financial domain.[8]	• "I feel like 36% conveys more kind of trustworthiness rather than just thinking about 36 people". (P38) • "I guess maybe just associate to the financial information with not serious graphs, but like, I guess more traditional bar graphs … better". (P35) • "Like coloured pictures of people doesn't seems that kind of scientific." (P38) • "Myself in medicine. So, I think if it was a medical one, it would be kind of just a person's risk in a certain time period, for example, having a heart attack. In this one, it would be like 24 people out of a 100 will have a heart attack. And they're all kind of in the same situation. And then the equivalent that is not having the heart attack. I think that's more simple than people who have lost at least a quarter, or people who have lost less than a quarter. So, I think in medicine just a bit simpler". (P10)
b.	The suggestion of how to utilise icon arrays for financial communciation.[13]	Refers to the participants' suggestion of how to utilise icon arrays.	• Introduction as the purpose of imparting gist information. [10] • Three critical factors of utilising icon arrays to impart gist information (i.e., number of compared options should be limited and the value differences should be considerable, with no decimals).[4]	• "It seems like it's more good for introduction, or if you need to give information quickly". (P16) • "It's quite clear, like this is much worse than this one, that B is much worse than C, but to actually understand how much worse it is, you have to kind of sit there and count it. So, just for comparison as introduction". (P40) • "However, I think when it comes down to like a 1% difference when you're really comparing three stocks, difficult". (P17) • "It could be useful as have 36%, because you do have to count them. I find like you get a good idea just by looking at them, but you do have to like be more careful to count if it you said 34. Or what if it was 34.5%, that will be hard to show. Yeah, it was like 37.8% that will be hard to know exactly just by looking at the people." (P25) • "It's nicer to see in the diagram. Um, but obviously, if you had loads and loads of these diagrams, it might be too much". (P32)
c.	The importance of having precise value in communicating financial information.[20]	Refers to the participants' suggestion of how to improve icon arrays in communicating financial-related information.	• Expected to see precise value in icon arrays when communicating financial information.[15] • Number-based formats were recommended when considering communicating financial information (more confident and reliable).[11]	• "If it didn't have an exact number, I would probably be a bit put off by it." (P32) • "Um, simply because you're investing your money into, so you want to see numbers in the graph". (P12) • "Um, personally, I would prefer it with the like the percentage numbers on. But that's just a personal preference. … Um, but I think it would make it slightly clearer for me to understand if it had precise numbers on it, because if I see anything that doesn't have a precise figure on it, I kind of think, okay, why are you not telling me? Like, you've shown me a picture that says, you've got x y z things that I've had to kind of decipher from it, but why are you not telling me in terms of numbers, you know, the things that I actually needed to see - numbers". (P19) • "I think the number itself more confidence. I think it is that of confusion of these pictures, I think because I had such difficulty reading the graph itself. I think I'd feel more comfortable at least with numbers. You can see straight ahead, and without that sort of doing counting or anything". (P37) • "And if I'm looking to invest money, then I wanna see numbers. I don't wanna see colour and shapes." (P18)

4.3.2 Mortgage Scenario

This study identified five dimensions in the mortgage scenario. The full coding structure of the participants' responses, following the content analysis for the mortgage scenario presented using bar charts and texts, is shown in Figure 4.4.



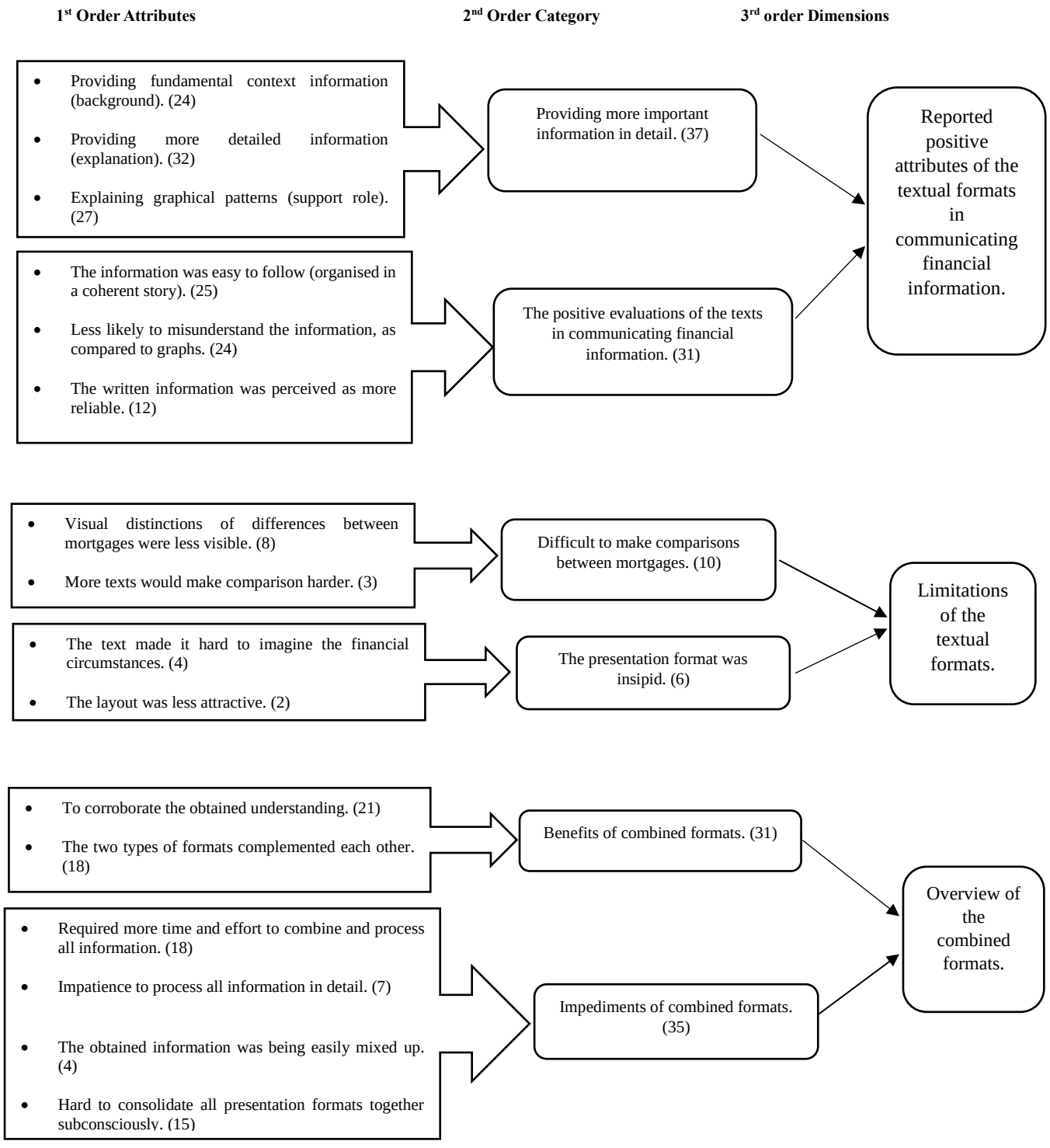


Figure 4.4 Structure of participants' responses following content analysis for the mortgage scenario presented using bar charts and texts

Dimension 1: Positive Attributes of Bar Charts in Communicating Financial Information

The effectiveness of bar charts to communicate mortgages was categorised into three aspects. The coding explanation and sample quotes are shown in Table 4.5.

(a) Time-series charts: visualised financial situations

For time-series charts, which displayed the financial changes for each mortgage throughout the 25-year mortgage term, the majority (31/40) was initially more attracted to the noticeable trend of the outstanding balance than to other features, such as the arrows, legends, titles or green columns. Most of them explained that because the outstanding balance was represented by a red colour, it led them to notice this significant financial difference between the two mortgages. Twenty participants commented that these time-series charts were helpful because they illustrated an overview of financial change through time for each mortgage.

In addition, thirteen participants emphasised that in the interest-only mortgage chart, the final green bar stood out significantly in year 25. They perceived that this prominent bar raised their awareness significantly, drawing attention to the lump sum repayment more than the texts were able to. One participant even stated that he seemed to have ignored or neglected this final repayment difference in the texts but not so in the bar charts. For instance:

> *"I felt like I learned this was more…, I had more of a 'wow, that's ridiculous'. The amount that you're paying off, so that the sudden repayment here of 250,000 like that kind of feeling, that was crazy and I am not sure I got that from the [information] sheet."* (Participant 39)

Meanwhile, many participants (19/40) expressed that they were happier or relieved when they noticed the gradually decreasing red columns in the principle-repayment chart, but felt stressed and overwhelmed to see the constant red columns in the interest-only chart. Likewise, the final highlighted green bar has an influence on participants. As expressed, when they saw a large pay-out at the end of the mortgage year in the graph, they tried to avoid it because the tall and significant bar made them feel intimidated (9/40). This finding indicates that graphic formats made the financial

information more approachable and vivid, but also influenced some participants' affective reactions, as is illustrated:

> "*The fact that it red is worse and looking like trouble already. I like to see that gradually the money is coming down. This seems to make me a bit happier, a bit more relieved. Whereas it's just high, high and it goes higher, it doesn't help." (Participant 15)*

> *"The particular at the end, the bar is higher and still green, so, I have to carry on paying it. Um, so based on this, it seems immediately that I would go with that one [principle-repayment mortgage] because the money disappears at the end. Because the text there is a lot smaller, so immediately, you are drawn to the graph, and you're looking at what's going on make more sense. Because things are really happening with this one."* (Participant 19)

(b) Simple bar charts: visualised payment difference

The most concise bar chart, which only represented monthly repayments, was skim-read by the majority of participants. Only a few (5/40) mentioned that they properly compared the bar heights to look for monetary difference. It is plausible that the chart only imparted one simple piece of information and the height difference between the two bars was conspicuous, along with the precise repayment value at the top of each bar.

Regarding the segmented bar chart, which presented the proportions between total repayment and total interest repayment, eighteen participants stated this graph was useful and had an influence on their decisions. They explained that the contrasting colours (blue vs orange) assisted them to differentiate between two main repayment components (namely the original debt and the total interest repayments), and then to simply compare the size of the summarised area to determine that the significant repayment shortfall between the two mortgages was the total interest charged. Some expressed that the highlighted difference made them more apprehensive about the repayment and that it felt better to choose the principle-repayment mortgage, having less total interest to repay. Interestingly, although participants drew attention to the

heights or area differences, they also said they paid attention to the precisely stated values in the charts and believed having precise numbers in the graphs was very helpful.

(c) Positive evaluations of presented bar graphs for financial information communication

I have classified two general positive thoughts that participants referred to, regarding these four graphs. As consistent with the abovementioned observations, graphs helped make the written texts on mortgage information feel concrete and approachable, particularly the time-series charts (14/40). Some participants (6/40) mentioned that the graphs summarised and presented the main differences between two the mortgages into a single presentation, which assisted them in noticing the differences more easily.

In sum, these findings demonstrated that (1) graphs have the ability to raise participants' awareness of crucial information and of differences which may be neglected or not easily detected in a textual format, (2) the contrasting colours played a dominant role by attracting individuals' attention and eliciting affective responses, and (3) graphic formats can make abstract information more concrete.

Dimension 2: Limitations of Bar Charts in Communicating Financial Information

The data falls into four categories of how such bar charts prohibited participants from obtaining in-depth financial knowledge. The coding explanation and sample quotes are shown in Table 4.6.

(a) Difficulty in understanding the causes of chart patterns

The majority (31/40) stated that they felt challenged in understanding the graphs without reading the textual information first. The common reasons were that the graphs could not provide essential background information and lacked detail to explain the graphic patterns. This means that, although graphs facilitated participants to recognise the key differences or changes, alone they were unable to implicitly impart what repayment mechanisms caused such differences. This is illustrated by the following comment:

> *"Although this (red) is quite attractive to look at, I feel as if I had had this in isolation, I would have to look at the numbers, do more working out, more*

what's going on. I think that would have been more difficult to understand." (Participant 9)

(b) Greater effort required to comprehend graphs and construct meaning

Almost all participants (39/40) reported in common that they spent more effort to process, understand and construct meaning from the graphs compared to the texts. The analysis revealed detail on this. As a large number of participants (33/40) expressed, graphs included many dispersive elements requiring of them a certain degree of attention to retrieve, integrate and make inferences. In other words, constructing meaningful and accurate comprehension from these graphs needed certain cognitive abilities. Graph comprehension processes were elaborate, as illustrated:

"*There's quite a lot of figures in the graphs. There's a lot of numbers to get your head around because there's a total payback, mortgage debt, total repayment. Again, it's a lot of numbers to read through. Very hard to put all together, you know*." (Participant 2)

"*You would have to look here, here, here (i.e., each small piece of the information on the time-series charts), then, you have to work out for yourself*." (Participant 3)

Furthermore, some participants (13/40) stated that the inconspicuous information - such as small green columns, which represented the yearly repayments - was very hard to notice and consider when they were making financial judgements. The reported reason was that in the time-series charts, the red columns were more dominant in the graphs via taller bars, so they received the most attention and cognitive resources.

(c) Influence of graphic detail complexity on information engagement

With the examined bar charts in this study both simple and complex, the data suggests that the impression of graphic complexity could affect participants' willingness to actively engage in graph interpretation and comprehension. A small number of participants (13/40) reported that they were less willing to read the time-series charts because they appeared more difficult to understand. A few participants even suggested excluding the time-series charts because of their complexity. In addition, although some participants reported the monthly repayment chart as more comfortable to read, many

participants (21/40) judged this simple chart to be unnecessary because it did not provide extra benefit. These findings imply that graphic preference was quite varied among individuals.

(d) Negative evaluations of graphic formats for communicating financial information

Two categories were distilled from participants' negative overall judgements about the graphic formats. Firstly, thirteen participants particularly expressed that graphic formats can give rise to inaccurate comprehension. They reasoned that comprehension was dependent on how people interpret the graphs, which varies among diverse individuals. In addition, since the graphs included many small pieces of information, they stated that detail was more likely to be misread or neglected, leading to incomplete understanding. Secondly, twelve participants raised concern that information providers can manipulate graphs and misguide audiences. Also, some of them (8/40) stressed that, compared to textual formats, graphs were less clear and straightforward, causing them to feel less secure when considering financial decisions.

In sum, these results reveal that graph design can place a burden on readers. They need to exert considerable cognitive effort to process depicted information and construct relevant concepts. More importantly, participants found it hard to directly extract the more in-depth detail from graphic displays, and they had doubts about graphs' capacity to reliably communicate financial information.

Dimension 3: Positive Attributes of the Textual Formats

Table 4.7 presents the identified categories and some sample quotes of how textual formats facilitated participants to understand the mortgage information, as compared to graphic formats. First, almost all participants (37/40) reported that the texts provided important information that facilitated their understanding of mortgage products. Specifically, twenty-four participants believed that written texts provided fundamental context. Many of them expressed that it was confusing or meaningless to read the graphs without having any background. Meanwhile, a large proportion (32/40) commented that written texts provided more detailed information than graphs because they clearly explained how the mortgage repayments performed differently between the two mortgages. More importantly, twenty-seven participants noted that the written texts

assisted them in understanding the graphs better. In other words, textual formats also facilitated participants to construct relevant knowledge about the identified graphic patterns. For instance, the texts explained why the red columns were constant across 25 years in the interest-only mortgage chart. Further, the participants who read the graphs first commented that the written texts clarified any confusion they initially had had from the graphs. This result was in line with previous findings that it is hard to use graphic formats alone to explain complex patterns.

> *"The text to get sort of like the background information, you get all the smaller details."* (Participant 26)

Second, the data revealed two other positive evaluations of the written texts. One quite prevalent comment (25/40) was that the texts were easier to follow because they were organised and presented in a logical order. The other prevalent comment (24/40) was that they were more confident in their understanding when they read written texts than graphic formats. They explained that texts stated the details directly, thus, they were less likely to misinterpret or misread them. For example, the texts explicitly outlined the length of the mortgage term and the outstanding debt at the final year. As a result, about a quarter of the participants (12/40) agreed that written texts are more reliable than graphic formats for communicating financial information. Indeed, the written text format was viewed as a contract, somewhat like a legal document. For example:

> "*I found it (written texts) easier because the way it's written. It's quite logical. And it's easy to follow. And it tells you everything you need to know in the same order.*" (Participant 31)

Dimension 4: Limitations of the Textual Formats

Interestingly, the data revealed few limitations of the textual formats. In total, only fourteen participants expressed negative evaluations of texts in imparting mortgage information (see Table 4.8). Ten participants pointed out that it was not easy to detect or "visualise" the distinction between mortgages from the written texts. That is, participants required effort to select, compare and summarise the differences by themselves. In addition, a few participants (6/40) shared that the written texts were "insipid" because they only consisted of words.

In sum, the text format findings demonstrated that recipients often find written texts preferable to and more trustworthy than graphic presentations when receiving communication of financial matters. The revealed positive attributes of texts were that they were more straightforward with less integration processing required, and they explained the financial information in greater detail requiring less interpretation effort. However, the ability of texts to help participants recognise differences between financial products seems to be limited.

Dimension 5: Overview of the Combined Formats

Table 4.9 provides the coding explanation and sample quotes on how participants utilised and evaluated both texts and graphs presented together. About half the participants (21/40) appeared to use both types of formats to strengthen the accuracy of their understanding. The majority read the textual format first, and then examined the graphs to corroborate and visualise their understanding already obtained from the texts. To illustrate:

> "*The text one was definitely very useful. Because like it might have been easy for me to understand the text. But I found that the graphs just reinforced my knowledge. If once I understood what the writing was about, then this was just kind of confirmed in the in a big bar graph and then, confirmed further."* (Participant 4)

Furthermore, about half the participants (18/40) considered these two formats complementary. Graphic formats were evaluated as an aid to visualising the textual information. However, a few of them commented that a visual aid is a useful additional tool, but not essential. For example:

> *"Like you could get away without it (graphic displays). It's not like salt and pepper. But more like ketchup. You know, with chips. You know, it's a good compliment, but it's not essential."* (Participant 14)

On the other hand, the data revealed four impediments to using such multiple formats to impart mortgage information. First, it showed that to process and combine all identified information from all formats requires more effort and time. Eighteen participants noted that they kept going back and forth between formats to check whether

the information was consistent and whether they may have omitted any detail. Further, fifteen participants were unable to consolidate all the obtained knowledge subconsciously. That is, although the four graphs conferred distinct and essential elements of mortgage information, these participants stated that they could not construct all the identified patterns and detail as one coherent set of information. Interestingly, a few participants tended to make judgements on the benefits and drawbacks between graphs rather than considering them to be complementary to each other. Third, when the information was presented across various formats, participants were less likely to read all of it attentively. Specifically, seven participants overlooked certain important features in the graphs or neglected certain information in the written texts. Meanwhile, four participants were lost when they tried to process all the presentation formats simultaneously.

In sum, although multiple formats provide some benefits, to accomplish these benefits, participants should spend considerable effort and be sufficiently patient to process each presentation format verbatim. Indeed, they were expected to remember the knowledge they had already obtained and were able to consolidate all the information from the various formats to have a better understanding.

Table 4.5. Reported positive attributes of bar charts in communicating mortgage information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a.	The information was effectively obtained from time-series.[37]	Refers to the comprehension process of how participants understand the time- series charts and the information that obtained.	▪ The red bars and its constructed tendencies were eye-catching initially, guiding participants to easily notice the outstanding difference between two mortgages.[31] ▪ The graphic patterns visualised the financial changes for each mortgage (over 25 years).[20] ▪ The salient green bar was effective to raise the awareness of lump-sum repayment in interest-only mortgage.[13] ▪ The red colour and its constructed tendencies evoked affective reactions. [19]	• "So initially the red bars (attracted to). Um, I don't know whether it's because the red is a stronger in colour. Look at the red because obviously there's a trend." (P3) • "First, the red bars. Because quite bright. All these also quite bright colours, but I don't know. Yeah, I just find this (red) is more…you know, my eyes are drawn more towards this and wanna see it". (P9) • "I felt like I learned this was more… I had more of a wow, that's ridiculous. The amount that you're paying off, so that the sudden repayment here of 250,000 like that kind of feeling, that was crazy, and I didn't get it from sheet." (P39). • "From this (time-series charts), you can see what you're doing when you're making a decision about a mortgage. I think this gives you a good visualization of what the next 25 years might look like and whether it's something attainable for you." (P10) • "Being able to physically see actually where you would be financially and you can sort of see what your financial situation would be. So, you can see just where you would be financially. And you can really visualise where you want to be." (P21) • "Once I have an understanding of the text, graphs really helped to visualise the next 25 years." (P1) • "Um, the final bit, I didn't really pay attention when I was reading this. I kind of just thought, yeah, you pay off a certain amount every month. And then it was when I saw that one, it was like, oh, so that one you have to pay back a lot at the end." (P31) • "The one thing that struck me about option B, not looking at the red graph was the green bars. Um, how they were all low. And then suddenly year 25 had a massive, very tall green bar." (P4) • "Wow, so at the end of the 25 years, you still owe 250,000, the big green bar. I think that's what I understand. Um, that's very interesting but depressing." (P2) • "Red is always seen as bad, isn't it? So, decreasing weight is good thing. That's why I probably like that one better (option A), as less red by the end. This one is the red whole way through, you know. So, getting rid of the red is good." (P14) • "Whereas option A is now looking more attractive because I see that the debt is going down each year." (P34) • "Those red lines on the right-hand side, a kind of stuck indicator. God, option B looks awful. That kind of got my curiosity." (P2)

b	The information was effectively obtained from simple bar charts.[26]	Refers to the comprehension process of how participants understand the simple bar graphs.	▪ The difference of bar heights allowed the comparison of payment difference (monthly repayment chart).[5] ▪ The summarised blue area contrasted effectively with the summarised orange area, allowing effective recognition of repayment components.[18]	• "The very first thing I would do is just compare the bars (monthly repayment chart). So this is bigger than this, simple, easy. And then read the associated texts that said comparison of monthly repayments, which would mean that this one is better on a monthly pay". (P28) • "I'm looking at the ratios of between the two colours, the colours are helpful. But I think it's a bit I'm drawn to most is the colour distinction and the option B simply a lot of money than option A." (P37) • "And sort of back up my decision that I was thinking. I think this piece of data is probably the most influential for me." (P35) • "The most important is the orange. So is the interest, because obviously the blue is the same for both. um, that here it makes it very clear." (P3) • "I liked being able to see with using the blue and orange graph, because it may be quite hard to visualise how much £4000 more of option b over 25 years." (P17)
c	The positive evaluations of presented bar graphs (Overview). [16]	Refers to the positive thoughts of all four graphs (i.e., benefits).	▪ Visualising the mortgage information.[14] ▪ Summarising and illustrating the key differences into one presentation.[6]	• "The point of growth is being able to explain texts in a way that you could visualise." (P10) • "I think the… particularly this one with green and red bars was helpful to visualise what the text was talking about and see the changes." (P37) • "Being able to physically see actually where you would be financially and you can sort of see what your financial situation would be. So you can see just where you be financially. And so you can really visualise where you want to be." (P21) • "I think the graphs are a nice way of illustrating what's written in the text and summarising um, textural information." (P10) • "Visual kind of graphics and colours and things tends to make things a bit kind of more approachable. It's kind of visualised." (P38) • "From this (time-series charts), you can see what you're doing when you're making a decision about a mortgage. I think this gives you a good visualisation of what the next 25 years might look like and whether it's something attainable for you." (P10) • "Graphic formats are most straightforward because you don't have to read, you can just look at everything in one graph, a summarised graph." (P8) • "I think the graphs are a nice way of illustrating what's written in the text and summarising textual information." (P10)

Table 4.6. Reported limitations of bar charts in understanding mortgage information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a	Difficulty in understanding the causes of chart patterns. [31]	Refers to the thoughts and reactions of the difficulties in extracting in-depth mortgage information.	▪ Lacking detailed information to explain the graphic patterns.[28] ▪ Lacking background information. [11]	• "I think because I started with the graphs, which was a terrible mistake. Um, it was difficult to try to figure out just from that works on that it was talking about." (P4) • "Graph is always good, but they don't really tell you enough. Because without the context is kind of irrelevant, I don't know what option a and option b do". (P14) • "Um, I think because I know nothing about this kind of thing. Um, I've got four graphs here. I wouldn't know where to start with which graph to look at." (P39) • "If you read them (graphs) first, that would be pointless, because you would have read these graphs not understood and that's just waste." (P21) • "With these (graphs), it is sort of what is this and how does it relate to that or not? Like, oh, this part out that part, and they probably do relate them to the written texts. whereas if I just looked at these graphs, it had been harder for me to sort of piece together the story." (P35). • "Although this (red) is quite attractive to look at, I feel as if I had had this in isolation, I would have to look at the numbers, more workout, more what's going on. So, I think that would have been more difficulty to understand." (P9)
b	Greater effort required to comprehend graphs and construct meaning. [39]	Refers to the negative thoughts and reactions when participants try to understand the graphs in detail.	▪ Effortful to integrate graphic details. [33] ▪ Difficult to notice small graphic pattern.[13]	• "There's quite a lot of figures in the graphs. There's a lot of numbers to get your head round because there's a total payback, mortgage debt, total repayment. Again, it's a lot of numbers to read through. Very hard to put all together, you know." (P2) • "Whereas you would have to look here, here, here (i.e., each small piece of the information in graphs) you have to work out for yourself". (P3) • "Whereas the green information. It's a bit smaller to see. So it took me after the second time of looking at this that there were actual small green bars that floated around. This is important as well." (P13) • "It's quite difficult to see the little green bars. And I didn't notice on the first at all in that. and the second graph doing because there is so much disparity of the two takes; how much, how little you're paying versus how much there is." (P23)
c	Influence of graphic detail complexity on information engagement. [25]	Refers to the negative thoughts when participants see complicated graphs.	▪ Unwilling to process the complicated time-series charts.[13] ▪ Monthly repayment chart was less helpful (unnecessary).[21]	• "Like on first glance, when you first look at it, I think, oh, my god, that looks so complicated, because the way it's laid out. Don't wanna read it". (P19) • "Cross one and two (i.e., time-series charts) had a lot of lines and quite a lot of information, skinny bars and it just took longer for me to get my head wrapped round to understand what actually meant." (P2) • "These graphs just look a bit kind of intimidating, and lots of different lines. Read later." (P33) • "I did a quick little glance of the monthly payments, but those were conveyed in the text. So it didn't really …they didn't really do much." (P11) • "And then I looked at this (monthly repayment chart) because this didn't tell me much more." (P18) • "I don't really think it's (monthly repayment) quite as necessary. I mean if you're someone like me who does these sorts of comparisons anyway, then it's not really necessary. Kind of

				already have the idea of roughly what the proportions are." (P28)
d	Negative evaluations of graphic formats for communicating financial information. [24]	Refers to the negative evaluations of graphic displays in communicating financial information.	▪ The accuracy of graphic understanding was uncertain (lacking confidence).[13] ▪ Potential concerns about purposefully manipulated graphs (less straightforward manner). [12]	• "I think with graphs, because you have to interpret them. If you interpret them incorrectly, you could get it wrong." (P10) • "You can miss out information easily as you read the graph. That's just like what I did in the graphs." (P18) • "With the graph, especially when it's on its own, I think you might be scared, where is there something I'm missing or have a question about something?" (P33) • "Graphs can probably be interpreted in different ways. Lack security." (P14) • "If you don't know how to look at graphs properly, just gonna get mixed up in your mind." (P8) • "Researchers could kind of make graphs look a certain way or kind of do certain statistics or misleading and presenting the information wrongly." (P10) • "So I feel that you can kind of … you can lead people into believing in something with a picture." (P40) • "The text is always what people write first. Okay, so it's the original one. Then they do the graph. So sometimes people may represent the text wrong." (P8) • "I think it's likely hidden behind all the presentation for use, whereas the text is straightforward." (P30)

Table 4.7. Reported positive attributes of the textual formats in understanding mortgage information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a	Providing more important information in detail.[37]	Refers to the thoughts and reactions of how participants evaluated textual information.	▪ Providing fundamental context information (background). [24] ▪ Providing more detailed information (explanation). [32] ▪ Explaining graphic patterns (support role). [27]	• "I need the background, I believe I can get from the texts. Otherwise if you just present me those (graphs), I will be struggling for a while to work out what was going on, I think." (P11) • "I was assuming that if I read the written information first, it will be easy to understand graphs I was given because it will give me more context." (P13) • "The text is more background and more, you know, substantial things. Mortgage is a confusing thing, you want to try to keep less confusion." (P14) • "The texts to get sort of like the background information, you get all the smaller details." (P26) • "I think that (texts) summarises it quite nicely. So, for me it's quite good to understand, like the reason behind the difference." (P25) • "I thought the texts clarified what I didn't understand better. Because there was just lots of information. Um, and it did." (P16) • "This (written) is giving me more details than the graphs, because like this (the total repayment chart) hasn't told me technically what I am paying back." (P15)
b	The positive evaluations of the texts in communicating financial information.[31]	Refers to the thoughts of how participants judged the role of textual information in financial domain.	▪ The information was easy to follow (organised in a coherent story). [25] ▪ Less likely to misunderstand the information, as compared to graphs. [24] ▪ The written information was perceived as more reliable. [12]	• The written information is slightly easier to understand because you got everything in front of you, and it's quite clearly laid out." (P19) • "I think the text is more reliable. I think with text, it's just kind of giving you the facts." (P10) • "Text is that …is that, you cannot really interpret that any different." (P14) • "So, I think it's really important to have the text for kind of maybe like legality. And to kind of put the numbers in there and the calculations." (P10) • "And I think if I was just given graphs, I would almost a lack a sense of security. I feel like having it written down in sentences is more… Um, it almost seems more honest." (P32). • "Um, I think that I have to have a written text just maybe for coherence. And I think it's more the standard and you used to see everywhere. I think that it would be maybe potentially like not irresponsible to always use graphs for people who wouldn't be able to jusst understand straightaway, the written texts that people can understand better." (P35) • "What would be running through my mind is making sure that, you know, if anything goes wrong, I can refer back to something and with the text is something clearer. Rather than, if I had to explain to someone, I was explaining to pay this much because the bar on the graph is this high. I don't really feel that that would be so reliable, you know, they could just say we drew the bar the wrong height. If there were any discrepancy, I would probably prefer the texts in terms of reliability." (P28)

Table 4.8. Limitations of The Textual Formats in Understanding Mortgage Information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a	Difficult to make comparisons between mortgages.[10]	Refers to the negative evaluations of textual formats (vs graphs).	▪ Visual distinctions of differences between mortgages were less visible. [8] ▪ More texts would make comparison harder.[3]	• "So, you can't really see the difference on what you're paying because you can't really see the comparison that clearly when looking at texts". (P26) • "I think they give you the same information. I think these ones immediately highlight the difference in interest. whereas this one would take a little bit more time to do it; (texts) you have to summarise by yourself." (P31) • "Sometimes like if there was more texts you can get a bit lost like figure and reading and whereas the graph is quite helpful and see the difference immediately." (P20) • "And normally with texts, this amount is, I think, good enough, because for one whole option is this much. And there's a lot of numbers. Yeah, you will lose track as to what number represents what? And the basically … like too much information like a long paragraph, you can get mixed up and it is difficult to know what are the differences. But you can see from the graphs, right?" (P8)
b	The presentation format was insipid. [6]	Refers to the general evaluation textual presentation formats.	▪ The text made it hard to imagine the financial circumstances. [4] ▪ The layout was less attractive.[2]	• "Because without having these pictures, you have to build the picture in your head. So, you kind of have to think what these numbers mean, and compare it back to the information that you've been told before, which requires more effort than kind of just having a picture drawn for you. I guess." (P40) • "I think that it is harder in the texts because it's harder to envision sort of the exact relationship between the amount debt." (P35) • "It's only black and white. Um and figures and words. I don't like it (texts)." (P36)

Table 4.9. Overview of the combined formats in understanding mortgage information

	Category	Code Definition	Sub-Category Attributes	Sample quotes
a	Benefits of combined formats.[31]	Refers to the thoughts on how participants' use two types of formats.	▪ To corroborate the obtained understanding.[21] ▪ The two types of formats complemented each other.[18]	• "I think it's reinforced the texts already said, so your monthly payment, but and then it just reinforces the whole paying two hundred fifty thousand pound at the end of the twenty five years. (using the graph to reinforce your understanding from the texts)." (P24) • "I think that's just because I already understood a sort of concept from the texts and these are (graphs) just confirming it." (P35) • "I mean, I think the text was easy to understand, um, and I wouldn't have been able to understand the time series charts without the texts. Um. But then the texts didn't show effectively the effect over time." (P34) • "Some people might not process the texts straight away or using a text and graphs. The graphs are quick to read, and the text will reinforce. So, they complement each other, I think." (P15)
b	Impediments of combined formats. [35]	Refers to the thoughts and problems when participants read multiple formats.	▪ Required more time and efforts to combine and process all information.[18] ▪ Impatience to process all information in detail.[7] ▪ The obtained information was being easily mixed up.[4] ▪ Hard to consolidate all presentation formats together subconsciously.[15]	• "I checked if the amounts are the same or not between them (i.e., texts and graphs). But, any new information? Time consuming". (P35) • "Between them, I try to confirm, to see, like, okay its text saying the facts as well as the information here (graphs). And what is the information here trying to let me know through the text. So, making sure I am alright when I am interpreting graphs. Like matching between them. …that sort of thing. I think it is time consuming". (P15) • "The texts didn't tell me, it is 25 years. Let me check… oh, it does say 25 years, I missed that. Too much information." (P22) • "I forgot I had not read the part B, I wish I had read part B first and then it took the graph, it would have helped me a lot." (P5) • "I read it kind of read option a line by line. And then option B was more of … I took the numbers out of it, assumed that it would be the same kind of setup (unfinished readings)." (P12) • "These two pages (four graphs) didn't kind of correlate for me." (P19) • "I consider them separately. Um, I don't know why. I think they look like two different things. Um, may be because the green of the payback and the owing are separated here. I mean they are sort of here as well. I think that sort of looks different to this one. So, say that like completely separate." (P20)

4.3.3 The Results of Descriptive Data

The collected descriptive data were summarised and are presented in Table 4.10. In general, these descriptive data supported the above qualitative findings and provided for deeper clarity of the objectives[8].

First, participant familiarity with the icon arrays format was classified into four groups. Table 4.10 shows that, in general, most participants (27/40) have rarely or never seen icon arrays before. Importantly, among participants who had encountered them, the communicated information was usually health-related, such as disease statistics, and none of them declared having seen icon arrays used to present financial information. Moreover, only fourteen participants actively obtained precise percentage values (i.e., verbatim knowledge) when they looked at the icon arrays (see Table 4.10). This implies that the icon arrays format was not conducive to imparting verbatim knowledge. The data also revealed that half the participants preferred number-based formats, and over half of them believed having additional precise percentage values in the icon arrays was necessary for communicating financial information properly.

Second, regarding the comparison between texts and graphs in the mortgage scenario, the data reveals that the textual format was preferred by the majority of participants in receiving mortgage information. Table 4.10 demonstrates that thirty participants would choose texts over graphs to impart the mortgage information, and twenty-seven evaluated the texts as more helpful at helping them understand the mortgage information. Moreover, about half the participants (22/40) either skim read or only read half of the texts in the mortgage scenario, which suggests that various presentation formats could result in information overload and, hence, inattentive information processing behaviour.

[8] The additional descriptive data and discussion of participants' debt literacy related to graph comprehension can be found in Appendix D.3.

Table 4.10. Summary of descriptive data

Format familiarity of icon arrays: ***How many times have participants seen information presented in icon arrays?***	
Never	10 (25%)
Once to five times	17 (43%)
Approximately ten times	6 (15%)
More than twenty and very familiar	7 (18%)
Types of information participants have seen before presented by icon arrays	
Mathematics (textbook)	5 (13%)
Communication on disease	15 (38%)
Population statistics (e.g., incarceration, crime)	10 (25%)
Whether participants actively obtained precise probability value in icon arrays	
Yes	14 (35%)
No	26 (65%)
Participant preference between icon arrays and number-based formats in imparting financial probability	
Numbers (e.g., percentage)	20 (50%)
Icon arrays	10 (25%)
Neutral	10 (25%)
Participant evaluation: whether it is necessary to add precise probability values in the icon arrays	
Necessary	28 (70%)
Not necessary	12 (30%)
Participant preference between textual and graphic formats in communicating mortgage information	
Text	30 (75%)
Graphs	10 (25%)
Participant evaluation: the most helpful format that facilitated them in understanding mortgage information	
Text	27 (68%)
Graphs	13 (33%)
Participant behaviour in processing the written texts in the mortgage scenario	
Line	18 (45%)
Skim	14 (35%)
Unfinished	8 (20%)

4.4. Discussion

To the best of my knowledge, this was the first study to use qualitative methods to explore the insights of how individuals understand financial information when it is presented in graphs, as well as how they evaluate such formats in financial contexts. The cogent verbal analysis contributes to the related body of academic literature by identifying the attributes and premises of graphic displays that can inhibit and/or facilitate the comprehension of numerical information. It provided some evidence to explain why graphs are sometimes poor at facilitating comprehension of financial information and why individuals are impatient to understand graphs in detail.

4.4.1: Positive Attributes of Graphic Formats in Facilitating Financial Comprehension

Regardless of scenario applied as content in this study, three main positives of graphic displays were found that enhance the understanding of financial information by the public, as well as several related attributes contributing to such positives.

First, the attraction of graphic patterns to participants served to guide them to focus on key information. For example, in the icon arrays displays, most participants were attracted to the display of Stock B (cf. Stocks A and C) because it had more black icons, which led them to recognise that Stock B had the highest risk of losing more than 25% of the investment value. In addition, the abrupt green bar in the time-series chart significantly drew participants' attention towards recognising a lump sum repayment in the interest-only mortgage in year 25. This finding supports the claim by existing studies that graphs can highlight specific information that may be neglected in a text format from the overall content (Oestermeier and Hesse, 2000, Lipkus, 2007). Importantly, the data revealed that the use of more arresting colours in graphs – black (as against grey) in the stock scenario and red (as against green) in the mortgage scenario – is the main contributor to rendering the perceptual features more prominent and, as a result, led individuals to focus on the identified patterns more intuitively. This, in turn, guided recipients to process the pattern detail and the data overall. This finding extends the study by Freedman and Shah (2002), who argued that at the initial stage of processing graphic information, perceptual features could guide recipients to more actively

process graphic data; my finding confirms this with the example of colours playing a significant role in it.

Second, graphs allowed the participants to make comparisons between different elements of the financial data and notice the key ones easily. For instance, the contrasting summarised areas in icon arrays can be visually distinct, enabling participants to quickly differentiate the relative risk levels among stocks. Similarly, different graphic sizes for the total interest repayment in the segment bar chart facilitated participants' realisation that this was the main cost difference between the two mortgage plans. The study identified two further factors that contribute to support for graphs. One is their capacity to represent key differences in a single visualised pattern. The other is contrastive colour to categorise information into distinguishable features. In contrast, written texts lack such immediate benefits, thus, they were deemed more difficult for comparing options. Notably, the finding suggests that this comparison benefit of graphs comes from the relative magnitudes of difference between options. As De Jong (2010) proposed, such relative magnitudes determine the recognition of differences.

The above discussion of graphs' benefits highlights the importance of using colours to promote graph processing and comprehension. The findings of this study also suggest that colours can guide individuals to focus on highlighted information and, consequently, facilitate their recognition of feature differences among different financial data, which subsequently motivates them to investigate more. Furthermore, this study also highlights that effective use of colours contributes to the notion of making numerical information more perceptually obvious, which is deemed to be one of the most essential attributes for an effective graphic presentation by many existing studies (e.g., Winn, 1993, Djurica et al., 2020). Third, the present study supports the general idea that, in contrast to textual or numerical formats, graphic formats are visual-spatial representations that render information more vivid (Lipkus, 2007). To illustrate, the time-series charts in the mortgage scenario allowed participants to visualise changes in financial positions throughout a 25-year mortgage term. In the icon arrays, the selection of human figure icons to represent the probability of losing investment value made the financial risks seem more vivid. However, these graphic benefits appear to facilitate the understanding of gist information, which is more surface-level knowledge than verbatim information. For instance, the participants recognised from the graphs that there was a cost difference between mortgages, however, they struggled to understand what was causing the patterns in the charts.

4.4.2: Limitations of Graphic Formats in Communicating Financial Information

In the finance domain, an effective presentation format should encourage individuals to obtain deeper and more precise financial knowledge in order to make sound judgements. However, when it comes to imparting verbatim financial knowledge, this study reveals five main limitations of graphic displays.

4.4.2.1 Effort of Advanced Graph Comprehension

The processes of graph comprehension are complex and require considerable cognitive effort. For instance, in the mortgage scenario, participants had to (1) decode the legend with the red bars to realise what the bars represented, (2) read the arrows to understand the highlighted information, and (3) make comparisons with other patterns within the same graph to make inferences. Similarly, in the icon arrays displays, participants had to decode the legends of the black and grey icons with the category areas to understand the information depicted. In other words, participants had to translate the patterns they identified into meaningful information, by making inferences via attentive integrations of the graphic details. Such processes support the principles of the graph comprehension model (as discussed in Section 4.1). That is, despite the pattern-recognition stage, the other two stages of the interpretive and integrative processes are effortful and determine the accuracy of graph comprehension and its related inferences.

The participants recruited in this study appeared to be impatient to read and integrate all graphic details, thus, they had incomplete understanding. For example, in the stock scenario, most participants ignored the graph title, and some only noted the significance of the black human icons rather than the grey. This finding is congruent with a wealth of studies that individuals allocate insufficient attention to a graphs' details and, hence, fail to make accurate interpretations (Okan et al., 2016, 2018). Importantly, the present study provided evidence to confirm such impatience to integrate graphic details. Specifically, the dominant colours and abrupt patterns in graphs attracted most participants' attention, making them less likely to read or integrate other graphic detail such as titles or arrows, and concentrate more on the highlighted information for their inferences and judgements. In other words, although the results suggest that the arresting colours and patterns may assist participants in noticing key information, these prominent graphic features seem to reduce participants' attention on the less prominent graphic details and effectively reduce complete comprehension. In the same vein, Lipkus (2007) suggested that calling recipients' attention to certain elements and away from

others can result in less accurate understanding of risk and ultimately impact decision-making adversely. Certain psychology studies have indeed suggested that "salience detection" may lead people to focus their limited cognitive resources on specific information at the expense of being able to further retrieve, interpret and integrate other pieces of information that require additional cognitive effort (e.g., Taylor and Thompson, 1982). Overall, the benefit of graphs' "salience effect" can be a double-edged sword.

Another identified potential reason is that a graph can include many scattered pieces of information, which require participants to integrate them in order to construct deeper knowledge by themselves. This means that to have thorough comprehension from graphs requires some existing skill and related knowledge to ensure the inferences are accurate. For example, in comparing graphic and textual formats in the mortgage scenario, most participants commented that textual information was easier to process because it clearly presented all elements of the information in logical order, removing the need to construct meaning themselves. Furthermore, unexpectedly, most participants were unable to intuitively integrate the four presented graphs to view or conceptualise them as "one story". This indicates that integration among graphs is yet another challenge.

4.4.2.2 Effort in Obtaining Precise Financial Data

The study demonstrated that graphs required more effort than textual (or number-based) formats when participants tried to extract precise values. In icon arrays formats, participants uniformly found it too onerous to obtain precise probability values, because they had to either count rows and icons attentively or engage with mathematical calculations. This finding can be used to explain the inconsistent results on the capacity of icon arrays to impart verbatim knowledge in the studies by Hawley et al. (2008) and Tait et al. (2010). That is, the icon arrays presentations in the former did not provide precise percentages, thus, their participants in the number-based condition (tables) had better verbatim knowledge than those in the icon arrays condition. In contrast, the latter included precise numerical values in their icon arrays condition, thus, they found icon arrays to be better than text and tables in conveying verbatim information. In addition, the present study found that participants who used the numerical scale on the y-axis to obtain precise probability values were more likely to have incorrect values, because they prioritised focus on the numbers and thereby mismatched the lines. This finding potentially explains the puzzle reported by Zhang et al. (unpublisheda), that icon arrays with a

y-axis imparted less knowledge than those without. Future research could indeed consider examining the issue of positioning numerical scales in icon arrays to ensure format effectiveness. In brief, although participants can get verbatim information by simply counting icons and rows, this study suggests that the process can be cumbersome and error-prone. Unsurprisingly, many participants suggested providing precise values in the icon arrays rather than leaving it to the audience to count and calculate the values by themselves.

Likewise, in the mortgage scenario, participants judged that the explicitly stated numerical values at the top of each bar were helpful when seeking to pinpoint the exact monetary differences between the two mortgages. They also pointed out that additional numerical values in graphs strengthened their confidence in their graph comprehension. Therefore, these findings indicate that the inclusion of straightforward values in graphs can reduce effort and estimation errors and build individuals' confidence in enhancing their access to financial communication. This is in line with Okan et al. (2018) who proposed that simply presenting numerical values in graphs improved information understanding and was positively evaluated by their participants.

4.4.2.3 Lack of Explanations for Graphic Patterns

When considering graphs alone, participants demonstrated uncertainty and difficulty in generating deeper insights into the financial information provided. In the mortgage scenario, most participants stated that they could not process the graphic displays without reading the textual information first. They found the textual information to be explanatory scaffolding in the steps to understanding the presented graphic patterns. For example, the kind of repayment plan that results in the outstanding debt being gradually reduced or remaining constant across 25 years could easily be made explicit yet concise. The participants who read the graphic displays first stated they had many queries about the identified patterns. Likewise, although the stock scenario was simple and only presented three icon arrays to communicate the financial risks, participants still showed confusion and uncertainty with this financial information. These findings indicate that without written texts to explain the patterns, the accuracy of the obtained knowledge from graphic displays was evaluated as vague. Participants further reasoned that graph comprehension depends on how they are viewed by diverse recipients whose interpretations and inferences can vary.

In addition, the icon arrays findings may shed light on why Tait et al. (2010) found icon arrays to be more efficacious than textual and table formats, since their icon arrays condition included both numerical values and some textual information elaborating on the graphic patterns, resulting in more accurate health-related information comprehension achieved by their participants.

4.4.2.4 Other Attributes of Graphic Formats for Financial Information Communication

The findings from the current study concur with the literature that the efficacy of presentation formats to facilitate information communication can be affected by other factors. In particular, this study found that format familiarity, the nature of the content, the complexity of graphic detail and the number of presented formats all influence how individuals participate with and digest the information provided.

First, in line with the plausible concern over the infrequency of icon arrays format use in the finance domain, participants stressed that the communicated financial information was hard to extract and process. Consistent with this finding, Carpenter and Shah (1998) observed that students who had little familiarity with graphs had enormous difficulty interpreting data across a variety of graphs. Hence, it is important to consider that format familiarity might inhibit the comprehension of financial information. This study specifically found two attributes in icon arrays that impeded participants from understanding financial probability information effectively. One is that the unexpected graphic format requires additional effort to engage. During the interpretation step with the icon arrays displays, most participants demonstrated uncertainty about the representations of the icons arrays in a financial context. For example, some questioned the intended meaning of each human icon and were unsure whether the arrays represented percentages. Carpenter and Shah (1998) suggested that when individuals are less familiar with graphic conventions, their comprehension processes need more effort to identify the graphic features and resolve any uncertainties. Furthermore, some participants indicated that they preferred bar or pie charts, or simply percentages alone, because these formats are generally used in finance and despite communicating the same information, they are reported as easier to understand. This implies that more frequently used formats make information processing smoother and may assure or stimulate people to process information more intuitively.

Another important attribute is the nature of the communicated information. When using the icon arrays to present financial information, the meaning of the key feature (in this case human icon types) should be made explicit, such as in terms of "gain", "loss" or "no gain/loss". In this study, participants not only considered the group who had lost but also perhaps subconsciously considered the possibility of who may make a gain; even the graph title emphasised that the diagrams only depicted the "chance of losing". It is important to note that this study found that, even for the medical students who were familiar with icon arrays, some still found the format difficult to understand and feel confident using in a financial context. This further reinforces the proposition that coherence between the information content and the presentation format has an impact on the efficacy of the information processing and comprehension. Different domains seem to have different expected communication formats. In short, audience expectations for communication formats appear to differ among disciplines.

Second, this study reported new findings regarding information engagement when more intricate financial information was presented by different types of graph. The data revealed a tendency for participants to be less willing to process the complicated time-series chart information. This echoes the study of Pylar et al. (2007) who reported that the effort to decipher complex graphs affects the information communication adversely. This might be because complicated graphs precipitate the need to scale up the effort and iteration of graph comprehension processes to encode and interrelate the greater graphic detail and more patterns (Carpenter and Shah, 1998). Moreover, the "oversimplified" monthly repayment bar chart was largely perceived as redundant because it merely represented two numerical values. This supports the "redundancy effect" principle in cognitive load theory, in which it is deemed unnecessary to provide further formats unless they bring clear new benefits for information understanding (Clark and Feldon, 2005). Notably, this study discovers that the "redundancy effect" tends to occur when represented information is already relatively easily obtained from existing formats.

Third, the findings also provide novel contribution on the benefits of multiple formats depending on information complexity and the number of distinct formats presented. The results suggest that combined formats not only require both graphic and textual skills, but also more effort and time to compare, confirm and consolidate all the information imparted. Most participants in this study did not appear to have read all the information carefully. For instance, participants reported to have skimmed the textual information and neglected certain important

information. Also, a few were confused when they read both types of formats simultaneously. This infers that they became impatient and selective when presented with information across multiple formats. Hirshleifer and Teoh (2003) also documented that an individual's attention is limited, and they can only digest a limited amount of divergent information simultaneously. These results support cognitive load theory (Chandler and Sweller, 1991), which asserts that an individual's cognitive processing – in maintaining multiple generated knowledge elements in mind at once – is constrained by a limited working memory capacity. It becomes clear that using various presentation formats to portray and impart complicated financial information will cause higher demands on cognitive processing. Therefore, restricting the number of various presentation formats should be carefully considered when communicating intricate information.

4.4.3 Emotional Reactions and Evaluations of Graphic Formats

The qualitative methodology allowed me access to participants' reactions and thoughts when they processed the financial information. In a nutshell, this study suggests that (1) graphic presentations can inherently elicit a degree of emotional response, and (2) the capacity of graphs to communicate financial information reliably is questioned by individuals.

4.4.3.1 Emotional Reactions

In the icon arrays presentation, the study found evidence that human icons evoked participant response to the probability of losing investment value. Some participants emphasised their anxiety and conceived of avoiding the stock with the highest risk when they saw great numbers of highlighted human icons. This finding is compatible with the existing research that human icons feel more personal and relevant and add contextual meaning to numeric information, thus inducing a greater risk awareness (Schapira et al., 2001). This implies that different types of figure icon may result in different degrees of risk perception, and in turn, impacts on decision-making. It may be worthwhile for future research to investigate the influences between human icons and other types of icon such as dollar or pound icons to communicate financial information. Furthermore, this study provides another interesting finding: even though participants noticed the grey coloured human icons which represented a class of lower financial risk, they still focused more on the black human icons. This suggests that not only the icons being human evokes higher financial risk awareness, but also the colour does. It likely increases the salience of the higher risk class. Similarly, future research could usefully examine

whether the risk perception was consistent if the more strongly highlighted colour were to represent the lower risk class.

As discussed earlier, visual prominence can facilitate information processing but can also elicit disproportionate weighting on certain highlighted patterns relative to other information (Bordalo et al., 2012, Hellmann et al., 2017). As a result, highlighted visual patterns can trigger individuals' emotions and influence their information judgement. For instance, in the mortgage scenario, the participants viewed the colour red as an alarm and paid considerable attention to it. Indeed, they perceived the constant red columns representing unchanged debt levels as "horrible", but the decreasing red columns as "relief". Thus, participants expressed the idea that these startling visual features strengthened their preferences to take the mortgage with the decreasing red columns. Meanwhile, the less visible green columns, presented on the same chart and representing the yearly repayment values, were less likely to be noticed or were even not discussed. In other words, when the bars were dominated by a certain colour and size, participants appeared to omit other important representations. This result is in line with the study by Kliger and Gilad (2012) in which colours were said to affect individuals' risk attitudes and investment decisions. They observed that participants who read the information on red (cf. green) background screens assigned higher valuations and probabilities to the events showing a loss domain, relative to events showing a gain domain. Thus, finance sector communicators should be aware of colour selection in graphs when imparting financial information. Kliger and Gilad (2012) also highlighted how colours are widely used to communicate financial information. For instance, red and green are regularly used colours in annual reports or in security market publications. Indeed, colour in communication has been widely researched in marketing studies, which suggest that it can express certain moods and evoke certain psychological reactions (Eiseman, 2000). It is, therefore, surprising that little attention has been paid in finance studies on the influence of colour on laypersons' financial comprehension.

4.4.3.2 Evaluations of Graphic Displays in Communicating Financial Information

Regarding the participants' evaluations of different formats to communicate financial information, this study found that graphic displays are generally perceived as error-prone and less reliable than textual or number-based formats. This finding is consistent with Hawley et al. (2008) in which tables with straightforward numbers were considered more trustworthy than graphs for communicating health-related information. Similarly, other health communication studies have demonstrated that people experience more trust and comfort with numerical-based

information than graphic formats (Gurmankin et al., 2004, Bodemer and Gaissmaier, 2012, Wöhlke et al., 2019). Based on this study's findings, this is because graphs are less transparent and require interpretations by participants themselves. Thus, participants stated they were more easily misread or misinterpreted inaccuracy of understanding. More importantly, the participants commonly believed that since financial information is consequential, being about money, they preferred to see precisely stated numbers that make them feel more secure and confident in their comprehension. This implies that the nature of communicated information interplays with individuals' expectations of presented format and affects their judgement in ascertaining information reliability.

4.5. Study Limitations and Future Research

As with all studies, a number of limitations pertain to the present study that provide for investigations in future research. A first limitation is the nature of the qualitative method. It can be conceded that my participant sample included only relatively young individuals located in close contexts and geographies. Because the purpose of this study was to assess how graphic formats facilitate and inhibit the communication of financial information to people with little or no financial knowledge, this sample selection was congruent with the study aim. Evidence confirms that younger generations do lack financial experience compared with older generations, who tend to have greater ability in interpreting information and making financial decisions (Gathergood and Weber, 2017b). Nevertheless, future studies could perhaps investigate whether this study's findings concur with those derived from a broader population with more diverse socio-demographic characteristics.

Second, my findings indicate that graph comprehension requires a certain level of cognitive effort and ability. I acknowledge that graphic literacy plays a role in graph comprehension. Many health communication studies have highlighted that the extent to which graphic formats improve comprehension can largely depend on graphic literacy (Galesic and Garcia-Retamero, 2011, Okan et al., 2012). Therefore, future work could also usefully investigate the relationship between individuals' graphic literacy and graphic format efficacy in catalysing financial information comprehension.

Third, as identified in this study, the attributes of distinct colours, portraying differences in perceived relative magnitude among options and human icons within graphs, seem to have

powerful influences on judgements and information comprehension. Therefore, future research is needed to examine this potential causality. I believe that further testing of these attributes can strengthen consensus on the scope of such graphic format features to enable better communication of financial information.

4.6. Conclusion

While research on the efficacy of graphic displays for enhancing information comprehension is increasingly undertaken, the results have been mixed, and most studies have used questionnaire instruments to compare accuracy levels among individuals' understanding. Unfortunately, no study has yet sought to investigate deeper than this for qualitative insights into the capacity and limitations of specific attributes in graphic displays in successfully communicating financial information. In light of such shortcomings in this strand of literature, this study employed interviews with valuable think-aloud and think-after approaches aimed at specifically exploring why icon arrays and bar charts are proving less efficacious at communicating financial information than expected. Accordingly, this qualitative study fills this gap. Meanwhile, it provides new knowledge in the field on how individuals evaluate different presentation formats in financial contexts.

In general, the study suggests that graphic formats are effective in communicating gist information via contrasting colours, summarised patterns and reported basic value differences. On the other hand, when communicating in-depth insights from financial information, it is shown to be arduous for recipients to obtain verbatim knowledge from graphic rather than textual formats. Importantly, cogent verbal analysis has provided clear evidence that format familiarity and individuals' perspectives on the expected formats have effects on information engagement and comprehension. Moreover, this study enriches extant research, demonstrating that when communicating intrinsic financial knowledge via multiple formats, the number of presented formats and consideration of limitations such as the complexity level of graphic details, should be considered in the design process. This study also reveals that prominent graphic patterns and bright colours are a double-edged sword. Although these eye-catching features are important both to steer individuals towards crucial information and to help them recognise differences among various elements of financial information, they can have unintended emotive influences on their judgement and decision-making. Little attention has been paid to this in finance scholarship to date.

The abovementioned insights have valuable implications for finance sector institutions, whose communication practitioners could communicate more effective financial product information to the public if they simply develop their awareness of the attributes, constraints and other considerations of graphic communication that have been raised and clarified in this study.

Chapter Five

Conclusion

Conclusion

This chapter provides a summary of the research aims and the main findings, as well as the contributions of each of the three studies. It also summarises the thesis' overall research contributions that provide new knowledge in the field on how the efficacy of graphs can facilitate financial information comprehension. Section 5.2 presents a number of important practical implications. Last, Section 5.3 acknowledges the potential limitations of this research and provides promising avenues for future research.

5.1 Research Remarks and Contributions

5.1.1 Study One: Are icon arrays effective at communicating financial probability?

The primary aim of Study One was to investigate whether the fashionable graph icon arrays can facilitate individuals to have a better understanding of financial probability information than the traditional numerical-based formats of percentage and frequency. This was the first study to examine the efficacy of icon arrays in a financial context since the greatest proportion of evidence of icon arrays' efficacy is in the health-related domain (e.g., Tait et al., 2010, Garcia-Retamero and Hoffrage, 2013).

The findings obtained in the study make three important contributions. First, in contrast to health communication studies, Study One did not find that employing icon arrays alone to present financial probabilities can enhance the understanding to a larger extent than the number-based formats. In fact, percentages and frequencies' formats were more effective in improving the comprehension of both gist and verbatim information, particularly among lower numerates. The finding of verbatim knowledge was in accordance with previous studies, supporting the conclusion that numerical formats are more effective than graphs to impart precise numerical information (Feldman-Stewart et al., 2007, Gaissmaier et al., 2012). It is worth noting that, although the result of gist comprehension demonstrated a different story from health communication studies, the finding expands current literature by assessing recipients' short-term memory, which indicates that icon arrays were less intuitive to assist recipients in encoding and storing financial information than numerical formats were.

Second, the study emphasised two considerable implementation details of icon arrays that had

been neglected by previous studies. This study evinces that when icon arrays are employed alone to impart financial probability information (i.e., no concomitant with precise numerical value or texts), the benefits of icon arrays enhancing the comprehension of financial information are limited. In addition, adding a y-axis numerical scale in icon arrays (i.e., icon-scale format) has been shown to compromise comprehension more, regardless of the level of participants' numeracy. As a result, this study contributes to the literature that previously failed to draw the relationship between icon arrays' implementation details and their effectiveness of information communication. Third, participants' assessments on the effectiveness of different formats provide new insights to the presentation literature. The results suggest that the frequently implemented percentage format in the financial domain is more suitable in the financial domain because it brings more confidence in information understanding and is perceived as easier-to-understand financial information than the uncommonly used icon arrays.

5.1.2 Study Two: How well do commonly used presentation formats facilitate the comprehension of complicated financial information: mortgage products?

Study Two was the first study to examine the influence of different presentation formats on facilitating mortgage comprehension. Building on the knowledge gained from Study One, the second study provided further insight into the efficacy of commonly employed bar charts instead of rarely used graphic formats in communicating financial information. Meanwhile, this study advanced the existing knowledge of dual coding theory by examining the effectiveness of multiple formats (cf. text-only and graph-only) in facilitating complicated information, which no previous study has investigated.

Study Two's findings extended prior communication research in several notable ways. First, the study uncovered that simply presenting graphs and texts together to iterate the same mortgage information resulted in the least accurate comprehension than presenting either texts alone or graphs alone, regardless of participants' debt literacy. Therefore, it can be assumed that the benefits of multiple formats (i.e., including both graphs and texts) are overestimated when the communicated information is complicated with various pieces of information. Meanwhile, these results provided new evidence to support the information-processing literature and cognitive load theory. According to analysis, it can be inferred that the separated presentation layout between graphs and texts and the number of over-presented formats could

be major factors that degrade recipients' attention, create more cognitive tasks and eventually interfere with their performance of information comprehension.

Second, the study shows evidence that the efficacy of graphic displays alone to present mortgages is constrained by the individuals' debt knowledge since individuals with lower debt literacy obtain less knowledge from the graphs (cf. texts). This finding accords with previous research, documenting that individuals related prior knowledge (i.e., debt literacy in this study) with the depicted information could affect how easily and accurately individuals can obtain information from graphs (Stern et al., 2003). Third, the study identified a pattern showing that among more present-preferred participants, graphically displayed information (cf. texts) was more likely to arouse such present preference. This finding extends previous studies, suggesting that graphically displayed information may have affected an individual's perceptions of information provided and eventually affect their decision-making (e.g., Raghubir and Das, 2010, Duclos, 2015, Chin and Bruine de Bruin, 2019).

5.1.3 Study Three: How can graphic displays more effectively communicate financial information?

Study Three was motivated by the findings obtained from Study One and Study Two. It investigated what kinds of challenges impeded individuals from acquiring accurate financial knowledge from icon arrays and bar charts. This study conducted 40 interviews to obtain a precise understanding of decision-makers' immediate reactions when presented with different financial information forms. This was the first study to use valuable think-aloud and think-after approaches to gain a more profound knowledge of appropriately designing graphic displays to facilitate financial information comprehension from individuals' perspectives.

The verbal analysis makes several notable contributions to existing literature. First, the results support the notion that graphic formats are more conducive to convey general information (i.e., gist knowledge); however, they are less advantageous to facilitate the comprehension of insights into financial information (i.e., verbatim information: Hawley et al., 2008, Gaissmaier et al., 2012). More importantly, the verbal analysis has identified that the arresting colours and summarised patterns in graphs are the main factors that facilitated recipients to easily identify essential information and quickly recognise differences among various financial information elements. However, the data suggest that a deeper understanding of graphs requires more

considerable effort and attention from recipients. This study's results have demonstrated that recipients need to integrate scattered graphic details, interpret observed patterns, and then make inferences on the financial relationships behind the graphs by themselves. Additionally, recipients need to read the graph carefully to obtain precise financial data. Unfortunately, participants recruited in this study were impatient to read and integrate all graphic details, which resulted in reduced accuracy. In contrast, texts include precise financial data and relationships organised in a logical order, which is easier to process and understand. Such implications suggest that because individuals have already found that financial information is complicated, they are more likely to face challenges in understanding and constructing insightful financial information from graphs, particularly compared to textual formats.

Second, the verbal analysis provided insightful data to understand the previous two studies' findings in detail. The study identified that it was the numbers' location on the y-axis in icon arrays that led recipients to read the wrong numbers and generate inaccurate verbatim knowledge in Study One. This study also revealed that participants found it difficult to apply icon arrays within a financial context and perceived the information as mistrustful compared to the percentage format. This finding can be interpreted as evidence that an audience's expectations between presentation formats and the information content appear to matter when it comes to information engagement and comprehension.

Furthermore, Study Three validated the extrapolations proposed in the mortgage study (i.e., Study Two) and enriched related theories. It found that because mortgage information is already complicated enough, recipients' cognitive processing capacity is overwhelmed by the excessive number of formats; thus, they become impatient and selective on which information to attend to. The study also elaborated that the "redundancy effect" principle from cognitive load theory tended to occur when the reiterated information is simple and easy to obtain. Thus, these findings contribute to a better understanding of cognitive load theory, which indicates how overloaded information impedes individuals' cognitive performance. Another new knowledge is that when the graphic displays more than one graph, the collaboration between graphs to achieve better understanding appears unaccomplished. This finding expands the literature of graphic communication for facilitating information comprehension.

Third, this qualitative study reported new insights regarding how individuals react and evaluate when viewing different forms in communicating financial information. The results showed that,

despite human icons, the highlighted nominator class in icon arrays receives more attention than the denominator class. Likewise, prominent colours (e.g., red or black) appear to significantly influence an individual's judgement because they hold too much of the individual's attention. More importantly, since the communicated information is about financial products, the participants of this study preferred standard formats: written texts and numerical forms. In contrast, they perceived graphic displays as being easily misread, and that they can be manipulated by the providers. An implication of this is that the nature of the communicated content influences information trustworthiness and format selections, which provides valuable insights into understanding how presentation formats impact information communication.

Overall

The overall findings of this thesis contribute to the existing literature concerning different types of presentation format in communicating financial-related information. This thesis employed a mixed research method which has been rarely used by the existing studies, particularly the think-aloud and think-after approaches in the qualitative study of this thesis. Such mixed research methods overcame the limitations of using a single method and provided a rich understanding of the effectiveness of different types of format in facilitating financial information communication. The results provide new evidence showing that using graphic displays to communicate financial information does not necessarily facilitate individuals' information comprehension. Evidently, the findings suggest that individuals with lower numeracy or lower debt literacy have more difficulties in obtaining accurate financial knowledge from graphic displays. Furthermore, these findings advance the existing knowledge by explaining why graphic displays, textual and numerical formats contribute to various efficacy levels of facilitating understanding of financial information. New insights into how graphic displays affect recipients' evaluations of financial information were also obtained. Meanwhile, the findings enrich the extant theories (e.g., dual coding theory and cognitive load theory) that identified some important factors that needed to be considered when implementing multiple formats; for example, the numbers of presented formats and the intricacy level of the communicated information.

5.2 Practical Implications

Finance sector institutions and practitioners (e.g., banks or financial services companies) are responsible for communicating financial information to the public. The findings generated in this thesis have a number of important implications for future practice. First, while previous studies have suggested that individuals can count each icon and row to obtain verbatim information in icon arrays, the present thesis has documented that presenting precise numerical values (i.e., percentages) in icon arrays is easier for individuals to understand and reduces unnecessary errors. Additionally, if financial providers intend to use icon arrays to communicate financial probabilities, they should consider how to implement icon arrays in detail. That is, there should be consideration of whether including the y-axis numerical scale in icon arrays could affect the way individuals process information and the accuracy of information understanding.

Second, this thesis highlights some important factors that need to be considered when utilising graphs to communicate financial information. One is that individuals with lower numeracy or lower debt literacy are shown to have obtained less accurate knowledge from graphic-displayed finance-related information. Hence, financial practitioners should present financial information according to their audiences' background. Furthermore, although the data in Study three revealed that arresting colours and patterns (e.g., human icons, highlighted bar) in graphs can attract individuals' attention and guide them to identify some crucial information, these graphic attributes can also unduly bias individuals' evaluations of the information provided spontaneously. Financial information providers and graphics developers should consider potential visual impacts of graphs on financial information judgements, which should align with communication purposes. For example, graphic displays are used in a risk tolerance questionnaire aiming to measure investors' risk attitude. In this case, practitioners should carefully design graphs to limit visual influences on recipients' risk emotions and judgement. Otherwise, the measurement could be biased and inconsistent with customers' investment goals. In contrast, if the communication is to emphasise financial risks, practitioners can utilise colours and patterns to draw recipients' attention, thus evoking specific risk awareness. In other words, the design and the implementation of graphs should be tailored to communication purposes instead of applying the same graphs to all circumstances. It is worth noting that written texts and number-based formats continue to play an important role in delivering financial information. As consistently documented in the thesis, participants believe that the

traditional formats are more reliable than graphs because the former impart financial information more effectively and reliably.

Last but not least, exploration of the use of multiple formats to communicate mortgage information has shown that more does not mean better. Although there is a wide range of format selections in practice, to simply include all or most of these formats is ineffective. Finance practitioners should be award that the presentation of multiple formats could significantly increase audiences' cognitive burden, and thus exercise caution when using them. If formats are overloaded and appear complicated, audiences are more likely to be stressed and less able to obtain information attentively. For instance, practitioners should judge how many different formats would be reasonable and how to appropriately integrate texts and graphs in one message. Moreover, the reiterated information in a different format should bring additional benefits to better understand the displayed information. Individuals' subjective perspectives of presented formats for financial information communication should also be accounted for. This is important because, from the individual's perspective, financial information is already complicated and difficult to understand (Lusardi, 2012); therefore, the best way to present financial information is to align with an individual's expectations to minimise confusion and reduce stress. Therefore, the results of this thesis can benefit both practitioners and individuals. Practitioners can build from this thesis to develop an effective communication channel with their customers. It also enables their customers to obtain better financial knowledge from well-designed and appropriately selected formats.

5.3 Limitations and Future Research

The present thesis has several limitations that could be addressed in future studies. First, graphic presentations in this thesis were static. Recent non-financial studies have suggested that interactive diagrams are potent in enhancing information comprehension compared to static diagrams (Rasch and Schnotz, 2009). It is posited that interactive graphs stimulate individuals' learning process which, in turn, allows better knowledge acquisition. Thus, the efficacy of interactive diagrams is one fruitful area for future finance research. A note of caution is highlighted in this thesis; presentation formats should avoid overwhelming individuals' information-processing capacity and consider recipients' relevant prior knowledge (e.g., computer skills).

Second, participants in Study One and Study Two may have been inclined to answer the questions quickly in order to achieve personal financial goals. It is plausible that, in reality, individuals may spend more time reading the material. Future studies can examine whether this thesis' findings can be generalised to the situations when the amount of time spent on reading material is different. Specifically, it is worth investigating whether the amount of time available for the task will affect graphic displays' efficacy in promoting financial communication.

Third, the investigations of icon arrays in this thesis focused on the ability to facilitate the understanding of gist and verbatim knowledge of financial probabilities. Icon arrays are also recommended for other communication goals, such as reducing base-rate neglect that offers more accurate judgements of health risk (e.g., Garcia-Retamero et al., 2010). The financial probability information investigated in this thesis was a 100-based denominator, which consisted of three stocks. Future finance studies can examine whether icon arrays are helpful to eliminate denominator neglect-bias and their influence on financial risk judgements in the condition that base rates are different between stocks.

Final conclusion

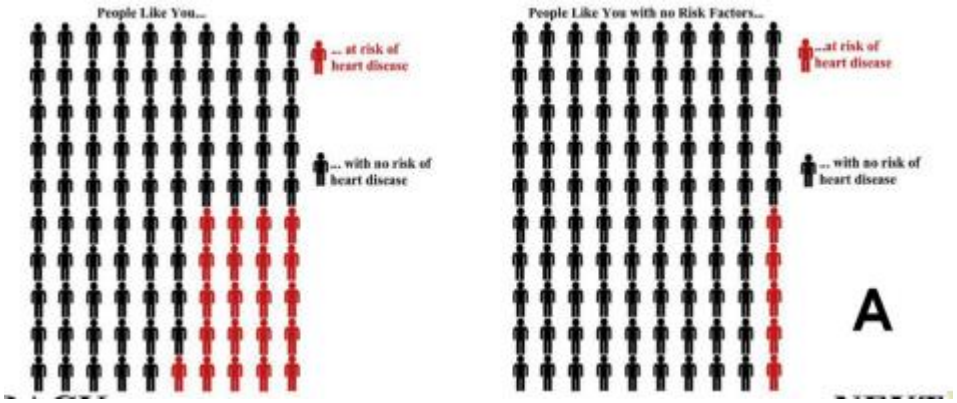
In conclusion, although graphic presentations are frequently employed in the finance sector, the efficacy of graphic formats to enhance financial information understanding has been largely neglected in the literature. This thesis filled this research gap by comparing the effectiveness of textual, numerical, and graphic presentation formats in facilitating financial information comprehension through a mixed research method. This thesis is one of the very few studies offering greater insights into what sorts of features in graphs inhibit and/or facilitate individuals' engagement with and understanding of financial information via think-aloud and think-after approaches. This thesis provides some worthy suggestions of how to present formats effectively to achieve better financial communication. Financial practitioners should recognise that uncommonly viewed formats could impede information engagement and understanding. When attempting to implement multiple formats to impart complicated financial information, recipients' information-processing capacity should be considered. Indeed, audiences' differences in related prior knowledge are closely associated with a format's efficacy. Likewise, the utilised colours and the design features in graphs should be employed with caution because they could affect individuals' emotions and judgement on the information provided. In general, this thesis suggests that graphic displays might prove detrimental to comprehension and, therefore, could elicit poor financial decision-making. Hence, graphic displays should only be

employed in the financial context where there is robust empirical evidence of their efficacy. Finally, based on the substantial contributions and implications developed in this thesis, future research is encouraged to better understand the relationship between presentation formats and financial communication, both academically and practically.

Appendices

Appendix A. Supplement to Chapter One

Appendix A.1. Examples of the use of icon arrays in the health practice for communicating medical risks. As shown below, the icon arrays diagrams depicted the global cardiovascular risk. In these diagrams, the black human icon represents the population at risk and the red human icon represents the people who will at risk of having heart disease in the next 10 years.



Source from: Ruiz et al. (2013)

Appendix A.2. The diagram below displays the pictograph developed by Otto Neurath. It was used in communicating the quantitative information of women's employment situations in a number of countries in 1930.

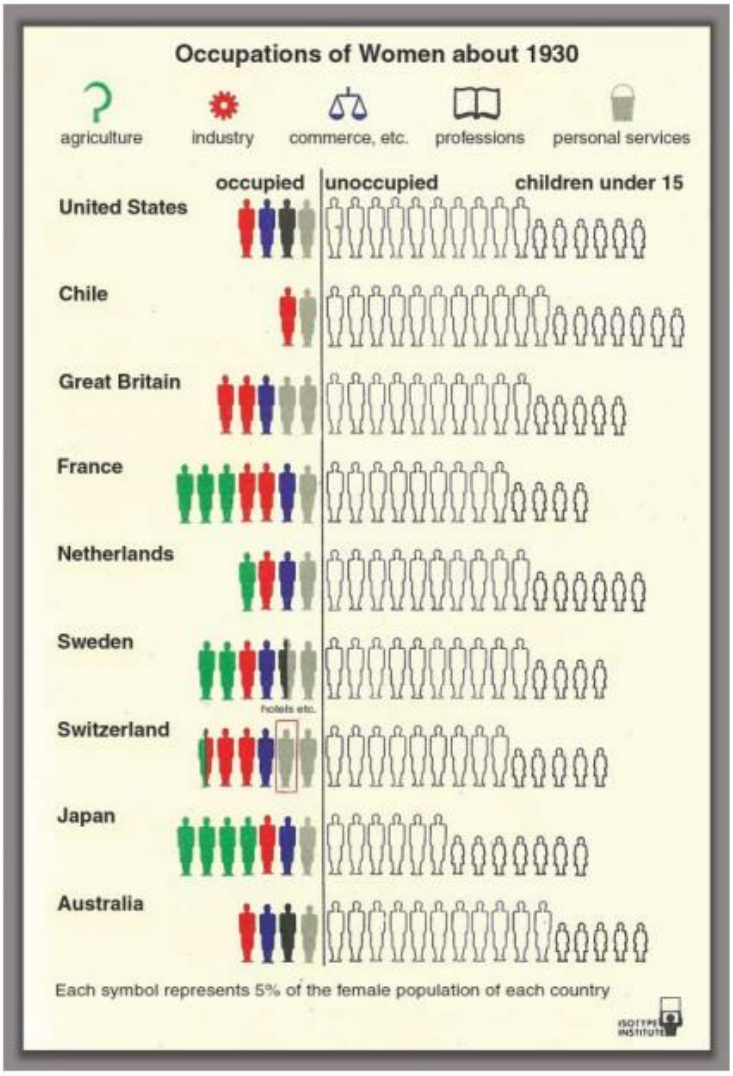
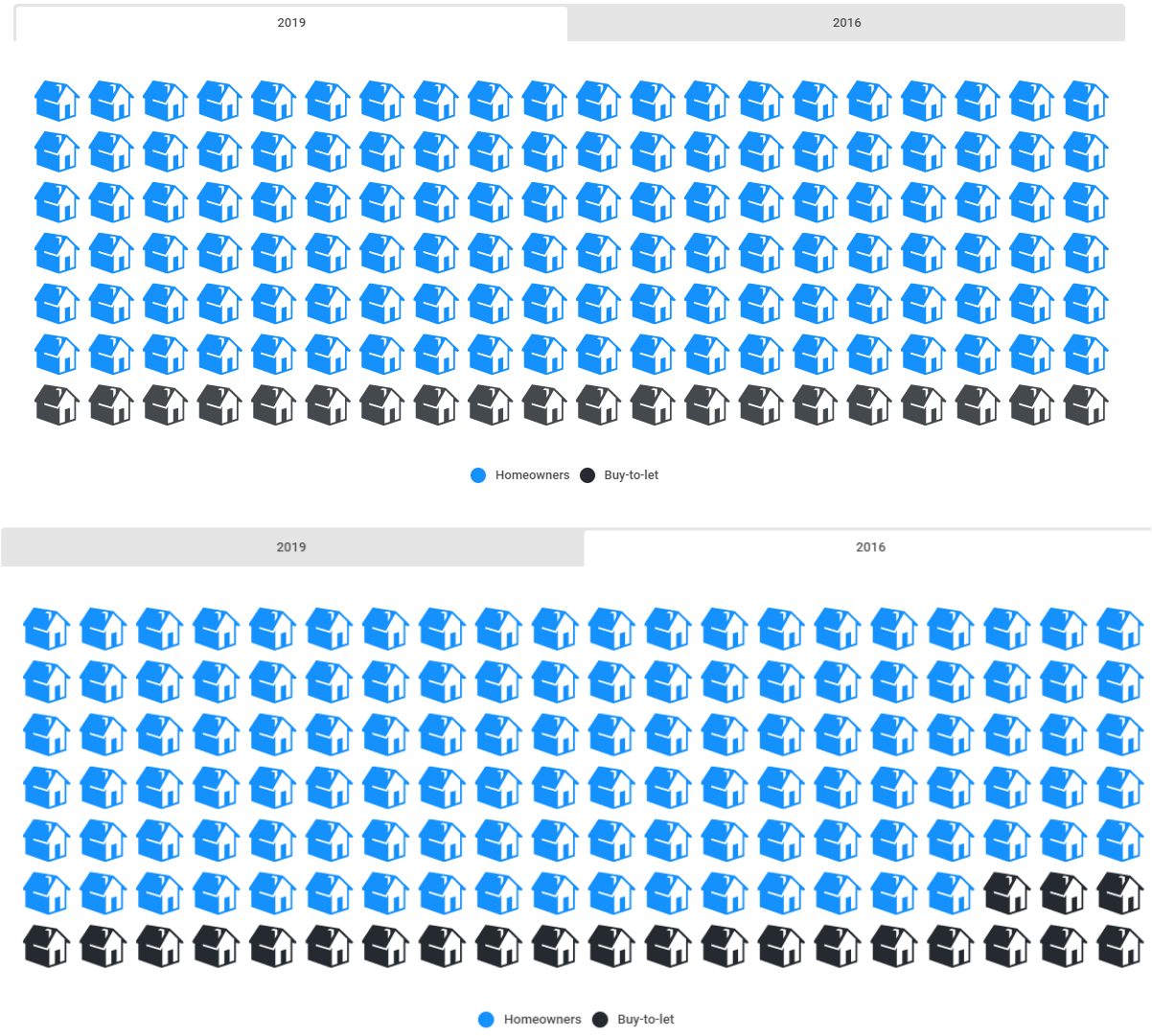


Fig. 2. Image from the Isotype Institute illustrating the proportions of women employed in different countries in 1930 and their occupations. [From (*63*)]

(Source from: Spiegelhalter et al., 2011)

Appendix A.3. This shows the use of icon arrays (cf. tables) in communicating the proportion of mortgage types in the UK industry.



Types of mortgages compared | Table

Mortgage type	Percentage of mortgages taken out in 2016	Percentage of mortgages taken out in 2019
Homeowner	83.30%	86%
Buy-to-let	16.70%	14%

(Source from: Matthew, 2020).

Appendix A.4. Examples of the bar charts examined in previous studies. As shown below, the charts impart a simple message rather than complicated information.

Example One:

Okan et al. (2018) study presented one of these four graphic figures that communicate the effectiveness of a hypothetical drug that reduces the risk of suffering a heart attack.

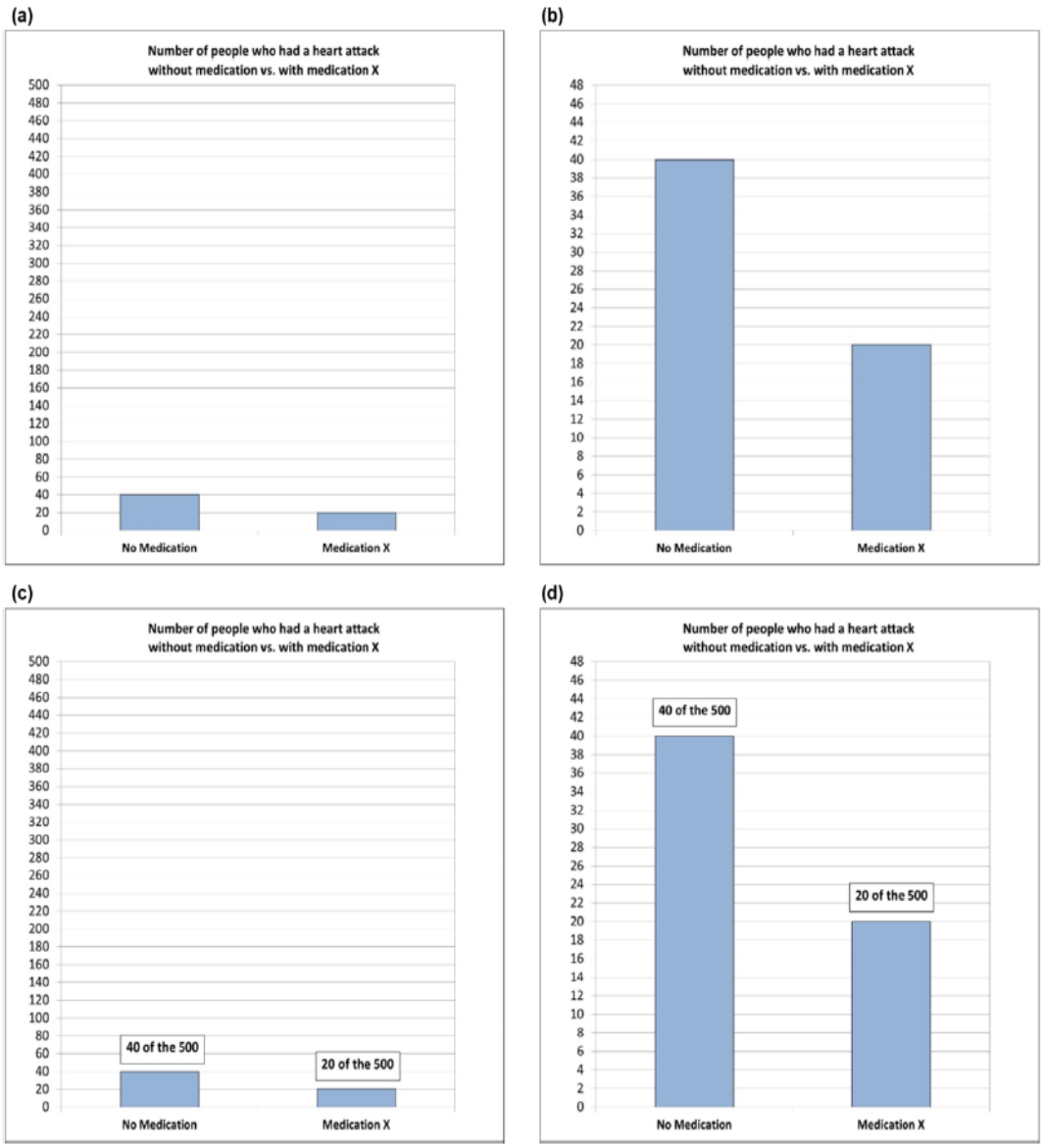
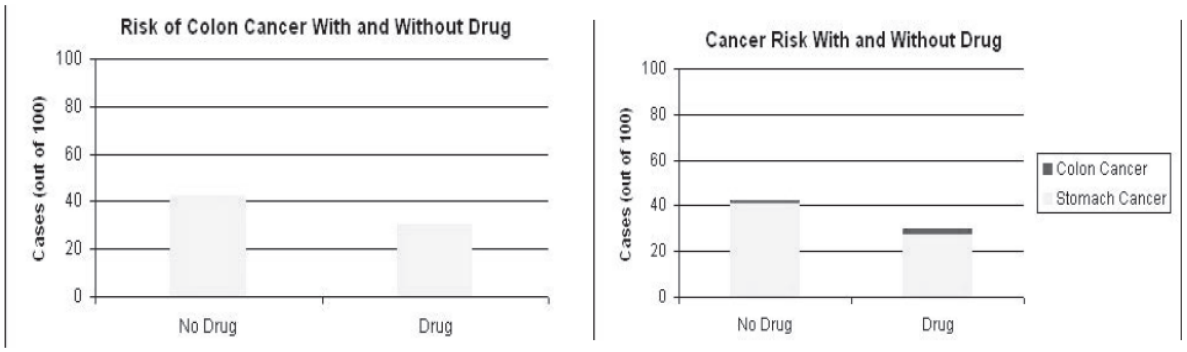


Fig. 1. Graphs viewed by participants in the different experimental conditions. (a) Foreground+background, without labels; (b) foreground-only, without labels; (c) foreground+background, with labels; (d) foreground-only with labels.

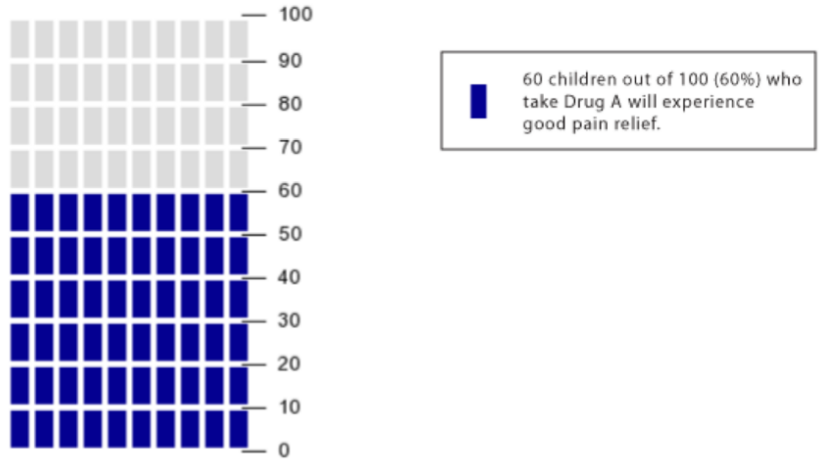
Example Two:

Waters, Weinstein *et al*. (2007) study utilised bar charts to present risk probability information for taking a hypothetical preventive treatment.

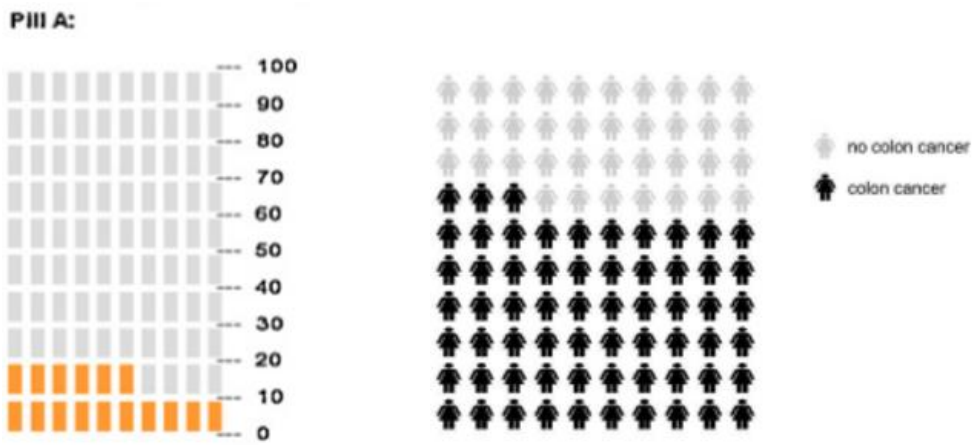


Appendix B. Supplement to Chapter Two

Appendix B.1. below shows the icon arrays condition which was designed by Tait et al. (2010)'s study. The diagram shows that in the icon arrays condition, the texts and numbers of the explanatory label were presented alongside icon arrays. Therefore, the icon arrays condition was not necessarily more effective at enhancing the comprehension of probability information since the information was not imparted by the icon arrays alone.



Appendix B.2. below provides two examples of icon arrays' different design features which were used in previous studies. That is, one icon arrays format included a numerical scale on y-axis, and the other one did not.



Source from Hawley et al. (2008) and Kreuzmair et al. (2017)

Note: the demonstrated examples of icon arrays in Appendix B.1 and Appendix B.2 were NOT used in my study.

Appendix B.3. This shows screenshots of instruction information and stock scenario presented to participants in all conditions, as well as four format conditions used in Study One.

Instruction

Important Instructions

1. During the survey, **please pay close attention to the information that is presented to you**. That information may then become **unavailable** to view, but you will still be asked questions about the information.

2. **This is not a test**, we are simply interested in your answers to the questions in this survey. Therefore, please complete the questions to reflect your personal opinions as accurately as possible and to answer factual questions to the best of your knowledge without consulting any other devices or sources of information (e.g., friends, books, the internet, etc.) and without writing down any information.

3. You must **complete this study in one sitting**. You will not be able to save the answers and continue at a later time. **You cannot return to the previous question** once you have moved on to the next question.

4. This survey will open in a new page and has **one question per page**.

5. Once you have answered each question, click the bottom of the page to get to the next question.

Please click on the button below if you are willing to participate in this survey:

I am willing to participate in this survey

Stock Scenario

Information about your investment options:

Imagine you have a certain amount of savings that you plan to invest in the stock market. Your financial advisor has told you that the gains you can make on your chosen stock will depend on the amount of risk associated with that stock. This risk is the chance of losing some of the money you invested in the stock in the year ahead.

The following information describes three stocks that your financial advisor has selected for you to choose from, each of which vary in risk. For each stock, the information describes the estimated risk of losing at least of a quarter of your initial investment if the worst economic conditions occur in any given year.

Format conditions

(1) Probability Format:

Stock A: 36% chance of losing at least a quarter of the investment in a given year.

Stock B: 48% chance of losing at least a quarter of the investment in a given year.

Stock C: 24% chance of losing at least a quarter of the investment in a given year.

(2) Frequency Format:

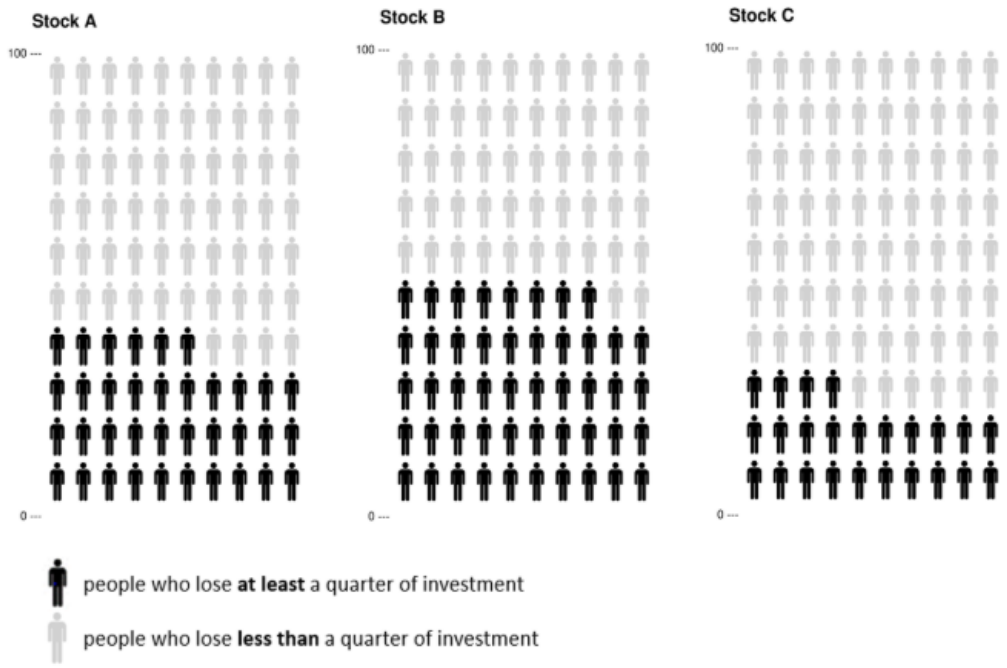
Stock A: 36 in 100 chance of losing at least a quarter of the investment in a given year.

Stock B: 48 in 100 chance of losing at least a quarter of the investment in a given year.

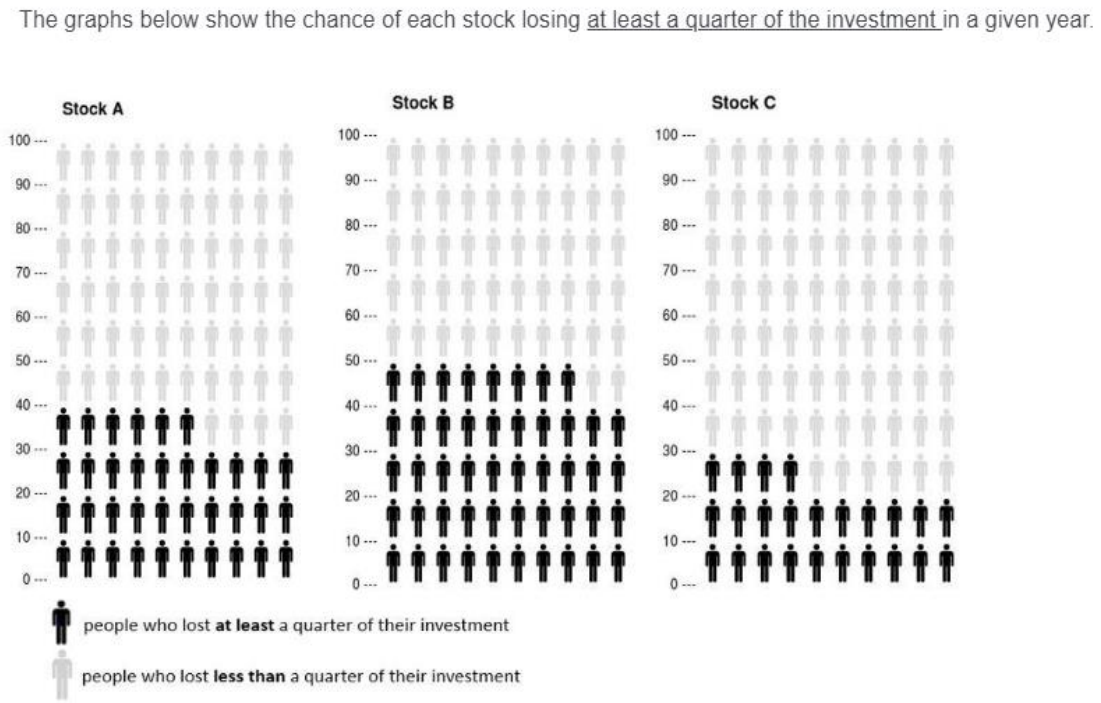
Stock C: 24 in 100 chance of losing at least a quarter of the investment in a given year.

(3) Icon-only Format:

The graphs below show the chance of each stock losing at least a quarter of the investment in a given year.



(4) Icon-scale Format:



Appendix B.4. below presents all questions examined in Study One (i.e., questionnaire used for Study One).

The measurement of gist knowledge.

In this section, you will be asked questions about Stock A, Stock B and Stock C. However, the information that you just viewed about those three stocks will not be available for you to view.

Q: Which stock is most likely to lose at least a quarter of the investment if the worst economic scenario occurs?
- Stock A
- Stock B
- Stock C

Q: Which stock has the lowest risk?
- Stock A
- Stock B
- Stock C

Q: Which of following statement is correct?
- I will be exposed to a higher level of risk if I invest in stock A rather than stock B.
- I will be exposed to a higher level of risk if I invest in stock A rather than stock C.

Q: Please rank the riskiness of stock A, stock B and stock C from the highest to the lowest.

- Highest _____
- Medium_____
- Lowest_____

Q: Which stocks will generate the highest expected return?
- Stock A
- Stock B
- Stock C
- Cannot say

<u>The measurement of verbatim knowledge.</u>

In this section, the information about the three stocks will be available for you to view while you answer the questions.

Q: What is the likelihood of losing at least a quarter of your investment funds if you invest in stock C?

Condition 1: A: 48%	B: 36%	C: 25%	D: 24%
Condition 2: A: 48 in 100	B: 36 in 100	C: 25 in 100	D: 24 in 100
Condition 3 & 4: A: 48 in 100	B: 36 in 100	C: 25 in 100	D: 24 in 100

Q: What is the difference in likelihood of risk between stock A and stock C?

Condition 1: A: 0%	B: 12%	C: 25 %	D: 24 %
Condition 2: A: 0 in 100	B: 12 in 100	C: 25 in 100	D: 24 in 100
Condition 3 & 4: A: 0 in 100	B: 12 in 100	C: 25 in 100	D: 24 in 100

Q: Which stock is twice as risky as stock C?
- Stock A
- Stock B
- Neither Stock A or Stock B

Q: Using the scale below, please indicate <u>how confident you felt</u> when answering the above questions about the stock risk information from Q1 to Q8.

Very Unconfident 1	2	3	4	5	6	7	8	9	**Very Confident** 10

Q: Using the scale below, please indicate the extent to which you found the <u>numerical questions</u> above from Q1 to Q8 easy/difficult to answer.

Very Difficult To Answer 1	2	3	4	5	6	7	8	9	**Very Easy To Answer 10**

Q: Using the scale below, please indicate the extent to which you found it <u>easy/difficult to understand</u> the information <u>about Stocks A, B and C</u> that you viewed at the beginning of the questionnaire.

Very Difficult To Understand 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Very Easy To Understand 10**

Q: Earlier in this questionnaire you saw some information about the chance of losing a quarter of an investment for Stocks A, B and C.

Using the scale below, please indicate the extent to which you believe that the way that the information was presented would help you to understand the risks associated with other financial investments in the future.

Very Unhelpful 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Very Helpful 10**

Q: Using the scale below, please indicate the extent to which you would personally consider Stock A to be a risky investment.

Not Risky At All 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Very Risky 10**

The measurement of Numeracy:

Q: Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up in 1,000 flips?

_____times out of 1,000

Q: Imagine that we rolled a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up even (2, 4, or 6)?

_____times out of 1,000

Q: In the BIG BUCKS LOTTERY, the chances of winning a $10.00 prize is 1%. What is your best guess about how many people would win a $10.00 prize if 1,000 people each buy a single ticket to BIG BUCKS? _____

_____person(s) out of 1,000

Q: In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSTAKES win a car?

_____%

Q: Which of the following numbers represents the biggest risk of getting a disease?

- 1 in 100
- 1 in 1000
- 1 in 10

Q: Which of the following numbers represents the biggest risk of getting a disease?

- 1%
- 10%
- 5%

Q: If Person A's risk of getting a disease is 1% in ten years, and person B's risk is double that of A's, what is B's risk?

_____%

Q: If Person A's chance of getting a disease is 1 in 100 in ten years, and person B's risk is double that of A's, what is B's risk?

_____out of 100.

Q: If the chance of getting a disease is 10%, how many people would be expected to get the disease:

_____Out of 100?
_____Out of 1000?

Q: If the chance of getting a disease is 20 out of 100, this would be the same as having a ____% chance of getting the disease.

Q: The chance of getting a viral infection is .0005. Out of 10,000 people, about how many of them are expected to get infected?

_____people

Sociodemographic questions:

Q: What is your age? _____

Q: Please indicate your gender.

- Male
- Female

Q: Please state the highest level of education that you have already completed.

- No schooling completed
- Secondary school
- level or equivalent
- Vocational/technical qualification
- Bachelor's degree
- Master's degree
- Doctoral degree
- Professional degree (MD, JD, etc.)
- Other (please specify) _____

[IMC] Q: Academic research in financial decision-making shows that choices can be affected by an investor's previous knowledge and experience. To help understand how people make decisions about financial matters, we are interested in obtaining some more information about you. It is important that we can be confident that each respondent, such as yourself, has taken the time to carefully read our questions and has paid close attention to the directions that we have provided. If participants have not paid close attention, some of our research aims will not have been achieved. Hence, to demonstrate that you have read this text and are following our instructions, please ignore the question below about the financial products, and simply type the words 'investment' into the other free text option as your answer to the question.

In your opinion, which of these investment options is most familiar to you?

- o Shares
- o Bonds
- o Treasury bills
- o Mutual funds
- o Options
- o Certificate of deposit
- o Other (please specify)_____

Q: Have you ever had any experience in investing in stocks, bonds, mutual funds or similar financial instruments?

- o Yes
- o No

Q: Please state which country you currently reside in? _____

Q: What is your current individual income in £ pounds before taxes during the past 12 months?

- o Under £10,000
- o £10,000 - £19,999
- o £20,000 - £29,999
- o £30,000 - £39,999
- o £40,000 - £49,999
- o £50,000 - £74,999
- o £75,000 - £99,999
- o £100,000 - £150,000
- o Over £150,000 s
- o Would rather not say

Appendix C. Supplement to Chapter Three

Appendix C.1. demonstrates the examples of the graphic displays which are currently used by finance sector institutions to communicate mortgage-related information.

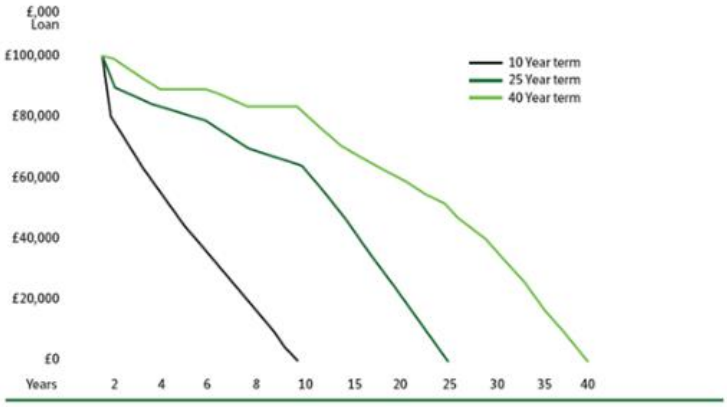
Repayment methods

There are three different ways of repaying your loan. These are repayment, interest-only, and a combination of repayment and interest-only.

Repayment

Every month, your payments go towards reducing the amount you owe as well as paying off the interest (see Figure 1). This means that each month you are paying off a small part of your loan. Your annual statement will show your loan getting smaller. However, in the early years your monthly payments will mainly go towards paying off the interest, so the amount you owe won't go down much at the start.

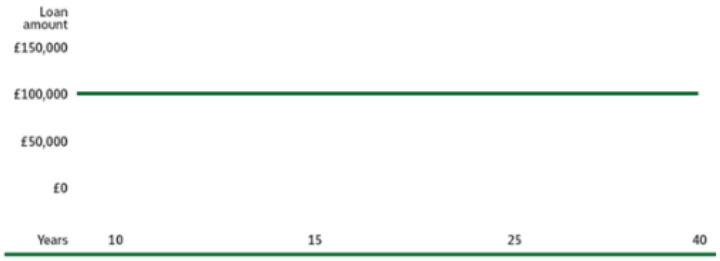
Figure 1: Illustration of the effect of monthly payments on a £100,000 repayment loan over the mortgage term



Interest-only

Your monthly payment pays only the interest charges on your loan - you don't pay off any of the loan amount (see Figure 2). This means your monthly payments will be less than if you had a repayment mortgage. However, the total cost of an interest-only mortgage will be higher because you will be paying interest on the full loan amount throughout the mortgage term.

Figure 2: Illustration of the effect of monthly payments on a £100,000 interest-only loan over the mortgage term



Source from: www.lloydsbank.com

Appendix C.2. below presents screenshots of mortgage scenario information (i.e., background information) presented to participants in all conditions and detail of the text condition used in Study Two.

Mortgage Scenario information

Information about you:

Imagine that you have just started a new job that pays you a gross salary of £45,000 each year. After various deductions (e.g., tax, pension, etc.), your net salary is £34,200 each year. This means that you take home £2,850 each month. You have to use this money for all of your living costs. Also, you currently have no savings to rely upon if your income stops.

Currently, you plan to take out a mortgage of £250,000 to buy your first house. You plan to live alone and will repay the mortgage by yourself over a term of 25 years. Your mortgage advisor states that you will have to choose between two types of mortgage repayment options. Both options have the same fixed-interest rate of 4%.

The information about the two types of repayments options will appear on the following page.

Texts Format conditions

Information about mortgage options:

Option A: principal-repayment mortgage.

The monthly payment will be £1,319. A part of this monthly payment goes towards paying off the mortgage debt, and the other part of the payment goes towards paying off the interest.

The amount you borrow on your mortgage at the very start of the mortgage term (Year 0) will be £250,000. With each monthly payment that you make, this amount of debt will gradually be reduced. In year 25, after your final payment, your mortgage debt will be £0. Over the whole 25 years, you will have to pay back the £250,000 mortgage, plus £145,712 in interest payments. Hence, the total amount that you will pay back will be £395,712.

Option B: interest-only mortgage.

The monthly payment will be £833. All of this monthly payment goes towards paying off the interest, and none of the payment goes towards paying off the mortgage debt.

The amount you borrow at the very start of the mortgage term (Year 0) will be £250,000. This amount of mortgage debt will remain the same throughout the 25-year mortgage term. Therefore, at the end of year 25, you will have to repay all of the £250,000 mortgage debt at once. Over the whole 25 years, you will have to pay back the £250,000 mortgage, plus £249,750 in interest payments. Hence, the total amount that you will pay back will be £499,750.

Appendix C.3. below provides screenshot of all questions asked in Study Two (i.e., questionnaire used for Study Two).

The measurement of mortgage comprehension:

You will now be presented with some questions about the two mortgage repayment options. For your reference, the information about the two types of repayments options will appear below each question.

Q: Which type of mortgage repayment option you would prefer to take?

Option A

Option B

Q: Please use the scale below to indicate how important the amount of you owe during the mortgage term was to you when choosing between the two types of mortgage repayment options.

Not important at all 1	2	3	4	5	6	7	8	9	very important 10

Q: Please use the scale below to indicate how important the amount of the monthly repayments was to you when choosing between the two types of mortgage repayment options.

Not important at all 1	2	3	4	5	6	7	8	9	very important 10

Q: Please use the scale below to indicate how important the amount of the total interest payment was to you when choosing between the two types of mortgage repayment options.

Not important at all 1	2	3	4	5	6	7	8	9	very important 10

Q: Which one of the two repayment types would enable you to start paying back the mortgage debt (i.e., £250,000) sooner ?

Option A

Option B

The same for Option A and Option B

Q: During the 25 year term, which one of the two repayment types would cause you to have the least money to spend on other things (e.g., other financial investments, consumption, etc.) over the first few years?

Option A

Option B

The same for Option A and Option B

Q: Which one of the two repayment types would lead to less financial strain at the end of mortgage term?

Option A

Option B

The same for Option A and Option B

Q: In year 15 of the mortgage, which one of the two repayment types would have the lowest remaining debt?

- Option A
- Option B
- The same for Option A and Option B

Q: Which one of the two repayment types would be better suited to someone who currently has a very unstable monthly income, but is likely to inherit a large quantity of cash that over £250,000 in approximately 25 years from now?

- Option A
- Option B
- The same for Option A and Option B

Q: Using the scale below, please indicate the extent to which you found it difficult/easy to understand the information about repayment options A and B.

very difficult to understand 1	2	3	4	5	6	7	8	9	very easy to understand 10

The measurement of Debt literacy:

Q: Sarah owes £1000 on her credit card and the interest rate she is charged is 20% per year compounded annually. If she didn't pay anything off, at this interest rate, how many years would it take for the amount she owes to double?

- Less than 5 years
- Between 5 and 10 years
- More than 10 years
- Do not know

Q: David has a credit card debt of £3000 at an Annual Percentage Rate of 12% (or 1% per month). He makes payments of £30 per month and does not gain any charges or additional spending on the card. How long will it take him to pay off this debt?

- Less than 5 years
- Between 5 and 10 years
- More than 10 years
- None of the above, he will continue to be in debt
- Do not know

You purchase an appliance which costs £ 1,000. To pay for this appliance, you are given the following two options:

a) Pay 12 monthly instalments of £100 each;
b) Borrow at a 20% annual interest rate and pay back £1,200 a year from now.

Which is the more advantageous offer?

- Option (a)
- Option (b)
- They are the same
- Do not know

The measurement of Present-bias:

Please use the scale below to indicate:

I am impulsive and tend to buy things even when I can't really afford them.

- Agree strongly
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Disagree strongly
- Do not know

The measurement of risk-attitude:

Section II:

For each of the following statements, please use the scale below to indicate the **likelihood** that you would engage in the described activity or behaviour if you were to find yourself in that situation.

	1 Extremely Unlikely	2 Moderately Unlikely	3 Somewhat Unlikely	4 Not Sure	5 Somewhat Likely	6 Moderately Likely	7 Extremely Likely
Betting a day's income at the horse races.	○	○	○	○	○	○	○
Investing 10% of your annual income in a moderate growth diversified fund.	○	○	○	○	○	○	○
Betting a day's income at a high-stake poker game.	○	○	○	○	○	○	○
Investing 5% of your annual income in a very speculative stock.	○	○	○	○	○	○	○
Investing 10% of your annual income in a new business venture.	○	○	○	○	○	○	○

The measurement of Debt experience:

Please choose the following you have done during your lifetime (select all if apply):

- Taken out a loan for student education
- Taken out a car loan
- Taken out a short-term "payday" loan
- Taken out a credit card
- None of the above

Sociodemographic questions:

Q: What is your age? _____

Q: Please indicate your gender.
- Male
- Female

Q: Please state the highest level of education that you have already completed.
- No schooling completed
- Secondary school

- level or equivalent
- Vocational/technical qualification
- Bachelor's degree
- Master’s degree
- Doctoral degree
- Professional degree (MD, JD, etc.)
- Other (please specify) _____

Q: What is your current individual income in £ pounds before taxes during the past 12 months?

- Under £10,000
- £10,000 - £19,999
- £20,000 - £29,999
- £30,000 - £39,999
- £40,000 - £49,999
- £50,000 - £74,999
- £75,000 - £99,999
- £100,000 - £150,000
- Over £150,000 ss
- Would rather not say

Q： Do you own the property you live in?

- I own the property I live in
- I am renting the property I live in
- I own a property (either a house or flat) but not currently live in.
- I own the property I live in and do not have a mortgage.
- I own the property I live in and have a mortgage on this property.
- Not applicable (please specify)

Appendix C.4. shows participants' decisions between principle-repayment and interest-only mortgages.

	A (the number of participants who selected Option A – principal mortgage)	B (the number of participants who selected Option B– interest-only mortgage)
Texts-only	55 (94.80%)	3 (5.20%)
Graphs –only	58 (93.5%)	4 (6.5%)
Combine-format	61 (96.8%)	2 (3.2%)
Full sample	174 (95.1%)	9 (4.9%)

Appendix D. Supplement to Chapter Four

Appendix D.1. is the background material of stock scenario provided to participants.

Information about your investment options:

Imagine you have a certain amount of savings that you plan to invest in the stock market. Your financial advisor has told you that the gains you can make on your chosen stock will depend on the amount of risk associated with that stock. This risk is the chance of losing some of the money you invested in the stock in the year ahead.

The following information describes three stocks that your financial advisor has selected for you to choose from, each of which vary in risk. For each stock, the information describes the estimated risk of losing at least of a quarter of your initial investment if the worst economic conditions occur over a given year.

Appendix D.2. is the background material of mortgage scenario.

Information about you

Imagine that you have just started a new job that pays you a gross salary of £45,000 each year. After various deductions (e.g., tax, pension, etc.), your net salary is £34,200 each year. This means that you take home £2,850 each month. You have to use this money for all of your living costs. Also, you currently have no savings to rely upon if your income stops.

Currently, you plan to take out a mortgage of £250,000 to buy your first house. You plan to live alone and will repay the mortgage by yourself over a term of 25 years. Your mortgage advisor states that you will have to choose between two types of mortgage repayment options. Both options have the same fixed-interest rate of 4%.

The information about the two types of repayments options will appear on the following page.

Appendix D.3. Additional descriptive data

Table D.1 presents the comparisons of the responses between lower debt-literate and higher debt-literate participants regarding the limitations of bar charts to impart mortgage-related information. In detail, I used the median of debt literacy of 1 as the cut-off value to split the participants into higher (≥ 1) debt-literates, 16 participants and lower (< 1) debt-literates, 24 participants.

The descriptive data, in general, showed that the participants with lower debt literacy appeared to have more negative comments on how difficult it is to understand graphs and obtain in-depth mortgage information from graphs, as compared to their higher debt-literacy counterparts. For example, most participants with lower (cf. higher) debt literacy found that, without texts, it was too cumbersome to interpret the graphs and construct mortgage knowledge from the graphs. This suggests that, because lower debt-literate individuals have less knowledge of financial information, do the effortful graph comprehension processes place more burden on them to understand financial information? In contrast, textual formats enabled the terms and the financial situation to be explained to every individual directly. This response pattern supported previous findings that lower debt-literate individuals had lower mortgage understanding in the graphic formats than in the textual format (Zhang et al., unpublished a). Moreover, graphs' efficacy is associated with audiences' prior knowledge of the depicted information (e.g., Stern et al., 2003). Future studies or surveys could build upon this pattern to develop a precise understanding of how lower debt or financial literacy impedes individuals from understanding financial information in graphic displays in a larger sample size.

Table D.1. The comparisons of bar chart limitations in understanding mortgage information between lower- and higher debt-literates

The limitations of bar charts in understanding mortgage information			
	Lower Debt literates (24)	**Higher Debt literates (16)**	**Total (40)**
Difficult to understand what was causing the patterns in the charts [a]			
Lacking detail information to explain the graphic patterns.	8 (72.73%)	3 (27.27%)	11
Lacking background information.	19 (67.86%)	9 (32.14%)	28
More effort required to comprehend the graphs [b]			
Difficult to notice small graphic pattern.	8 (61.54%)	5 (38.46%)	13
Effortful to integrate graphic details.	22 (66.67%)	11 (33.33%)	33
The influence of complexity level of graphs' detail on information engagement [c]			
Unwilling to process the complicated time-series charts.	10 (81.82%)	3 (18.18%)	13
Monthly repayment chart was less helpful (unnecessary).	12 (57.14%)	9 (42.86%)	21

[a] *i.e., from the 2nd order category (a) of Dimension 2: Difficult to understand what was causing the patterns in the charts.*

[b] *i.e., from the 2nd order category (b) of Dimension 2. More effort required to comprehend the graphs.*

[c] *i.e., from the 2nd order category (c) of Dimension 2. The influence of complexity level of graphs' detail on information engagement.*

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