The View from Elsewhere: Perspectives on ALife Modelling

Michael Wheeler[1], Seth Bullock[2], Ezequiel Di Paolo[3], Jason Noble[4], Mark Bedau[5], Philip Husbands[6], Simon Kirby[7], and Anil Seth[8] [9]

1. Introduction

This paper is the outcome of a workshop held on 9th September, 2001, at the University of Economics, Prague, Czech Republic, as part of the 6th European Conference on Artificial Life. Entitled 'The View from Elsewhere: Perspectives on ALife Modelling', the event was organised by four of the present authors (Bullock, Di Paolo, Noble, and Wheeler). Its aim was to review and discuss artificial life (ALife) as it is depicted in, and as it interfaces with, adjacent disciplines. If, as many ALifers hope, ALife is to interface successfully with biology, philosophy, linguistics, economics, and other fields of scientific enquiry, it is important to consider the opinions and attitudes of practitioners from these disciplines. What can we learn from their conceptions and misconceptions? What lessons are there to be learned from ALife research of a genuinely interdisciplinary character, and from the history of interdisciplinary research into adaptive systems? How can we improve the ability of ALife to "cross over"?

The workshop was divided into five hour-long sessions. Each of the first three sessions addressed a different ALife-related interdisciplinary interface. In the context of the issues targeted by the workshop, the various speakers either (a) examined bodies of research (often their own) located at the specific interdisciplinary interface in question, or (b) presented critical reactions to writings on ALife authored by researchers who are interested in A-Life, but who work primarily in the targeted adjacent discipline, or (c) both. The interfaces chosen for investigation were those with philosophy, biology, and linguistics. The fourth session of the workshop shifted the focus somewhat, in that it concentrated on a particular historical experience of cross-disciplinary understanding and misunderstanding, one which is close to the hearts of many ALifers, namely cybernetics. The first four sessions allowed plenty of time for constructive discussion and debate, but to ensure that there was a proper opportunity for participants to collectively investigate the issues, the fifth and final session was reserved for open discussion.

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[1] Department of Philosophy, University of Dundee, UK.
[2] Informatics Research Institute, School of Computing, University of Leeds, UK.
[3] School of Cognitive and Computing Sciences, University of Sussex, UK.
[4] Informatics Research Institute, School of Computing, University of Leeds, UK.
[5] Reed College, Portland, Oregon, USA. Currently, Visiting Research Associate, University of Oklahoma, USA.
[6] School of Cognitive and Computing Sciences, and Centre for Computational Neuroscience and Robotics, University of Sussex, UK.
[7] Language Evolution and Computation Research Unit, Department of Theoretical and Applied Linguistics, University of Edinburgh, UK.
[8] The Neurosciences Institute, San Diego, California, USA.
[9] The authors' names have been ordered as follows: The first-named was primarily responsible for the co-ordinating and editing of the present report. Next come the three other organisers of the workshop, in alphabetical order, followed by the four invited additional participants, in alphabetical order. No other significance should be attached to the ordering.

The main body of this paper is organised as follows: Each of the four main speakers at the workshop (Bedau, Bullock, Noble, and Husbands) and each of the four discussants (Wheeler, Seth, Kirby, and Di Paolo) has contributed a summary of what he considers to have been the main points of his presentation, typically written so as to take into account aspects of the discussions that followed. Each of these summaries appears as a distinct subsection of sections 2-5 inclusive. The title of each of these subsections is the name of the author concerned. These eight contributions are followed by a 'Reactions' section in which certain themes from the various discussions are described. It is important to note that this paper does not have a single voice, but rather many voices. Indeed, the word 'perspectives' in the title is deliberately ambiguous. It signals not only the various perspectives on ALife adopted by researchers from other disciplines, as targeted by the workshop, but also the often differing perspectives on ALife adopted by the eight authors of this report.

2. The View From Philosophy

2.1 Mark Bedau

I think philosophy and ALife are natural partners. Neither enterprise is monolithic; each is diverse and continually evolving. Nevertheless, both share an interest in relatively abstract essences over contingent details, and so-called "thought experiments" figure centrally in both. (Philosophers conduct the experiments in their armchairs while computer simulations are used in ALife; see Bedau 1998.) So it is no surprise that combining expertise from philosophy and ALife enables us to make new progress on a number of central issues in both fields, such as emergence, adaptationism, evolutionary directionality, and whether ALife simulations can literally be alive (see, e.g., Bedau, forthcoming). Here I will focus on another issue – the nature of life – because it figures centrally in Kim Sterelny's recent critique of ALife (Sterelny 1997, Sterelny and Griffiths 1999) and it highlights how philosophy and ALife are connected.

Sterelny (1997) is struck by A-Life's resuscitation of "a quaintly old-fashioned project: defining life" (p. 587). When he asks "why suppose biology needs a definition of life?" (p. 587), he could just as well ask the same question about philosophy, for contemporary discussions of life are virtually absent from both disciplines. But I think Sterelny misconstrues the contemporary interest in life. First, contrary to what Sterelny suggests, the central concern is not to analyse our *concept* of life. This concept is an historical artifact, which varies across different cultures and which changes as our beliefs and preconceptions evolve. This concept might be an appropriate subject for anthropologists to study, but not natural scientists or philosophers.

The question about life that interests scientists (and philosophers) concerns the natural world, not our concepts. Living systems have a variety of hallmarks, such as having an enormously complex and adaptive organization at all levels, and being composed of a chemically unique set of macromolecules. It's widely recognized that these hallmarks do not constitute necessary and sufficient conditions for life, but they still raise an interesting question: Why are those hallmarks characteristically present together in nature? That is, why do the phenomena underlying life give rise to those hallmarks and not others? This is a question about how best to understand a fundamental feature of the natural world. Analysing our existing concepts will not yield the answer. In fact, the answer may well require creating new concepts.

The combined efforts of ALife and philosophy are well suited to attack this question. Philosophy offers the benefit of two thousand years of experience in examining and clarifying very abstract hypotheses about the most fundamental aspects of nature (existence, causation, mind, etc.). One contribution of ALife is to push the boundaries of what life-like systems can actually exist. But more important, ALife systems provide one of the few feasible ways to explore unifying principles that might explain the hallmarks of life.

It is still an open question whether we will find any such unifying principles or, indeed, whether any exist. Sterelny doubts whether ALife will shed any light on the general nature of life. He is surely right that the abstractness of ALife systems makes it difficult to connect their behaviour to the behaviour of natural living systems. On the other hand, how can we clarify and evaluate candidate explanations of life's hallmarks without computer simulations? Purely verbal theories often sound plausible before one tries to make them concrete enough to simulate, and the behaviour of complex adaptive systems is notoriously hard to predict except through extensive simulations.

Computer simulations are foreign to philosophical methodology today, but I think this will change in the near future. Thought experiments involving complex phenomena like emergence and the creative potential of evolving systems are too difficult to analyse from the armchair, but we now are able to study them with computer simulations. This new methodology enables us to pursue issues that are ignored today, such as the ultimate nature of life. Some people want to show how ALife work helps answer the questions currently pursued in other disciplines. I want to make a different point: partnership with ALife can enable philosophy (and other disciplines) to pursue new fruitful research directions. It is always controversial to propose changing the questions a discipline addresses. Nevertheless, I think we should embrace this controversy, since the possible fruits are so attractive.

2.2 Michael Wheeler

When philosophers look at A-Life, what do they see? Dennett (1994) offers two possible answers:

1. ALife as a philosophical method.
2. ALife as an object for philosophical study.

Dennett sanctions both options, but favours the first. I think his positive argument for the first option is problematic. Here's why.

Dennett's argument rests on the claim that ALife models (simulations and robots) are "prosthetically controlled thought experiments" (p.291). The idea is that while ALife models are realised as computers and robots, they retain the status of thought experiments, in that they are "arguments about what is possible, necessary and impossible under various assumptions" (p.291; cf. Bedau 1998, and in section 2.1 above). The argument is completed by the claim that thought experiments are a distinctively philosophical tool. Let’s start with that latter claim. It seems straightforwardly false: thought experiments are a recognized tool of science too (e.g. Galileo’s falling bodies, Einstein’s train). And notice that this gap wouldn’t be bridged by the additional point that ALife gains its philosophical credentials by addressing questions of philosophical interest. Science and the arts routinely tackle such questions, without thereby turning into sub-disciplines of philosophy.

In any case, ALife models are not thought experiments – philosophical or scientific. Consider: If one maintains that ALife models are thought experiments because they provide insights into possible worlds (life as it could be and maybe is), rather than the actual world, one risks counting many well-known mathematical models from, say, theoretical biology (e.g. Grafen’s 1990 handicap principle models) as thought experiments. And that is to lose a distinction (between mathematical models and thought experiments) which is worth having. This loss prevails even if one adds in Dennett’s rider about possibility and necessity, or, in the case of simulations, Di Paolo et al.’s (2000) neo-Kuhnian analysis that ALife models are thought experiments because they work by provoking a re-organisation of our concepts. Here is a way forward: On a no-nonsense account, a thought experiment is “a device that takes place in the imagination” (Brown 1997). Unlike other accounts, the no-nonsense account allows us to draw the line in the right place. Since neither ALife models nor mathematical models are (in the relevant sense) realised in the imagination, they are not thought experiments. So we end up with thought experiments on one side of the line, and ALife models and biological mathematical models on the other.

This suggests a better account of ALife models, or of ALife simulations at least. These are best conceived as close relations of biological mathematical models (cf. Sterelny’s 1997 conclusion that ALife simulations are representations of biological processes). They are useful relations: they allow us to drop some of the unrealistic assumptions which mathematical models often make for reasons of mathematics rather than biology (e.g. random mating, infinite populations). But they are relations, nonetheless. That, I think, is the right thing for philosophers to see.

3. The View from Biology

3.1 Seth Bullock

Could ALife simulation modelling be a lingua franca between theoretical and empirical biology?

Within the ALife community, computer simulations are being designed and built such that their ongoing dynamic behaviour reflects that of natural processes as they unfold over time. Through exploring how these simulation models behave, and how this behaviour changes as their parameters, initial conditions, etc. are varied, modellers hope to learn more about (our theories of) the natural processes that these computer simulations were modelled upon. If ALife simulations are to play this kind of scientific role successfully, if they are to serve as useful scientific *models*, it is important that (i) they meet the same methodological standards as models from more orthodox modelling paradigms and (ii) they offer something beyond and possibly above these existing modelling approaches.

These twin concerns motivate the majority of writing on ALife modelling methodology (Bonabeau and Theraulaz 1994; Taylor and Jefferson 1994; Miller 1995; Bullock 2000; Di Paolo et al. 2000). When is ALife simulation appropriate? What are its strengths and weaknesses? How can ALife simulation models be verified, calibrated, assessed and employed to best effect? How realistic should an ALife model be? In what senses are they superior to formal mathematical models? In what senses are they inferior? How can we improve their rigour and their ability to interface with existing modelling traditions?

In my opinion these debates are necessary and important if ALife simulation modelling is to engage successfully with mainstream science. However, I believe that in concentrating on issues of methodological rigour and in identifying the benefits of simulation models with their ability to augment, extend, or challenge existing modelling paradigms, an important potential role for these models is being neglected.

Over the last few decades, theoretical biologists have made important inroads into modelling what were often previously pretty informal evolutionary and ecological ideas. However, these models tend to be couched in terms of formulae, calculus, game theory, etc. While empirical biologists in the field and laboratory appreciate that these models are crucially important to ecology and evolutionary biology, many have little inclination to digest the maths. This appears to be leading to an increasing divide between the theoretical and empirical camps. Field biology, theoretical modelling and experimentation were once carried out by the same individuals. However, as with most modern science, it is now the norm to find greater specialisation. As has been pointed out (Ortega y Gasset 1930) these increases in specialisation often take place at the expense of genuine dialogue between specialists.

Against the backdrop provided by this crude caricature of modern biology, ALife simulations seem extraordinarily well-positioned to provide a modelling vocabulary capable of supporting genuine communication between theoretical and empirical biologists. Individual- or agent-based simulation models resemble the process models that biologists make use of in their informal discussions of animal behaviour. As such these simulation models have an immediacy that their formal cousins lack. When successful, these same simulations also capture the formal relationships that drive theoretical biological models. In order to maximise the ability of ALife simulation models to serve the purposes of the whole biology community, these models must meet the formal criteria of rigour, etc. demanded of them by the theoretical biology community, but they must also meet the pedagogical criteria of transparency, clarity, appropriateness, straightforwardness, etc. demanded by the more general biology community. The ALife methodology debate has tended to focus on the former aspect while downplaying the latter.

There are few ALife papers introducing ways of better conveying the structure of a simulation model on paper, or techniques for effectively visualising the often high-dimensional data sets that simulations produce. In addition, there is little explicit work on combatting the downside of a simulation model's immediacy – the tendency of some audiences to “project” added reality onto a simple simulation, mistakenly understanding the superficial similarity between simulated agents and real organisms as the point of a model, for instance.

Both experimental and formal math modelling paradigms have gradually developed well-understood orthodox presentation methods that effectively encourage clarity, brevity, etc. By contrast, there simply has not been enough time for equivalent practices to arise and fixate within the simulation modelling community. While it is likely that, given time, an orthodoxy will develop organically, this process can be hastened by research into the pedagogy of simulation modelling. In my opinion this work should be explicitly encouraged if ALife simulation modelling is to fulfil its potential as a modelling practice that is both completely rigorous *and* maximally luminous.

3.2 Anil Seth

Can simulation models of an ALife flavour successfully mediate between theoretical and empirical biology? The recent history of ecological modelling suggests, cautiously, that they can. For more than a decade ecologists have debated the merits of 'individual-based' models (IBMs), which "treat individuals as unique and discrete entities which have at least one property … that changes during the life cycle" (Grimm 1999, p.130), over those of more traditional 'state-variable' models (SVMs), which utilise population averages. Early propaganda emphasised that IBMs, like many ALife models, can accommodate individual and local interactions forever beyond the ken of SVMs and critical in accounting for a wealth of empirical data (Huston et al. 1988). It was even hoped that IBMs might thus 'unify' ecology, offering up general principles of ecological systems in place of contingent 'rules of thumb' (Judson 1994).

Ten years later, in a sobering review, Grimm (1999) identified a number of difficulties with this vision, many of which also found voice in the present workshop in the context of ALife. To give a taste: IBMs are hard to develop, hard to communicate (see section 3.1 above), and hard to understand. The abundance of free parameters runs the risk of 'WYWIWYG' (what-you-want-is-what-you-get). The flood of data produced by IBMs is hard to analyse, and the role of statistics unclear. Perhaps most significant of all, Grimm argued that IBMs must make greater reference to the concepts of population ecology inherited from SVMs, such as 'stability' and 'persistence', if they are to successfully mediate theory and experiment.

It is not hard to see in this history a parallel with the development of ALife, from an early idealism to recent concerns over methodology and interaction with empirical data. The concerns of Grimm are therefore to be duly noted, but a question arises: what conceptual framework should ALife make reference to? Perhaps, rather than accepting with Grimm a framework as given, ALife models by their flexibility can encourage a dialectic between alternative theoretical perspectives. Whereas ecological IBMs have focussed almost exclusively on the consequences of individual variation, ALife models can and regularly do incorporate many other aspects of agent-environment interaction. For example, by modelling individual rate-maximising behaviour, insights and ideas from population ecology and optimal foraging theory can encounter each other, and – more generally – the much criticised gulf between IBMs and optimality modelling can be reduced (Seth 2000). Situated perception and action and/or spatially structured environments also suggest themselves as means by which ALife models may challenge the utility of (whilst continuing to make reference to) theoretical entities derived from 'higher' levels of description (see, for example, Seth 2001).

The optimistic view, then, is that ALife models can not only mediate theory and experiment, but also encourage theoretical evolution and hence increasingly effective mediation in the future. What is required: close targeting of ALife models to specific empirical and conceptual issues, and a healthy appreciation of the many pitfalls involved.

4. The View From Linguistics

4.1 Jason Noble

What has work in ALife told us about language? If we look at the early proceedings volumes for the International and European Conferences on ALife, language and communication was a hot topic. There was great enthusiasm for ALife models that were going to tell us about the selective pressures that lead to simple signalling systems in animals, and about how language could have developed from one such simple system. Although there has arguably been some progress on the first of these issues, ALife has failed to give much insight into the second.

Most ALife work advertised as being relevant to the evolution of language or communication is really about the evolution of coherent two-way mappings between meanings, signals, and meanings again. That is, speakers must evolve a mapping between private meanings and public signals, and hearers must evolve a complementary mapping such that private meanings can be recovered, more or less reliably, from public signals (see, e.g., MacLennan 1992; Steels and Vogt 1997). The fact that under the right circumstances such mappings can arise has now been safely established.

Have such findings in ALife been picked up on by linguistics? The short answer is no. An examination of recent 'Introduction to Linguistics' courses and textbooks shows that ALife does not register on the radar. This is not surprising, as the two fields have different goals. Linguistics is concerned with the empirical investigation of a well-defined, concrete phenomenon: human language. ALife, on the other hand, attempts to cast light on the origins of complexity, by modelling such processes as the origin of life, or the cell, or cognition, or sociality, or indeed language. Whereas the average linguist might examine many languages for evidence of a proposed universal, or study the way children acquire language, he or she would be unlikely to speculate too much about the evolutionary origins of the language faculty. Chomsky's well-known reticence on this point has been as influential as his positive contributions to the discipline (Chomsky 1987).

Thus, most linguists have taken the existence of meaning-signal-meaning mappings as a given, and ALife work showing the evolution of such mappings was never likely to catch their imagination. Some ALife research has tackled the more difficult question of syntactic communication – an area that would certainly be more relevant to the interests of modern linguists – but this work has usually failed to get far. Partly this is because explaining the evolution of syntax is a very hard problem. However, as often happens in ALife, another problem has been that skills in computational modelling are not combined with adequate knowledge in the application domain. An exception to this rule is the *Language Evolution and Computation* (LEC) group, based in Edinburgh. This group of linguists and computer scientists stands out as doing ALife work that is likely to be of interest to the mainstream linguistics world, e.g., Kirby and Hurford's (1997) paper on how glossogenetic evolution reduces the theoretical demands on any hypothesized language acquisition device.

The work of the LEC group is often presented at the 'Evolution of Language' conference series. Although these conferences are not exactly mainstream linguistics, there should definitely be room for more contact between ALife researchers and this community, as both groups are interested in the adaptive function and origins of language. There is some risk of the blind leading the blind, in that many of the theories proposed by evolution-of-language theorists such as Bickerton (1998), Dunbar (1996), and Deacon (1997) are not specified in enough detail to support good model building. This can be contrasted with, for example, behavioural ecology, where theories on the evolution of signalling are well-developed enough for a useful simulation to be constructed. It follows that a practical goal for ALife researchers would be to work with the evolution-of-language community to devise more specific theories and to explore them in ALife simulations.

4.2 Simon Kirby

Initially it might seem inappropriate to apply ALife techniques to linguistics. After all, it seems that by its very name ALife is concerned with exploring phenomena that are intimately related to life. Linguistics, on the other hand, takes as its object of study the peculiar system of communication that is specific to humans. Nevertheless, an increasing number of papers are being presented at ALife conferences and appearing in ALife journals that tackle issues that overlap (at least) with those that linguists are interested in (e.g. Steels 1997).

Why are ALife techniques appropriate for the linguist? The answer to this question lies in an understanding of some of the primary concerns of linguistics, and the unusual complexity of the dynamic systems that under-pin language. Fundamentally, modern explanatory linguistics is concerned with answering the following two questions:

1. *Why* is language the way it is and not some other way?
2. *How* did language arise out of non-language?

We can think of these questions in terms of the set of logically possible communication systems C. Linguistics is concerned with the set of *possible human languages*, $L_{PH} \subset C$. The two questions above are essentially about explaining the particular properties of the shape of L_{PH} and showing how this set came to be from some prior (unknown) set $L_{PH'}$ (Kirby 1999). Before any of this is possible, there is also a non-trivial descriptive task of determining L_{PH}. Thankfully, there is an enormous amount of excellent descriptive work in the linguistics literature that covers all aspects of language, from research into the syntax of individual languages – both synchronic (Napoli 1993) and diachronic (McMahon 1994) – to large scale cross-linguistic studies that look at the distribution of features of languages in very large samples (Croft 1990).

What possible approaches are there to tackling these *why* and *how* questions? An influential perspective has been the synthesis of Chomskyan approaches to explanation on the one hand, and evolutionary psychology on the other:

1. *Why?* L_{PH} is determined directly by our biological makeup. In particular, we have an innate language acquisition device, *LAD*, that constrains us to learn a $L_{LAD} \equiv L_{PH}$ (Chomsky 1987).

2. *How?* L_{LAD} is also the set of languages that are functional as communicative systems for the human species. The *LAD*, like any other complex functional biological structure, evolved through a process of natural selection (Pinker and Bloom 1990).

Already, we can see why ALife techniques might be useful to check the claims of explanatory linguistics. After all, in its short history, ALife has regularly tackled issues such as: communication, learning, and biological adaptation. However, the case for ALife as an approach has become stronger in recent years as a number of authors have suggested that the evolved-learner approach understates the complexity of language in a fundamental way (Batali 1998; Kirby 2000). In the Chomskyan framework, the key to answering the why question is the idealisation that $L_{LAD} \equiv L_{PH}$. However, this can only be true under conditions where the data to the learner are drawn from a single stationary target language, and all languages in L_{LAD} are equally learnable. The extensive literature on language development (MacWhinney 1999), computational models of learning, and socio-linguistics (Trudgill 1995) show this is not the case. This matters because it means there is a new dynamic to consider in addition to learning and evolution: culture.

We can think of this problem as one involving a cycle of three adaptive systems. Learning involves the adaptation, within the lifetime of an individual, of internal representations to the utterances presented to the child. Languages adapt to the biases inherent in the learning mechanism over a historical time-scale. The innate specification of learning biases adapts on a biological time-scale in order to make the languages that emerge from the cultural process learnable by children.

To determine whether this tangled hierarchy of adaptation can answer the *why* and *how* questions, linguistics may well need ALife. This is the “weak” ALife position: that language can be modelled using ALife. Conversely, there is a “strong” position too. It might eventually prove interesting to consider language itself as alive (a non-obligate symbiont; Christiansen 1994), and that it could be possible to create a genuine language *in silico* (Steels 2001).

5. The View from History: Cybernetics

5.1 Philip Husbands

From September 1949 to July 1953 a select dining club met regularly to discuss ideas and issues relating to cybernetics. The Ratio Club, as the group became known after the second meeting, usually gathered in a room in the National Hospital, London, where, after a meal and drinks, participants "… would turn in their easy chairs towards a blackboard where someone would open a discussion …" (Bates 1949). The club was founded and organized by John Bates, a physiologist at the National Hospital. The other twenty carefully selected members were a mixed group of mainly young physiologists, engineers and mathematicians. Only "those who had Wiener's ideas before Wiener's [1948] book appeared" (Bates 1949) qualified for membership. In order to avoid restricting open discussion, no one of professorial rank could join and if any members should be promoted to that level, a club rule stated that they must resign (Bates, unpublished papers). There are two things that make the club truly extraordinary from an historical perspective. The first is the fact that many of its members went on to become extremely prominent scientists. The second is the important influence that the club meetings, particularly the earlier ones, had on the development of the scientific contributions many of that remarkable group would later make.

Space restrictions preclude a full description of the achievements of the whole group. Instead, very brief outlines of those of a somewhat arbitrarily chosen subset are given below.

Alan Turing is universally regarded as one of the fathers of both computer science and artificial intelligence (AI). He also anticipated some of the central ideas and methodologies of ALife and Nouvelle AI by half a century – for instance, he proposed artificial evolutionary approaches to AI in 1950 (Turing 1950) and published work on reaction-diffusion models of the chemical origins of biological form in 1952 (Turing 1952). **Horace Barlow** is an enormously influential neuroscientist, particularly in the field of vision, and was one of the pioneers of using information-theoretic ideas to understand neural mechanisms (Barlow 1953, 1972, 1989). **Grey Walter** made crucial contributions to the technology of EEG recordings, to ideas in pattern recognition, and of course built his autonomous turtles to study mechanisms underlying the generation of adaptive behaviour (Walter 1950). **W. Ross Ashby** formulated theoretical frameworks for understanding adaptive behaviour which are experiencing something of a renaissance in ALife and modern AI (Ashby 1952, 1958). Among many other achievements in a variety of scientific fields, **Thomas Gold** was a co-author of the steady-state theory of the universe and founded the Cornell Astrophysics department. **Jack Good** became a very prominent statistician making important contributions in Bayesian methods. **Eliot Slater** became an influential psychologist, while **Albert Uttley** and **Donald Mackay** were, among many other things, artificial neural network and machine learning pioneers (Uttley 1959, Mackay 1956). **D.A. Sholl** did classic work on neuron morphologies and **P. Merton** made very important contributions to single neuron recording techniques and servo theories of muscular control.

Club meetings were typically informal affairs with one or two presentations followed by open and lively discussion. Topics ranged from members educating their colleagues on the latest ideas in e.g. probability theory or information theory, to debates on the scientific status of telepathy. However, most meetings centred around one of the research pre-occupations of that night's main speaker. Meetings included: Ashby on statistical machinery; Turing on educating a digital computer; Walter on adaptive behaviour; Uttley, Mackay and Barlow on pattern recognition; Turing on morphogenesis; and Merton on the servo control of muscular movements (Bates, unpublished papers).

The Ratio Club was a very fruitful interdisciplinary activity resulting in the highly productive movement of tools and ideas across traditional discipline boundaries, influencing the subsequent scientific trajectories of many members (Barlow, personal communication). A high proportion of the group had previously known each other at Cambridge University and most had been involved in war-time scientific work which forced them to think about issues, e.g. in gun control or code cracking, that would not normally have engaged them. This seems to have led to a strong desire to explore interdisciplinary approaches, as many had begun to see their potential during this war-time work. However, the vast majority of members still saw themselves as primarily physiologists or engineers or mathematicians or physicists. With the possible exception of Ashby, there does not appear to have been any significant will to start a movement or forge a new academic discipline. Of course, strong arguments can be made for the view that new disciplines, such as control theory, computer science and AI, did later emerge from the kind of work that many members, such as Mackay, Turing and Uttley, pursued. But this was not the underlying motivation of the Ratio Club.

It is worth reflecting today on whether ALife is, or should be, an identifiable discipline or a loose support structure to encourage interdisciplinary collaborations and exchanges. We should avoid the unfortunate image some biologists had a few years ago of ALife researchers: that of a group of meddlers regarding themselves as a crack team of scientific trouble shooters, armed only with lap-top computers and naïve enthusiasm, ready to solve the fundamental problems of biology before moving on to the next mission. The most fruitful roles, both scientifically and strategically, will mostly be cross-discipline collaborations and the absorption of tools and methodologies into existing disciplines where they can be used from a position of authority – just as it was half a century ago.

5.2 Ezequiel Di Paolo

Whilst those involved in the Ratio Club found little reason to consider themselves as spearheading the development of a novel discipline, parallel currents in the American scene sought the definition of a new interdisciplinary identity. The cybernetic movement developed through a series of meetings from 1946 to 1953 bringing together engineers, mathematicians, neuroscientists, psychologists, and social scientists. Well-known for its contributions to the development of control theory, communication engineering, and operations research, cybernetics was short-lived as a movement, giving rise to the offspring disciplines of AI and cognitive science (as well as the less conspicuous second-order cybernetics). This genealogical relation is well argued for by Dupuy's study of the history of ideas leading to the sciences of cognition in the second half of the twentieth century (Dupuy 2000).

In the current context, it is interesting to mention the relation of cybernetics to other relevant disciplines also preoccupied with the study of the brain and the mind. Cybernetics' main tenet was that the mind was a manifestation of physics and was susceptible to being studied by the methods of physics. Against the backdrop of the logical revolution of the 1930s, the brain was conceived as a logical machine. The key model embodying these ideas was McCulloch and Pitts' (1943) idealisation of neural circuits in which neurons played the role of digital gates. The idea saw little support from neurophysiologists and Gestalt psychologists, mainly because its reductive atomism was not justified empirically. Further developments of the model served only partially to respond to these criticisms. Cyberneticians were accused of infatuation with their own creations. The very concept of a model started to reveal the ambiguity in the everyday use of the word: a model as the imitation of something else, a model as something to be imitated. Models turned into legitimate objects of study – goals rather than means. This ambiguity, and its pitfalls, did not disappear with AI or with ALife. However, it never caught on so strongly in other disciplines. Models in science are mostly seen as tools for understanding – they are limited in scope, austere, and pragmatic. It is here that ALife mostly resembles its ancestors, in the confusion between simulations and instantiations; and it is here that it must tread most carefully if it is not to repeat the mistakes of the past.

Non-parallels also must be noticed. Cybernetics contributed key concepts to other fields, whereas ALife is, for the moment, most likely to contribute innovative methods such as evolutionary simulation modelling. The technical power behind cybernetics is dwarfed by today's computing resources. Cybernetics was the meeting point of researchers trained in very different disciplines. Although, to a limited extent, this last point is also true of ALife, the overwhelming majority of ALife practitioners can claim a background in, or an affiliation with, computer science.

Which model should ALife follow? A flag of convenience as the Ratio Club? A banner for the fruitful exploration of ideas? Or, as early cybernetics, a discipline meant to do the job of other disciplines, only with a different, more abstract approach? If the second alternative is chosen, then we must seriously contemplate its difficulties, and we must take a close look at cybernetics and its failure at engaging in a productive dialogue with relevant fields. Collaborations with willing biologists may be the way forward to resolve these problems, but where does this leave the identity of the discipline? Overall, the flag of convenience alternative looks more realistic and possibly more productive. ALife may turn out to be short-lived and badly remembered, but it can aspire to have provided the space for the development of methods and ideas that, at least during our time, may have been hard to develop anywhere else. The job done, the results should be reaped by other disciplines. As of now, it is not even clear which model ALife is trying to follow. Clarifying this question is the next logical step.

6. Reactions

Once targeted explicitly by the cybernetics speakers, questions concerning the status and the future of ALife as a discipline (which in truth had been bubbling away just under the surface ever since the philosophy session) became the principal focus of the workshop. During the final, open discussion session, many participants (perhaps surprisingly) endorsed versions of the view that ALife is not a unified intellectual endeavour with a well-defined explanatory space all of its own. Rather, ALife is (something like) a liberating intellectual environment, an academic context within which new or under-explored techniques and ideas for exploring the phenomena of life can be clarified and developed. Often, these are techniques and ideas which are marginalised within the more traditional life-related disciplines such as biology, neuroscience, or AI.

On the basis of this kind of assessment, some participants drew the following, radical conclusions: (a) ALife enjoys a rather precarious position as a scientific endeavour; (b) ALife should use the intellectual freedom provided by the field to refine its techniques and ideas, at which point the appropriate thing to do would be to dissolve into the more traditional disciplines (biology, neuroscience, AI, linguistics, economics, philosophy etc.). It should be noted, however, that this critical re-thinking of the place of ALife on the scientific map was not universally accepted. For example, Bedau, in his presentation (see section 2.1 above), had already argued that ALife can enable other disciplines to pursue new research directions. In debate, other dissenters argued that the integrity of ALife as a discipline flows precisely from, and crucially will be maintained by, the fact that it has developed, and (one hopes) will continue to develop, new investigative and explanatory tools that are potentially of use to other disciplines. Yet other participants argued that the integrity of ALife may be secured by the strong ALife programme, which claims not merely to study, in distinctive ways, life-related phenomena that are already within the explanatory remits of other disciplines, but also to create novel phenomena of life. Of course, one will be tempted by this final position only if one endorses strong ALife.

Despite these clear differences of opinion, most participants in the debates agreed that cross-disciplinary interactions, and better still joint initiatives between ALifers and researchers from adjacent disciplines, are likely to represent the most promising strategies for ALifers to adopt. The discussion undoubtedly fostered an increased sensitivity to the necessity of cross-disciplinary work, and to the massive opportunities that it presents, but also to the problems that it faces. In particular, it was noted that such work is neither easy to launch nor easy to sustain, given the undermining effects of conceptual misunderstandings, clashes of practice, and unhelpful institutional divisions between disciplines. Thus the existence of genuinely cross-disciplinary collaboration, let alone its success, is far from inevitable.

Although the status and the likely future of ALife was the issue that commanded most of the discussion time, it was certainly not the only matter placed under the spotlight. For example, the question of whether or not it is correct and/or useful to interpret ALife models as thought experiments was pursued in the discussion period of the philosophy session, and clearly remains an open question of some importance to the community. Similarly, Bullock’s claim that ALife needs well-understood, orthodox presentation methods that encourage clarity and understanding was taken up at some length in the biology session. Of course, these more specific issues are far from orthogonal to what we have isolated as the dominant theme. Space prevents us from mentioning a number of other such questions which were explored.

We believe that the ‘View from Elsewhere’ workshop was a notable success in providing a platform and some direction for important debates which will no doubt be continued in new forms and new contexts at future ALife conferences. We hope that this paper is not only a faithful record many of the ideas that were expressed in Prague on 9th September 2001, but also a point of departure for those future deliberations and disputes. Next stop: ALife VIII.

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