The Contribution of Society to the Construction of Individual Intelligence

Bruce Edmonds[*] and Kerstin Dautenhahn[†]

[*]Centre for Policy Modelling, Manchester Metropolitan University.

http://www.cpm.mmu.ac.uk/~bruce

[†]Department of Cybernetics,University of Reading.

http://www.cyber.rdg.ac.uk/people/kd/WWW/home.html

Abstract

It is argued that society is a crucial factor in the construction of individual intelligence. In other words that it is important that intelligence is *socially* situated in an analogous way to the physical situation of robots. Evidence that this may be the case is taken from developmental linguistics, the social intelligence hypothesis, the complexity of society, the need for self-reflection and autism. The consequences for the development of artificial social agents is briefly considered. Finally some challenges for research into socially situated intelligence are highlighted.

Keywords: society, intelligence, language, reflection, evolution, development

1 Introduction

Several studies of how individual intelligences can interact to allow the emergence of social structures exist. The field of Artificial Life teems with computational models composed of interacting units where it is claimed that even a modicum of 'intelligence' (in the form of some computational capacity) can result in the emergence of phenomena more usually attributed to societies. These studies are focused on the basic model that interacting units cause society. In the following we refer to this as 'approach A'.

What is rarer (especially outside the domains of sociology and linguistics) are investigations into the possibility that society is a causal factor in the emergence of individual intelligence in the individuals it is composed of (approach B).

To researchers accustomed to thinking along approach A, this may seem a little strange: for society is obviously physically composed of individuals and not the other way around. However in one supremely important respect the matter is already all but settled: humans need other humans to interact with if they are to acquire a fully functional language, and they need a fully functional language to realise much of their potential intelligence[1]. The lack of a fully functional language does not only limit an individual's social intelligence, but it also limits that individual's general

[1] ·A fully functional language includes, of course, creoles, sign-languages etc. which are languages in the full sense of the word, but sometimes ignored.

problem-solving ability, for example, it is inconceivable that a human without mastery of a sophisticated language could perform abstract mathematics[2].

This paper examines possibility B. Section 2 examines the analogy with the discovery of the importance of the physical situation in robotics. Section 3 looks at some reasons why we would expect that the social situation might be critical for the development of individual (human) intelligence. Section 4 discusses some of the consequences for the development of artificial social agents if this does turn out to be the case and section 5concludes with a plea for more research on this topic.

2 The physical situation compared to the social situation

When Brooks [8] made his now famous critique of AI (as it was then) he was specifically addressing shortcomings with respect to the problem of getting robots to master a physical environment. This spawned a whole field of research based on the premise that the physical situation was critically important in the design of agents (and in particular robots).

Three critical aspects of being 'physically situated' are listed below, each has an analog for the social situation.

1. Frequent probing and sensing – that the agent uses the frequent probing and sensing of its environment to determine its states and processes rather than attempting to use explicit models and inferential processes to predict these.

The frequent probing and sampling of the social environment of a human is called 'gossip'. On the whole we do not try and predict the details of our social environment, instead we trade information about it as frequently as we can.

2. Goal directed, interactive learning – that much learning occurs in a practical interactive way in the pursuit of some specific goal rather than trying to discover general truths in a passive deductive way.

The methodology of Embodied Artificial Intelligence (EAI) approach which has influenced research into robotics and adaptive systems has according to Erich Prem [36] a number of implications for cognitive science: "Cognition is a timely process driven by forces internal and external to the system, cognition happens in close interaction with the world, often in order to manipulate the world." [36]. If we replace 'world' by 'social world' then Prem's citation relates nicely to our notion of socially situated intelligence. For an embodied agent situatedness in the world matters, as for a social agent situatedness in the social world matters. A stronger claim, for which evidence is increasing but not yet sufficient, is that human intelligence (e.g. problem-solving abilities) has evolved in evolutionary terms literally as a side-effect of social intelligence (cf. our discussion on autism and the social intelligence hypothesis in this paper). Thus, research into socially situated intelligent, e.g. studying simulation models of human interactions/societies, or building embodied artifacts like robots, can provide valuable input to this discussion. We almost never learn about our social environment in a passive, detached way but through constant interaction with it in order to achieve our social (and other) goals.

[2] ·Of course, abstract mathematics is usually a highly social activity, but this only reinforces the point that it is difficult to imagine any sophisticated human behaviour that is not socially grounded or embedded in some way.

See our discussion on the social intelligence hypothesis in section 3.2 and autism in section 3.5.

3. Specific adaptions – many adaptions in a successful situated agent are very specific to the particular environment the agent occupies, exploiting its features for efficiency and effectiveness.

Humans have many adaptions that are considered as specifically social in their utility. These include: our linguistic ability; the whites of our eyes; our ability to recognise individual faces; our enjoyment of gossip; our elaborated sexuality; the expressiveness of our faces in displaying emotions; our ability to empathise with others; and our apparent predisposition towards accepting norms and cooperation. Thus humans are socially situated, if anything is. This does not necessarily mean that any of their features rely on this situation for its effective functioning. It may be the case that some aspects are somehow abstracted (or abstractable) from this particular situation to hold more generally. If this were the case and the abstraction preserved the feasibility then one might be able to ignore the situation and model the agent without it. On the face of it this would seem unlikely – surely the burden of proof must rest with those who would try such a task.

3 Why one might expect the social situation to matter

Below we outline some arguments as to why one would expect the social situation to be important for the development of an individual's intelligence.

3.1 Language

As mentioned above, language is important for individual intelligence and language is a social construct. This means that society is critical in the development of individual intelligence unless: either language (once constructed) could be learnt as a entirely abstract and passive way without social interaction or that it might be possible to acquire a language that is not socially constructed in origin.

The first seems unlikely to be the case, at least for humans. Humans learn language in a different way as a child than later, and in fact use different areas of the brain. It seems that a first, full language with all its power can only learnt by a young child, and it is unlikely that such a child would be able to learn a language in an abstract and passive way.

The possibility of the second (an non-socially constructed language) is almost impossible to judge, because we are the only example of language users and all our (full) languages are socially constructed. It is notable that languages that are artificially devised (i.e. less socially constructed) are not as expressive or useful as full languages – on exposure to such artificial languages children seem to immediately change these into fully expressive languages in one generation as a result of their innate linguistic ability and the way they interactively acquire them (examples are the development of sign language in Nicaraguan from an artificial creation and creole languages from pidgins [38]).

It must be concluded that, although the last word is not in (so to speak), that language is an inherently social construct. In a related question, the possibility of private languages, there are strong arguments to say that a language cannot be private [44].

3.2 The co-evolution of human intelligence and social cooperation

The social intelligence or "Machiavellian intelligence" hypothesis (for a recent discussion see [28]) put forward the view that substantial aspects of our intelligence evolved because its possession conferred social advantage. The idea is that our extensive intelligence is primarily evolved in order to keep our place in the social order and to manage the intricate cooperation and competition that this involves.

If this is indeed the case (and it would be very odd if none of our intelligent capacity has been shaped by evolutionary pressures that are socially grounded), and given the intricacy of our present society (which presupposes the possession of individual intelligence) then it seems likely that our intelligence and our society have co-evolved. If this is the case then one would expect that many aspects of our intelligence have evolved to 'fit in' with our society (and vice versa).

It is certainly difficult to argue from single cases, but the fact that the only species to evolve a sophisticated intelligence has also evolved a sophisticated society cannot be totally ignored.

3.3 The richness of society as an informational and computational resource

One aspect of a society of roughly commensurate social agents which is almost inevitable, is that it will quickly develop so as to be more complex than any single agent can completely model. This is especially true of a society where there is sometimes advantage in 'out-guessing' the actions of the other agents, in which case a sort of modelling 'arms-race' quickly develops which in its turn makes the prediction and comprehension of the society even more difficult.

In such a complex entity it would be strange if it did not offer some informational and computational resources to some agents for certain aspects for some of the time. Given this availability it would also be odd if these resources were not exploitable by the composite agents. Hence one would expect agents that were situated in such a society to evolve ways of exploiting such social resources.

If this were the case, then we would expect that we would possess some faculties usually attributed to our 'intelligence' that were evolved to use such resources and save ourselves (individually) considerable expenditure in terms of time and effort.

3.4 The need for social reflection in the development of the self

The role of the 'self' in intelligence and consciousness is a hotly disputed one. Some philosophers see all usage of "I", "myself" and similar utterances as merely a linguistic device with no real referent[3]. Others see the self as a real entity but as one whose essence is not usefully expressible from an exterior perspective[4].

What is clearer is that: some form of self-modelling is a crucial part of the machinery of our social intelligence; this ability to model ourselves and others develops, at least partly, as the result of a learning process; this learning process requires some reflective mechanisms to occur; and that the reflection that occurs via social, linguistic mechanisms is by far the most expressive and effective that is presently

[3] For example: Anscombe, G.E.M. (1981). The First Person. In *her Metaphysics and the Philosophy of Mind, Collected Papers* Vol. II. Oxford: Blackwell, 21-36 or more recently Pears, D. (1996). Wittgenstein's Criticism of Cartesianism. *Synthese*, 106:49-55.

[4] See the collection at URL: http://www.zynet.co.uk/imprint/hardprob.html

available to us. In this way a reflective social environment to interact with is not only essential via language to symbolic thought but also to the development of the self.

The processes by which the self comes into existence and its relation to social reflection is unclear, but [42] makes a first cut at it and [6] examines the philosophical arguments.

3.5 Autism

Since the early 40ies of this century autism is known as a syndrome which involves, among other features, the striking lack of social competence. A variety of explanations have been discussed, among them the widely discussed 'theory of mind' model which is conceiving autism as a cognitive disorder [1], and, a more recent explanation given by Hendriks-Jansen [25]. He hypothesises as the primary cause early developmental disorders which prevent the child and its caretakers to 'get the interaction dynamics right' which normally scaffold the development of appropriate social interactions in the sense of situated dialogues between infant and caretaker.

The importance of interaction dynamics are also part of the explanation given in [15] which suggests a lack of empathic processes which prevent the child to develop 'normal' kinds of social action and interaction. Why is it important to discuss potential explanations of the autistic syndrome? People with autism never develop into social beings as we expect of 'normal' people, although some of them show high intelligence in non-social domains, they are never able to communicate and interact properly with other people. They are not able to understand the social world around them, which therefore appears often scary and completely unpredictable to them. This deficit influences their lives to the extend that they often are not able to lead an independent life, in this way clearly demonstrating the central role of sociality in individual intelligence. This gives evidence that the study of socially situated intelligence does not merely provide an important add-on to other faculties of intelligence (like spatial thinking or mathematical reasoning), but that human intelligence (its development and expression) is embedded (and embodied) in a social being, and can in this way not be separated from non-social kinds of intelligence.

4 Consequences for the development of artificial social agents

If the above is the case and important aspects of our social intelligence require to be socially situated for their complete development, then this has consequences for programmers who are trying to construct or model such agents. Generally such a process of construction happens separately from the social situation that the agents are to inhabit – the programmer has a goal or specification in mind, tries to implement the agent to meet these and later the agents are situated so as to interact with others.

Whether this is possible to do depends on the extent to which the aspects of its intelligence are practically abstractable to a model which is analysable into two (essentially) unitary parts: the agent and its environment. If this can be done then one can indeed design the agent with this environment in mind. In this case the social environment is effectively modellable from the agent's point of view.

If this sort of process is impractical (e.g. all the interactions in the social environment actually matter to the agent) this corresponds to a situation in which the agent is socially embedded (see section 5.5). Here the agent cannot model its social environment as a whole and thus is forced to evolve heuristics based on the individuals it knows about in that enivronment. Some of these heristics are listed below.

There are a number of possible responses to inhabiting such a social environment, including:

- Developing ways of structuring relationships to make them more reliable/predictable, e.g. contracts and friendship networks;
- Developing constraints on normal social behaviour via social norms and enforceable laws [5];
- Developing institutions and groupings that act to ‘filter out’ the complexity of the exterior social environment [2];
- To try and indentify good sources of information and opinion and rely on these as a basis for decision making;
- To imitate those agents who many others imitate;
- To frequently sample the social environnment via ‘gossip’;
- and, finally, to develop ones heuristics over time from within the relevant society and so avoid having to infer them later.

In practice many models of socially interacting agents take one (or a limited selection of) these heuristics as the basis for their agents. This is fine as long as one does not then make the false step of defining a social agent on the basis of one such heuristic. It is likely that intelligent and creative social agents that co-evolve within a society of other such agent that are individually recognisable will develop a many separate and different heuristics [18]. The heuristics are merely a result of being such an agent in such an environment. This leads us to believe that a bottom-up[5] (or constructivist [17, 19, 22, 37, 40]) approach may be more profitable to a top-down a priori approach.

5 Challenges in SSI research

This section outlines a few research topics which we consider important to SSI research and which have in our view not yet gained as much attention as they deserve in the current research landscape. The list is not meant to be complete.

5.1 Culturally Situated Agents

The intelligent agents community which consists of people building software or hardware agents, or modelling societies of agents which show certain (social) intelligence, has so far not paid much attention to the issue that all technological products reflect the culture from which they originate. In the following we like to consider autonomous agents, following the definition given by Franklin and Graesser [21]: “An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future”. Currently, a paradigm shift from algorithms to interaction is acknowledged, see [41] which argues that recent technology is more than a continued development of more and more powerful rule-based Turing machines based on the closed-system metaphor. Instead, interactive

[5] ·This is attempted in [13].

systems, interaction machines which are inherently open systems are supposed to be the computational paradigm of the future. The shift of attention from algorithms to interaction also indicates a shift in beliefs, from the belief to discover and implement a universally intelligent, and general purpose machine towards an interactive machine, i.e. an agent which is not intelligent by itself by only behaves intelligently during interaction with other agents of the same or different kind, e.g. which interact with humans.Thus, the (social) context strongly matters, and in the case of interactions with humans such a socially situated agent which is used in different countries and communities also has to be a culturally situated agent [34] and a PRICAI98 workshop which addresses this topic[6]. We cannot expect that agents, both natural and artificial, behave identically in different social and cultural contexts. Thus, design and evaluation of agents could benefit from considering these issues.

5.2 Imitation and the 'like-me' test

A workshop at the latest Autonomous Agents AA'98 conference characterized imitation as follows: "Imitation is supposed to be among the least common and most complex forms of animal learning". It is found in highly socially living species which show, from a human observer point of view, 'intelligent' behaviour and signs for the evolution of traditions and culture. There is strong evidence for imitation in certain primates (humans and chimpanzees), cetaceans (whales and dolphins) and specific birds like parrots. Recently, imitation has begun to be studied in domains dealing with such non-natural agents as robots, as a tool for easing the programming of complex tasks or endowing groups of robots with the ability to share skills without the intervention of a programmer. Imitation plays an important role in the more general context of interaction and collaboration between agents and humans,e.g. between software agents and human users. Intelligent software agents need to get to know their users in order to assist them and do their work on behalf of humans. Imitation is therefore a means of establishing a 'social relationship' and learning about the actions of the user, in order include them into the agent's own behavioural repertoire[7].

Imitation is on the one hand considered an efficient mechanism of social learning, on the other hand experiments in developmental psychology suggest that infants use imitation to get to know persons, possibly applying a 'like-me' test ('persons are objects which I can imitate and which imitate me'), see discussion in [14]. Imitation (e.g. as social reinforcement techniques or programming by demonstration setups in robotics and machine learning) has been used primarily by focusing on the 'technological' dimension (e.g. imitation providing the context of learning sequences of action), and disregarded the social function of imitation.Additionally, the split between imitation research in natural sciences and the sciences of the artificial are difficult to bridge, we are far from a common research framework supporting an interdisciplinary approach toward simulation, cf. [33] for an attempt to provide a mathematical framework to facilitate analysis and evaluation of imitation research. With an embodied system inhabiting a non-trivial environment imitation addresses all major AI problems from perception-action coupling, body-schemata, recognition and matching of movements, reactive and cognitive aspects of imitation, the development

[6] ·http://www.nttmsc.com.my/kido/pricai98cfp.html

[7] ·http://www.cis.udel.edu/~agents98/workshops/interaction.html

of sociality, or the notion of 'self', just to mention a few issues. Imitation involves at least two agents sharing a context, allowing one agent to learn from the other. The exchange of skills, knowledge, and experience between natural agents cannot be done by brain-to-brain communication in the way how computers can communicate via the internet, it its mediated via the body, the environment, the verbal or non-verbal expression or body language of the 'sender', which in return has to be interpreted and integrated in the 'listener's' own understanding and behavioural repertoire. And, as imitation games between babies and parents show, the metaphor of 'sender' and 'receiver' is deceptive, since the game emerges from the engagement of both agents in the interaction (see notions of situated activity and interactive emergence in [24].

5.3 New Trends in Social Robotics: From sorting ants to soccer playing robots

In [9] Rodney Brooks gives a 'historical' overview on the shift of viewpoint from classical to behaviour-based robotics. Brooks was one of the strongest proponents of this shift of viewpoint or paradigm. Linked to the availability of simple and relatively inexpensive robots the new paradigm allowed to study robot group behaviour, instead of the classical approach which often focused on one monolithic system. A decade of research along the behaviour-oriented and artificial life approach has resulted in a number of impressive experiments demonstrating the emergence of group behaviour based on the interaction of simple robots performing simple behaviours, see [30] for an overview. For much of this work insect-like, in particular ant-like behaviour has been implicitly or explicitly served as a biological model. However, there are limits to the behavioural complexity one can achieve with this approach when trying to go beyond wall-following, flocking, herding, collective sorting, etc. In [9] again Rodney Brooks gives a strong push towards the direction of cognitive robotics. Rather than insects, mammals or even humans become popular models. Issues like memory and history, see [16] and [31] are among the currently investigated issues.

Recently a particular 'application domain' has gained a lot of attention in the autonomous agents community, namely the RoboCup[8] (see [27]). Teams of software and robotic agents join a competition and have to cope with real world constraints (e.g. noise) and limited resources (e.g. time constraints). Imitating human soccer playing is the target, and therefore cognitive aspects like individual roles, strategies, teamwork and cooperation (see [39]) have to be combined with the well-known low level behaviours like target following or obstacles avoidance. Thus, for those who cannot effort to buy or build a humanoid robot, the RoboCup challenge allows to tackle cognitive robotics on the team level! Additionally, modelling human soccer playing with autonomous robots (or software agents) opens the field of autonomous agents towards other fields like computational organisation theory (see an attempt towards a symbiosis of both in [32]).

5.4 Effective Heuristics for Socially Embedded Agents

An agent is socially embedded if it is not practical to model its society as a unitary environment. If this is the case (i.e. there are not easy and effective simplifying assumptions it can make) then it is confronted with a situation where it is forced to pay attention to the other agents and their interactions individually but where it is

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[8] ·http://www.robocup.org/

very unlikely that it will be possible to model all these relevant important aspects. This definition and its ramifications is presented in [19].

If such an agent is to succeed (and it is endowed with some open-ended and creative learning abilities as discussed in [18]) then it will be advantageous for it to develop a series of heuristics. Some suggestions for these are listed in section 4. Of course, the modelling problem is not much easier for the research seeking a handle on the complexity of the interactions of the agents. The relationship between the effectiveness of possible heuristics and effective ways of modelling and analysing societies of agents is perhaps the hub of the problems facing researchers in this field. There are several ways of posing the questions, including:

- When are certain simplifying assumptions (for example in economics, agent negotiation protocols etc.) unjustified? In other words when is one forced to abandon such tractable approaches?[9]
- Given a certain society of such agents, what are the profitable ways of analysing and modelling it? Memetics modelling approaches is one such way that has arisen [26].
- Given a certain society of such agents, what might be the heuristics that may be useful to an agent that inhabits them? Norm adaptation may be one [5].
- Given a class of heuristics that agents may use, what are the sorts of societies that may result from them? An example of such a bottom-up approach is [13].

Each of these is a different way of effectively reducing the overall problem that in some situations the society and the heuristics used by the agent co-evolve. This is a very difficulty case to examine, but also the most interesting. It will involve questions like:

- What are the *processes* whereby behaviour patterns emerge in such a co-developing situation?
- What are their life-cycles?
- How are they perpetuated?

We suspect that in order to approach such questions we will have no choice but to adopt a more constructivist and less analytical approach, perhaps corresponding to a move away from a paradigm of physics as way of working and moving towards the paradigm of biology. A lot of field work will have to be done.

5.5 Modelling Social Modelling

Biology rests on a very large body of observational fieldwork. This is available as a huge resource for the inspiration and verification of biological models and theories. However the "flowering" of the field that we have witnessed in the last half of this century only occurred when the some of the basic chemistry underlying biological processes had been sorted out. This body of bio-chemistry constrains and validates biological models. If we are to succeed in making sense of societies of agents and their processes we may have to undertake a similar project to provide the underpinning of our models.

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[9] I think the reader will be able to guess my opinion of the applicability of such modelling approaches for most collections of agents that have effective learning abilities.

One of requisite foundational projects that will need to be done is the development of a set of models of how individuals *actually* model others and themselves. This is also a complex area but a start has been made in the area of imitation (see section 5.2 and papers [4, 15]) and evidence of what can occur in the absence of social modelling ability may be gleaned from cases of autism (section 3.5).

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