The Lemur's Tale - Story-Telling in Primates and Other Socially Intelligent Agents

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Abstract

This paper addresses the relationship between social intelligence and narrative intelligence, with a particular emphasis on 1) the phylogenetic origins of primate (narrative) intelligence, and 2) the ontogenetic origin of autobiographical stories. The 'Narrative Intelligence Hypothesis' (NIH) is introduced according to which the evolutionary origin of stories and narrativity was correlated with increasing social dynamics in primate societies, in particular the need to communicate about third-party relationships. Requirements for artificial socially intelligent story-tellers are outlined, and the issue of testing social intelligence is discussed.

Complexity of Primate Societies

Many researchers in primatology have contributed to the *Social Intelligence Hypothesis* (SIH), sometimes also called *Machiavellian Intelligence Hypothesis* (Byrne & Whiten 1988), according to which social dynamics were among the crucial selective pressures which have driven the evolution of primate intelligence. Identifying friends and allies, predicting others' behaviour, knowing how to form alliances, manipulating group members, making war, love and peace, are important ingredients of primate politics (de Waal 1982), and differences between social complexity in human societies and non-human primate societies appear to be relatively small.

How can we characterize social complexity? According to (Philips & Austad 1996) complexity is a function of: 1) the number of functionally distinct elements (parts, jobs, roles), 2) the number of ways in which these elements can interact to perpetuate the system or to promote its goals (or, if it is an artifact, the goals of its users), 3) the number of different elements (parts, jobs, roles) any individual within the system can assume at different times or at a given time, and 4) the capacity of the system to transform itself to meet new contingencies (i.e. the capacity of the system to produce new elements or new relations between elements).

Conditions 1 and 2 can be applied to many systems from machines to languages. Conditions 3 and 4 are particularly suited to social organization.

Item 1 in the list above addresses important issues of group size. According to Dunbar (Dunbar 1993) group-size is a function of relative neocortical volume in nonhuman primates. In human societies 150 appears to be the upper group size limit which still allows social contacts that can be regularly maintained, allowing effective coordination of tasks and information-flow via direct person-to-person contacts. Such a figure derived from the analysis of historical as well as contemporary human societies. Dunbar suggests that 1) there is a cognitive limit to the number of individuals with whom any one person can maintain stable relationships (depending on personal knowledge, face-to-face interactions), 2) that this limit is a direct function of relative neocortex size, and 3) that this in turn limits group size. Dunbar proposes that in order to preserve stability and coherence human language has provided an efficient means of social bonding, which is provided in non-human primate societies by direct physical contact during social grooming (allowing only much smaller groups). Following this argument, language allowed an increase in group size while still preserving stability and cohesion within the group.

Thus, a primary role of language might have been to communicate about social issues, to get to know other group members, to synchronize group behavior. Language is based on representations and the possibility to combine them in arbitrary ways. Representations need not be 'symbols', they can be spatial or visual in nature, and can be verbal or nonverbal. Although apes can be trained to use keyboards or a subset of American Sign Language in order to communicate with humans, they have not developed such representational systems in the wild. Gorillas do not extensively sign to each other, neither do they draw figures in the sand. Obviously there has not been a selective advantage for them in developing representational systems. As Oliphant (Oliphant 1999) points out, a representational system which can learn 'word-meaning' associations need not be computationally very expensive. Brainsize can therefore not be responsible for the fact that humans use representational systems and chimpanzees in the wild do not. However, the form of language as such is meaningless, it requires the cognitive effort to give meaning and to put messages in context. The ability to construct and give meaning to representations *is* a 'computationally' expensive process, e.g. it requires identification and interpretation of the context of the communicative event, such as the 'personality' of the sender (is he trustworthy?), the relationship between 'sender' and 'recipient' of a message (potential mate?), important third-party relationships, positions in the group hierarchy etc. Thus, one and the same 'message' can have potentially many different interpretations and 'meanings', depending on the complexity of the primate social field (discussed below), the number of different roles an individual can have, and the potential to create new roles and relationships.

Although humans use gestures, 'body language' and other non-verbal means to convey (social) meaning, human communication is dominated by verbal communication which is serial in nature. Thus, given the serial communication channel of human language, what is the best means to communicate social issues, namely learning about the who, what, and why? Physical grooming, the main group cohesion mechanism in non-human primates is 'holistic', parallel, spatial, sensual. How can a stream of words convey meaning such as bodily grooming does? Narrative structure seems to be particularly suited: usually a narrative is giving a certain introduction of the characters (making contact between individuals, actors, listener and speaker), develops a plot, namely a sequence of actions that convey meaning (value, pleasurable, unpleasurable), usually with a high point and a resolution (reinforcement or break-up of relationships), and focuses on 'unusual' events rather than stereotypical events. In this way, stories seem to give language a structure which resembles (and goes beyond) physical grooming, namely replacing physical presence and actions by the creation of a mental picture of physical actions, providing the stage, actors, intentions and a storyline. Thus, both story-telling and grooming are social bonding mechanisms, and humans use language extensively to discuss social matters. According to Dunbar (1993) people spend about 60 percent of conversations on gossiping about relationships and personal experiences. Humans use language to learn about other people and third-party relationships, to manipulate people, to bond with people, to break-up or reinforce relationships.

Narrativity, the capacity to communicate in terms of stories is therefore regarded an efficient means to communicate social matters, and the origin of narratives might therefore have been a crucial milestone in the evolution of primate social intelligence (Read & Miller 1995). According to what we call the 'Narrative Intelligence Hypothesis' (NIH) the evolutionary origin of stories and narrativity was correlated with increasing social dynamics in primate societies, in particular the need to communicate about third-party relationships. In the following sections we analyze the primate social field, and in more depth social understanding and the role of narrative in autobiography.

Evidence suggests that the evolution of the human story-telling mind was strongly correlated with the evolution of complex mechanisms of social understanding and a complex social field. This suggests that if we intend to develop a socially intelligent agent (Dautenhahn 1998) which can truly understand and respond to stories in human-agent interaction then we need to model at least to a certain extend social relationships and primate social life.

The Primate Social Field

The primate family tree split up about forty million years ago into prosimians which might resemble early arboreal primates (e.g. lemurs), and anthropoids (monkeys, apes, incl. humans). The problems of social life are especially complex for species whose cognitive skills create a complex 'social field' which is based on several fundamental components:

1) Individuals specifically recognize other individuals in their groups. Primate societies are 'individualized societies'. It is thought that many mammalian species are able to recognize individual group mates and remember past interactions with them but it is not established whether they understand third party relationships, which would seem to be a skill only possessed by primates. Two separate mechanisms have been proposed for kin-recognition: early familiarity (i.e. previous experience with individuals in question) and phenotypic matching (using visual or non-visual cues). Generally it is assumed that kin recognition in primates depends on previous experience. However, chimpanzees have been shown to match related but unknown individuals by visual cues, in the same way as humans can match persons in a family album. In the wild, chimpanzees form loosely organized fission-fusion communities where even closely related individuals spend considerable time apart. Under such conditions phenotypic kin recognition could be greatly advantageous. As Parr and de Waal showed (Parr & de Waal 1999) chimpanzees can perceive similari-

ties in the faces of related but unfamilar individuals, indicating visual kin recognition at a purely phenotypic level. Their results show that chimpanzees can match very well faces of mothers and their sons, but not mother-daughter pairs. This preference might be due to the particular ecological and social conditions of chimpanzee life.

How individual recognition substantially increases social complexity is shown by the following example described in (Philips & Austad 1996):

> "...imagine a social group composed of six individuals, two unrelated sets of three full siblings. Consider an individual within that group seeking to join two other individuals for the purposes of cooperative hunting. With recognition only of group members versus nongroup members, there is only one recognizable hunting group - himself plus two other group members. If kinship were also recognized, then this individual could discriminate between three kind of groups (two fellow sibs, two nonsibs, one sib and one nonsib). If all group members were individually recognizable, our focal individual could potentially join twenty unique groups.".

Thus, the more individuals can be recognized, the greater the number of social contexts recognized which can potentially lead to different responses and interpretations of communicated signals.

2) Individuals can understand and predict at least part of the behavior of other animals. A variety of behavioral and contextual clues are used to predict another animal's behavior. The human ape is possibly the most social animal of all primates, and shows highly complex social structures and organizations. Elaborate mechanisms of social understanding, including sympathy and empathy (discussed below), a rich body language and facial expressions which are used to express internal states, moods etc. facilitate communication. Humans from a certain age on also attribute mental states to others, they possess a 'theory-of-mind' (Baron-Cohen 1995) and can reason about beliefs, desires, wishes and goals of others. The abilities of humans to get along with each other, despite frequent violent encounters, is remarkable. Imagine one hundred chimpanzees, unfamiliar with each other, crowded in a metro coach. Very soon injuries, even deaths of animals are almost certain to occur. However, millions of (human) commuters survive exactly the same scenario day after day. Surviving in large 'anonymous' groups of people is controlled in human society by a number of norms and regulations. Thus, human cannot only understand and predict individuals, they can apply the same mechanisms to a crowd (as a kind of meta-organism).

3) Individuals remember aspects of previous interactions with group members and so form 'direct relationships' with them. Cognitive processes of learning and memory makes this possible.

4) Individuals remember something of the interactions other group members have with each other, this allows them to understand the social relationships of others, i.e. their 'third-party' relationships. Kinship (based on certain patterns of association rather than on genetics), friendship (based on relatively recent aggressive or affiliative encounters) and dominance rank are all involved in the most important kinds of relationships recognized by primates. For more information on the primate social field see (Tomasello & Call 1997).

In terms of social complexity (and cognitive processes needed to deal with it), the world of an animal which takes into account third party actions is more complex than the world of an animal which only interacts dyadically. The social problems are still greater if an animal takes into account the probable thoughts as well as actions of its partners in interaction (Byrne & Whiten 1997).

Stories, social understanding, and autobiographic agents

Previously we suggested that two mechanisms are important to human social understanding: 1) empathic resonance, the ability to 'open' oneself towards another self, and to re-experience part of the other person's experiences, and 2) biographical reconstruction, the interpretation of another person's behavior and appearance based on the situatedness of another's mind in time and space (Dautenhahn 1997). The behavior and appearance of any biological agent can only be understood with reference to its history, considering its context, past, present and future situations. This is particularly important for life-long learning human agents who are continuously learning about themselves and their environment and are able to modify and their goals and motivations. Autobiographical memory develops during the lifetime of a human being, and the capacity to fully develop an autobiographic is not innate. In Nelson's discussion of the social origins of autobiographical memory in children she supports the 'social interaction hypothesis', namely that children gradually learn the forms of how to talk about memory with others, and thereby learn how to formulate their own memories as narratives (Nelson 1993).

Humans are constantly telling and re-telling stories about themselves and others. Humans are autobiographic agents, agents which are embodied and situated in a particular environment (including other agents), and which dynamically reconstruct their individual 'history' (autobiography) during their lifetimes (Dautenhahn 1996). The biologist Steven Rose uses the term lifelines in order to refer to an living organism's trajectory through time and space which make each organism an 'individual': "..it is in the nature of living systems to be radically indeterminate, to continually construct their - our - own futures, albeit circumstances not of our own choosing" ((Rose 1997), p. 7).

Telling (part of) a plausible autobiographical story to others is more than showing a plausible sequence of episodic events, it includes the construction of a plausible story based on one's goals, intentions and motivations. If we listen to a story originating from a completely different cultural background, then the main problem of understanding is usually not to figure out what the actors do, but why they are doing it, i.e. understanding their goals and intentions. Once we understand the underlying motivations for their behavior it helps us to make the link to similar situations which we, the listeners, experienced ourselves. We then might recall events which are from their appearance completely different, but the meaning these events had to us could be similar, which allows an understanding on a level of similarity which addresses the experiential, rather than cognitive aspects of story understanding.

This creative aspect of story-telling, i.e. to tell autobiographic stories about oneself and biographic reconstructions about other persons, is linked to the empathic, experiential way of relating other persons to oneself. Story-telling is therefore a central mechanism in human social understanding.

The Social Life of *Lemur catta*

To give an example of the social life of a non-human primate: The primate Center at Duke University gives the following information on *Lemur catta*, a prosimian primate unique to Madagascar: "Ring-tailed lemurs are found in social groups of 3 - 25 individuals. Females remain in the group to which they were born for their entire lives, while males may change groups when they reach sexual maturity. Ringtail groups range over a considerable area each day in search of food. All group members use this common home range, and groups are often aggressive towards other groups at the borders of these areas. Females are usually dominant to males, which gives them referential access to food and the choice of whom to mate with. (Female dominance in primates is unique to prosimians.) Social bonds within the group are established and reinforced by grooming. Prosimians groom in a rather unique way, all prosimians (ringtail lemurs included) have six lower teeth that stick straight out from their jaw, forming a comb that the animals use to groom their fur and the fur of other members of their social group." (http://www.duke.edu/web/primate/).

Lemur catta is very popular with many people because these creatures are seen as very gentle and 'friendly' primates. According to Jolly (Jolly 1966) the fact that social lemurs show the usual primate type of society and social learning without the capacity to manipulate objects as monkeys do, might indicate the primacy of social intelligence in the evolution of primate intelligence. Although it is likely that lemurs can interpret a variety of social cues in order to predict others and use body 'language' and social grooming as social cohesion mechanisms (for which humans mainly use language (Dunbar 1993)), they are not known to be elaborate story-tellers. According to Nelson (Nelson 1993) "an important development takes place when the process of sharing memories with others through language becomes available as a means of reinstating memory...Language opens up possibilities for sharing and retaining memories in a culturally shared format for both personal and social functions. Sharing memory narratives is important to establish the new social function of autobiographical memory, as well as to make reinstatement through language possible." Thus, autobiographical memory as we know it, i.e. human style autobiographical memory, seems to go hand in hand with the development of language. Lemurs are not likely to be able tell us stories about themselves and others, even if we would be able to fully understand their communication system. However, humans interpret the lives of these gentle and beautiful lemurs in the most natural way, namely as stories, and tales.

Of course we cannot look into a lemur's mind, so this is a field of speculation. Neither do we know what stories elephants and dolphins are telling, and what a 'story' could mean to their lives in the first place. However, imagine that young dolphins grow up while being taught the structure of narratives through story-telling, with their parents, peers and relatives, then the structure of these stories can be expected to be well adapted to life and living as a dolphin, and adapted to the structure of the dolphin's mind, and it might turn out not to be compatible to the human mind. The way humans tell stories might only be one instantiation in a huge space of possible story-telling minds, natural and artificial.

Autism and Believable Agents

In natural sciences experimentation is often driven by the insight that by mere undisturbed observation of an animal numerous explanations and models might match the observations, and that only disturbances and observations on how the animal copes with them can be used to test hypothesis. To give an example: a stick insect walking with its nicely coordinated tripod gate does not reveal by observation whether a central pattern generator or distributed control is underlying the tripod gait pattern. Both architectures (and various others, too) can produce tripod gait. In addition to neurophysiological experiments, experiments proved successful where e.g. obstacles were used to interrupt the normal tripod gait. The animal could nicely cope with this situation and the way how it did it ultimately led to the construction of a six-legged robot as a 'working model' (Cruse 1990), (Cruse *et al.* 1991). Similarly, people with brain damage can provide scientifically 'interesting' cases for brain scientists (Sacks 1985). Likewise, for the investigation of social intelligence and narrative, people with autism can show us forms of sociality which are very different from what we are used to.

In (Dautenhahn 1997) I suggested that an impairment of the processes of empathic understanding and biographical reconstruction might contribute to the symptoms which people with autism show, who are generally not able to build up 'normal' social relationships, nor can they show 'adequate' behavior in social interactions. Autistic people definitely possess strong emotions, but they seem to lack the ability of empathy and attribution of mental states to other people. Moreover, children with autism generally do not show pretend-play with dolls or stuffed animals.

A set of standardized experiments are used to identify autistic symptoms in children, among them experiments in which a particular story is presented and the child has to answer questions about the actors' current beliefs (false belief test). The 'Sally-Anne' test (Baron-Cohen, Leslie, & Frith 1985) is about two dolls. 1) Sally and Anne are together in a room, 2) Sally puts a marble in a basket and leaves the room, 3) Anne takes the marble out of the basket and puts it into a box, 4) Sally returns. The child is then asked where Sally will look for the marble. Normal children until the age of four and most autistic children (of all ages) give 'Anne's box' as the answer, e.g. they cannot attribute to Sally a different belief then they have themselves (and they know that the marble is now in Anne's box). Tests like the Sally-Anne test require you to be able to distinguish yourself and your beliefs and perceptions from those of others: what I know, believe, perceive, feel is not necessarily identical with what you know, believe, perceive, feel. This ability is not innate, children develop this ability during their first years of life. By the age of 3-4 years a child's 'theory-of-mind' is usually well developed, while most children with autism will not succeed. The term 'theory-of-mind' has recently been replaced by the term 'mind-reading', in order to express that the skill to understand the social world is not necessarily 'theory-based' (e.g. based on a set of axioms and logical rules). Moreover, interpersonal processes of joint-attention and/or empathy are alternative approaches to autism, see discussion e.g. in (Dautenhahn 1997).

I am not aware whether experiments have been done with autistic children's understanding of stories with believable characters like Luxo Jr. or Toy Story, but the evidence from false belief tests suggests that they will have difficulty understanding the story, the intentions and goals of the actors, and that empathic understanding will be difficult. Children with autism often respond well to toys which have distinctive tactile, motor, sound or other features which children with autism are interested in. Observations (Rachel Smith 1999, pers. comm.) show that at least some children with autism enjoy to interact with one of the latest robot pets, the Furby (http://www.game.com/furby/index.html), for reasons which are yet unclear. It is unlikely that the children like Furbies because they are 'cute', have 'big eyes', and features other children find attractive (features which invite children anthropomorphizing the toys). Tests which we did at the end of 1998 using a robot doll (designed and programmed by Aude Billard, see (Billard, Dautenhahn, & Hayes 1998)) indicate that children with autism did not respond particularly well to the 'doll features' of the robot but rather to the 'reactive part', i.e. they were interested in investigating the sensory 'channels' of the doll and other details which made the robot reacting. More information on the project AURORA which aims at using a mobile robot as a remedial tool for children with autism is given in (Dautenhahn 1999), (Werry & Dautenhahn 1999).

However, some people with autism show animal empathy (i.e. they can 'understand' animals), so a mechanism of empathic resonance (with animals) seems to exist. Moreover, some high-functioning people with autism can learn and train themselves in social behavior to some extent, by learning and applying generic rules of human interaction, although they usually fail to recognize ideosyncratic social cues (i.e. they fail to construct the individual biographic history). Thus, I expect that the more human-like actors in a story are, the more sophisticated their behavior is, i.e. the more biographical reconstruction of the story is required, the more difficulty people with autism will have to understand the story. Children with autism need structure in their lives, they prefer to stick to a fixed daily routine, and they have difficulty to remember and describe what *actually* happened to them, in contrast to what *usually* happens to them. This suggests an impairment of narrative skills, in particular those narratives which are special and individual and which contribute to autobiographical memory.

According to Nelson (Nelson 1986) children experience their day as a series of scripts (as suggested in (Schank & Abelson 1977)) and routines which help them to structure their world of experiences and language. Scripts help them to understand what is going to happen and who is going to do what. However, as Bruner points out (Bruner 1991), narratives require scripts as necessary background (the 'skeleton'), but they do not constitute narrativity itself. Scripts are not 'worth telling' unless they include the 'unusual', breaches, violations to the script which make a story interesting.

People with autism have difficulty relating to people, including difficulty in telling stories about themselves. Powell (Stuart Powell 1999, pers. comm.) therefore recommends that in teaching people with autism pointers have to be given explicitly about what is important and useful (to remember) and what is not.

Requirements for Narrative Agents

Evidence indicates that in the evolution and development of natural social intelligence story-telling can hardly be separated from the primate social field. Research in primatology points to the importance of social intelligence for the evolution of primate intelligence (phylogeny), autism shows how fundamentally an impairment of social skills can influence the life of people, even if they show good non-social skills of intelligence (ontogeny). Thus, in order to make artificial (hardware or software) agents story-tellers, we have to give them not only language but social intelligence. Based on our analysis of the primate social field the following list of necessary requirements for a story-telling agent is suggested:

1. Ability to *recognize* individuals. Agents need to recognize other agents.

2. Ability to *understand* others, most elaborated in humans which show complex mechanisms of empathy, biographical reconstruction, and an individual autobiography. Agents need social skills, ways to figure out what other agents are doing and the ability to communicate with them.

3. Ability to *predict* the behavior of others and outcomes of interaction. Agents need enough 'experience' and background knowledge in order to predict the future, and make the link to the past and present.

4. Ability to remember and learn interactions with others and to build *direct relationships*: As we discussed above the upper limit of the group size was estimated for humans as 150 , representing a cognitive limit on the number of individuals with whom one person can maintain stable relationships, as a function of brain size. The 'brain' of a software or robotic agent (at least in terms of storage capacity) can be huge. Thus, agents can have many friends.

5. Ability to remember and learn interaction between others, to understand *third-party relationships*. Since human communication is dominated by gossiping about other people, artificial agents talking about other agents seems to be suggested.

Building an artificial story-telling agent based on its social field contradicts the traditional GOFAI view of intelligence. If related to psychology/social sciences at all, then the GOFAI view is linked with Piaget's view of the child as a solitary thinker (Lee & Gupta 1995). Here, the cognitive development from child to adult is based on qualitatively different universal stages. The social context might assist development, but the child's own activity plays the essential role in the progression of cognitive stages. At the center of Piaget's theory is the isolated child as a 'little scientist', namely exploring and testing the world on its own. According to Piaget the child goes through different stages or periods according to an invariant sequence which holds across cultures. This view is challenged by the developmental psychologist Vygotsky and his view of the 'child in society' (Wertsch 1985). The notion of agents and narratives which we outlined in this paper is more related to Vygotsky's ideas. Here, interactions with adults and peers and teaching are essential for cognitive development, the social and cultural context matters. Human cognitive capacities change as a result of historical development and new cultural tools (technological and psychological tools). Vygotsky's work addresses how the child acquires cultural tools through development and in interaction with other persons. He argues that concepts, language, voluntary attention and memory originate in culture, i.e. are interpersonal processes before they become internalized by the child as intrapersonal processes. Vygotsky stresses the role of teaching, in particular for guiding the development of abstract modes of thought. A discussion of Vygotsky's theory applied to experiments with socially intelligent robotic agents can be found in (Dautenhahn & Billard 1999).

Can Social Intelligence be Tested?

GOFAI research has long focused on the Turing-Test, as the ultimate test for artificial intelligence. Recently, the Prisoner's Dilemma (a simple two-person game, originating in game theory) is often used to demonstrate 'social skills' of simulated agents, however, the simulations are often not addressing any aspects relevant in real-life social interactions.

An agent which is able to get a special discount while talking to a human on the phone and making a hotel-room reservation might better address real-life social skills. An advanced version of such an agent, which can participate in a budget committee meeting and succeeds in getting the money, would be an example of a truly successful Machiavellian agent (cf. (Sindermann 1982)).

Can social intelligence and mind-reading be taught? Howlin *et al.* (Howlin, Baron-Cohen, & Hadwin 1999) give a practical guide to teaching children with autism to mind-read. They distinguish three classes of mental state concepts (emotion, pretence/play, informational state-belief) which are addressed on five levels of mental state teaching. Assessment and teaching procedures are described for each of these levels and classes. To give an example, teaching about emotions consists of the following levels: 1) recognition of facial expression from photographs, 2) recognition of emotion from schematic drawings, 3) identification of situation-based emotions, 4) desire-based emotions, and 5) belief-based emotions.

Can we teach an artifact to mind-read in a similar way as we teach a child with autism? What kind of test for social intelligence is suitable? The Sally-Anne-Test which we described above could qualify to assess the 'mind-reading' skills of agents. However, as an anonymous reviewer pointed out, an appropriate logical framework might allow passing the Sally-Anne-Test. However, the crucial step is not the 'logic behind' this test, but the understanding of the situation and the particular context, the attribution of beliefs based on previous experience and knowledge about oneself and other persons, the grounding of mental concepts in observations and interactions, i.e. it requires processes of understanding in a situated, embodied agent which is able to properly perceive, interpret and act in social contexts, being able both to generalize from individual experiences to general rules of social interactions, and to reconstruct individual experiences. As Howlin *et al.* discuss (Howlin, Baron-Cohen, & Hadwin 1999) there are no simple recipe books which can teach mind-reading and overcome the fundamental disabilities in autism: "Understanding - and reacting appropriately to - people's emotions, involves more than the ability to recognize a few clear and relatively simple emotions from pictures and cartoons. Whether a situation is construed as being happy, sad or frightening will depend, not only on the current context but on the past history of the individual(s) involved. Moreover, facial expression alone may not always be a true representation of how someone is feeling - a smile, for example maybe used in a brave attempt to disguise sadness or pain. And, being able to recognize certain unambiguous emotions in other people, may not necessarily help children with autism fully understand or cope with their own emotional responses, especially if these differ from those of others.".

Thus, as we discussed earlier, social understanding requires an autobiographic agent which is able to reconstruct its own and other people's experiences, an agent with a history, an agent which has a body as the point of reference which gives a unique perspective on the (social) world, which allows to generalize from experiences and to reconstruct specific, individual experiences.

Humphrey (Humphrey 1988), in a famous paper (originally published in 1976) which discusses primate intelligence, argues for the necessity of developing a laboratory test of 'social skill'. His suggestion is: "The essential feature of such a test would be that it places the subject in a transactional situation where he can achieve a desired goal only by adapting his strategy to conditions which are continually changing as a consequence partly, but not wholly of his own behavior. The 'social partner' in the test need not be animate (though my guess is that the subject would regard it in an 'animistic' way); possibly it could be a kind of 'social robot', a mechanical device which is programmed on-line from a computer to behave in a pseudo-social way.". Thus, for Humphrey a test of social intelligence does not measure social 'reasoning', but addresses a social interaction situation. Nowadays we do have humanoid social robots (e.g. (Breazeal & Scassellati 1999), (Breazeal & Scassellati 2000)) which, in case they are accepted by human and non-human primates, could take the role of the interaction partner in such a social intelligence test. Generally, interactions between animate and inanimate social agents can indicate what kind of social knowledge is necessary in order to achieve a certain social behavior, e.g. how much 'theory' a social (and autobiographic) agent requires in order to be able to read others' minds.

Narrative agents as we know them, e.g. humans, are social agents, are growing up in a society, learning about other agents and how to predict them. For narrative agents as they could be, in software or hardware, can it be otherwise?

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