The Narrative Intelligence Hypothesis: In Search of the Transactional Format of Narratives in Humans and Other Social Animals

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Abstract. This article discusses narrative intelligence in the context of the evolution of primate (social) intelligence, and with respect to the particular cognitive limits that constrain the development of human social networks and societies. The Narrative Intelligence Hypothesis suggests that the evolutionary origin of communicating in a narrative format co-evolved with increasingly complex social dynamics among our human ancestors. This article gives examples of social interactions in non-human primates and how these interactions can be interpreted in terms of nonverbal narratives. The particular format of preverbal narrative that infants learn through transactions with others is important for the development of communication and social skills. A possible impairment of the construction of narrative formats in children with autism is discussed. Implications of the Narrative Intelligence Hypothesis for research into communication and social interactions in animals and robots are outlined. The article concludes by discussing implications for humane technology development.

1 Introduction: The Social Animals

Humans are primates, and share fundamental cognitive and behavioral characteristics with other primates, in particular apes (orangutan, gorilla, chimpanzee, bonobo). Although it is widely accepted that humans and other apes have a common ancestor and that human behavior and cognition is grounded in evolutionary 'older' characteristics, many people believe that human intelligence and human culture are 'unique' and qualitatively different from most (if not all) other non-human animals. Human language often serves as an example of a 'unique' characteristic. With a few exceptions [Read & Miller 95], most discussions on the 'narrative mind' neglect the evolutionary origins of narrative. Therefore, it is not surprising that most research on narrative focuses almost exclusively on language in humans (see e.g. [Turner 96]). The work that is presented in this paper attempts to complement these works: instead of focussing on differences between human and other animal societies, we point out similarities and evolutionary shared histories of primates with specific regard to the origins and the transactional format of narratives (cf. [Dautenhahn 99], [Dautenhahn, to appear]).

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The article sets off by reviewing the main arguments of a debate that is currently discussed intensively in primatology and anthropology, namely that the characteristic properties of human 'minds' and human culture are grounded in the human's capacity to use language, and that the primary function of language was that it affords to cope with increasingly complex social dynamics. Based on this framework on the social origin of human intelligence we discuss the *Narrative Intelligence Hypothesis* (NIH), first suggested in [Dautenhahn 99a], that points out the intertwined relationship between the evolution of narrative and the evolution of social complexity in primate societies. The underlying assumptions and arguments are discussed in more detail. The NIH as referred to in this paper consists of the following line of arguments:

a) *individualized societies* are a necessary (but possibly not sufficient) 'substrate' for the evolution of narratives. In such societies members know each other and relate to each other on an individual level (animals with 'personalities', 'minds'), and interact with each other through transactional processes,
b) the specific *narrative format* of such transactions serves an *important communicative function* among primates, and possibly independently in other groups of species that live in individualized societies,
c) narrative co-evolved along and in order to cope with increasingly complex dynamics in the primate social field,
d) the evolution of communication in terms of narrative language (story-telling) was an important factor in human evolution that has shaped the evolution of human cognition, societies and human culture. The use of language in a narrative format provided an efficient means of 'social grooming'
e) human cultures which are fundamentally 'narrative' in nature provide an environment that young human primates are immersed in and facilitates not only the development of a skilled story-teller and communicator, but the development of an autobiographical self.

The NIH is speculative and part of ongoing research. The particular contribution of this article is that it analyses in more detail the *structure* and *canonical format* of narrative that can be found in different verbal and non-verbal social interactions among primates, and in preverbal communication of human infants. The relationships between narrative and culture and autobiography are touched upon but discussed in more detail elsewhere ([Dautenhahn 99a,c], [Dautenhahn, to appear], [Dautenhahn, submitted]).

Implications of the NIH are on the one hand a better understanding of the origins of narrative intelligence in humans and other animals, on the other hand such an understanding can point out issues that are relevant in the design of *narrative technology* that meets the social and cognitive needs of human users of such technology.

2 The Social Brain Hypothesis

Primate societies belong to individualized societies with complex kinds of social interaction and the development of various forms of social relationships and networks. In individualized societies group members individually recognize each other and interact with each other based on a history of interactions as part of a social network. Many mammal species (such as primates, elephants, cetaceans) live in highly

individualized societies, so do bird species such as corvids and parrots. Preserving social coherence and managing cooperation and competition with group members are important aspects of living in individualized societies. Dealing with such a complex social field often requires sophisticated means of interaction and communication which are important for the Narrative Intelligence Hypothesis that is discussed in this article.

In the context of human (or generally primate) intelligence the *Social Intelligence Hypothesis* (SIH), sometimes also called Machiavellian Intelligence Hypothesis or *Social Brain Hypothesis*, suggests that the primate brain and primate intelligence evolved in adaptation to the need to operate in large groups where structure and cohesion of the group required a detailed understanding of group members, cf. [Byrne & Whiten 88], [Whiten & Byrne 97], [Byrne 97]. It is assumed that social complexity that required the evolution of social skills (which allow to interpret, predict and manipulate conspecifics) has been a prominent selective factor accelerating primate brain evolution, given that maintaining a large brain is very costly. Identifying friends and allies, predicting others' behavior, knowing how to form alliances, manipulating group members, making war, love and peace, are important ingredients of primate politics [de Waal 82]. Thus, there are two interesting aspects to human sociality: it served as an evolutionary constraint which led to an increase of brain size in primates, which in return led to an increased capacity to further develop social complexity.

Research in primatology that studies and compares cognitive and behavioral complexity in and among primate species can give exciting hints on the origins of human cultures and societies. Particularly relevant for the theme of this article are the potential relationships between social complexity and brain evolution. A detailed analysis by Dunbar and his collaborators gives evidence (e.g. [Dunbar 92,93,98] and other publications) that the size of a cohesive social group in primates is a function of relative neocortical volume (volume of neocortex divided by volume of the rest of the brain). This evidence supports the argument that social complexity played a causal role in primate brain evolution, namely that in order to manage larger groups, bigger brains are needed to provide the required 'information processing capacity'. Note, that group size as such is not the only indicator of social complexity: other researchers have found supporting evidence, e.g. that primate species with relatively larger neocortices exhibit more *complex social strategies* than species with smaller neocortices [Pawlowski et al 98].

What specifically characterizes social complexity? Here, a definition that applies to many systems from machines to animal societies might be useful. According to [Philips & Austad 96] 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). According to Philips and Austad conditions 1 and 2 can be applied to many systems from machines to societies. Conditions 3 and 4 are particularly suited to social organization. Condition 3 refers to the number of different roles an animal can play in a social network, and how these roles and relations to other animals dynamically change over time (condition 4).

How are social networks and relations established and maintained? Judging from our own experience as a member of human society, communicating via *language* seems to be the dominant mechanism for this purpose. Non-human primates in the wild do not seem to use a human-like language. Here, social cohesion is maintained through time by social grooming. Social grooming patterns generally reflect social relationships, they are used as a means to establish coalition bonds, for reconciliation and consolation and other important aspects of primate politics. Social grooming is a one-to-one behavior extended over time that poses particular constraints on the amount of time an animal can spend on it, given other needs such as feeding, sleeping etc. Also, cognitive constraints limit the complexity of social dynamics that primates can cope with, as discussed in the following paragraph.

Given the neocortical size of modern humans, Dunbar (1993) extrapolated from the non-human primate regression (relative neocortical volume vs. group size) and predicted a group size of 150 for human societies. This number limits the number of relationships that an individual human can monitor simultaneously, it is the upper group size limit which still allows social contacts that can be regularly maintained, supporting effective coordination of tasks and information-flow via direct person-to-person contacts. The number 150 is supported by evidence from analyzing contemporary and historical human societies. But how do humans preserve cohesion in groups of 150 individuals, a function that (physical) social grooming serves in non-human primate societies? In terms of survival needs (resting, feeding etc.) primates can only afford to spend around 20 % of their time on social interactions and social grooming, much less than a group size of 150 requires. It was therefore suggested by Dunbar (1993) that in order to preserve stability and coherence in human societies, human language has evolved as an efficient mechanism of social bonding, replacing social grooming mechanisms in non-human primate societies with direct physical contact (allowing only much smaller groups). Following this argument, language allowed an increase in group size while still preserving stability and cohesion within the group. The next section will elaborate this argument further by analyzing what the particular features of communication via language are that makes it an efficient 'social glue' in human societies.

3 The Narrative Intelligence Hypothesis

In the context of the evolution of human intelligence, the Social Intelligence Hypothesis offers little explanation for the evolution of specific ape and human kinds of intelligence (e.g. involving mental representations): clear evidence for a systematic monkey-ape difference in neocortex ratio is lacking. Great apes do not form systematically larger groups than monkeys do, which draws attention to physical rather than social factors (e.g. tool use, processing plant food etc.) that drove the evolution of mental representations in apes and humans. Why have in particular human apes evolved sophisticated representational and mental skills, are there any candidate factors that could have accelerated the evolution of human intelligence? If the evolution of language played an important role, as suggested by others (e.g. [Dunbar 93], [Donald 93]), what are the particular characteristics of language that matter?

We discussed previously [Dautenhahn 99a] that a closer look at the ontogeny of language and narrative, i.e. the role of language in the development of children could

provide an important hint: Evidence shows that narratives play a crucial role in how young human primates become socially skilled individuals with an autobiography, being able to effectively communicate with others [Nelson 93; Engel 95].

Narrative psychology suggests that stories are the most efficient and natural human way to communicate, in particular to communicate about others [Bruner 87; 90; 91]. As Reader and Miller suggest "stories are universally basic to conversation and meaning making", and as developmental and cross-cultural studies suggest "humans appear to have a readiness, from the beginning of life, to hear and understand stories" [Read & Miller 95: p. 143]. The *Narrative Intelligence Hypothesis* [Dautenhahn 99a] interprets such evidence from the ontogeny of human language in the context of primate evolution: it proposes that the evolutionary origin of communicating in stories co-evolved with increasing social dynamics among our human ancestors, in particular the necessity to communicate about third-party relationships (which in humans seems to reach the highest degree of sophistication among all apes, cf. gossip and manipulation, [Sinderman 82]). According to the NIH human narrative intelligence might have evolved because the structure and format of narrative is particularly suited to communicate about the social world.

Looking at human evolution, we can observe an evolutionary trend from physical contact (non-human primates) to vocal communication and language (hominids) to communicating in stories (highly 'enculturated' humans living in complex societies) correlated with an increase in complexity and sophistication of social interaction and 'mindreading'. This trend demonstrates the evolution of increasingly efficient mechanisms for time-sharing the processes of social bonding. While physical grooming is generally a dyadic activity, language can be used in a variety of ways extending the dyadic use in dialogues to e.g. one-to-many communication as it is today used extensively in the mass media (television, books, email etc.). It can be estimated [Dunbar 93] that the human bonding mechanism of language is about 2.8 times as efficient as social grooming (the non-human primate bonding mechanism). Indeed, evidence suggests that conversational groups usually consist of one speaker plus two or three listeners. Of course larger groups can be formed easily, but in terms of actively participating and following different arguments within the group 1+2(3) seem to be the upper limit for avoiding information processing overload in the primate social brain. Also, language because of its representational nature affords documentation, preservation in storage media and transmission of (social) knowledge to the next generation, as well as communication between geographically separated locations [Donald 93].

Discussions in the social domain (e.g. on social relationships and feelings of group members) are fundamentally about personal meaning, different from e.g. discussions in the technical domain (e.g. about how to operate a tool or where to find food). *Narrative might be the 'natural' format for encoding and transmitting meaningful, socially relevant information (e.g. emotions and intentions of group members).* 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. Studies show that people spend about 60 % of conversations on gossiping about relationships and personal experiences [Dunbar 93]. 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, to preserve group cohesion.

Although humans use gestures, facial expressions, body language and other non-verbal means to convey (social) meaning, human communication is dominated by

verbal communication, which is serial in nature (although in face-to-face interaction accompanied by non-verbal cues). Thus, given the serial communication channel of human language, what is the best means to communicate social issues - so important for primates as argued above - namely, learning about the who, what, and why? Physical social grooming, the main group cohesion mechanism in non-human primates is 'holistic', parallel, spatial, sensual, meaningful. How can a stream of symbols that are in themselves meaningless convey meaning such as bodily grooming does? I argue that narrative structure and format seems to be particularly suited: usually a narrative gives 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. Story-telling also gives more flexibility than social grooming as to the actors and content of the stories: stories can include people that are part of the current audience, as well as absent persons, historical characters, fictional characters, etc. Stories that are told by a skilled story-teller (e.g. using appropriate body language, exploiting prosody, and possessing a rich repertoire of verbal expressions) can give very good examples of 'the power of words'. The format of a story can provide sensual, emotional, and meaningful aspects to otherwise 'factual' information, e.g. people often clearly remember works of literature that elicited strong emotional responses and were influential at a particular time during their lives.

To summarize, the following strategies of coping with a complex social field in primate societies were outlined in the preceding sections:

a) non-verbal, physical social grooming as a means of preserving group cohesion, limited to one-to-one interaction
b) communicating about social matters and relating to others in the narrative format of transactions with non-verbal 'enacted' stories
c) using language and verbal narratives in order to cope with social life

The Narrative Intelligence Hypothesis suggests that the evolution of human societies might have gone through these different stages, not replacing preceding stages, but adding additional strategies that extend an individual's repertoire of social interaction, ranging from physical contact (e.g. in families and very close relationships), to preverbal 'narrative' communication in transactions with others (let alone the subtleties of body language and nonverbal social cues, not necessarily conscious, cf. [Hall 68], [Farnell 99], [Gill et al 99]), to developing into a skilled story-teller within the first years of life and refining these skills throughout one's life. The next section gives a few examples of where we might find narratives in the behavior of humans, other animals, and possibly even artifacts. To begin with, we need to have a closer look that the specific canonical format of narrative.

4 In Search for Narratives

4.1 What Exactly Are Narratives?

Many definitions and theories of narrative and narrative intelligence exist in the literature. This paper follows a particular theory formulated by Jerome Bruner and discussed in his publications, e.g [Bruner 87,90,91].

Bruner's account of narrative needs to be placed in the context of his distinctions of two complimentary modes of thought and understanding the world Bruner (1990):

The *paradigmatic mode* or logico-scientific one is based on the idea of a formal, mathematical system of descriptions and explanations. Discourse in this mode requires consistency and noncontradiction. Tools such as logic, symbol-systems, mathematics, sciences, and automata have been developed in order to experience and learn about the 'truth' in the *physical world*.

The second mode of thought according to Bruner is *the narrative mode* that deals with human intentions and that we use to understand the *social and cultural world* through stories. These stories remain stories whether they are true or not, and whether they are based on facts or fiction.

Thus, stories are primarily dealing with people and their intentions, they are about the social and cultural domain rather than the domain of the physical word. Narratives are often centered towards subjective and personal experience. According to Bruner (1991) narrative is a conventional form that is culturally transmitted and constrained. Children are not born as skilled story-tellers, the grow up immersed in a culture of story-tellers (parents, peers) who help them develop and shape their narrative skills and autobiographical selves [Nelson 93; Engel 95]. Narrative is not just a way of representing or communicating about reality, it is constituting and understanding (social) reality.

More specifically, Bruner (1991) discusses different characteristics of narrative, properties that distinguish an utterance or any part of language from a story:

1. Narratives describe sequences of events, in 'human time' rather than 'clock time'
2. Narratives are about 'unusual events', 'things worth telling' that can nevertheless be embedded in generic scripts
3. Narratives describe people or other agents, endowed with intentional states, acting in a setting in a way that is relevant to their beliefs, desires, theories, values etc.
4. Narratives must have a plot that conveys meaning, and a high point

The complete list of characteristics is described in [Bruner 91]. A detailed discussions of these criteria and implications for agent design are discussed in [Sengers 2000].

Particularly important for the theme of this paper are characteristics 2 and 3: different from episodic memory that can for example be represented in scripts [Schank & Abelson 77], such as the famous 'restaurant script', narratives are about breaches and violations to routine behavior. Also, stories are about the social field, about people as intentional and mental agents, and how they relate to each other.

Narrative capacities (understanding and producing stories) are capacities shaped by society, but developing in an *individual* being (cf. [Nehaniv 97], [Dautenhahn & Coles 01]). Also, stories have an important meaning for the individual agent, e.g. stories that children tell to *themselves* play an important part of a child's abilities to make meaning of events (cf. [Nelson 89], [Engel 95]). Similarly, a human profes-

sional story-teller might rehearse relevant material in solitude, but in the actual performance takes into account the specific audience, its reactions, and other indications on how the audience 'might think and feel', so that the actual story can be adapted appropriately. Thus, stories, at least for fundamentally social animals such as humans, are most effective in communication in a social context:

> "We converse in order to understand the world, exchange information, persuade, cooperate, deal with problems, and plan for the future. Other human beings are a central focus on each of these domains: We wish to understand other people and their social interactions; we need to deal with problems involving others; and other people are at the heart of many of our plans for the future." [Read & Miller 95: p. 147].

Bruner's above mentioned criteria of narrative structure and format do not only apply to stories that are told and written, but equally well to other formats such as comics [McCloud 94]. Human culture has developed various means of artistic expression (sequential visual arts, dance, pantomine, literature etc.) which are fundamentally 'narrative' in nature, conveying meaning about people and how people relate to the world. Children who are immersed in human culture, exposed to those narratives, develop as skilled story-tellers, as is shown in the following story of an 11-year old when asked to write a story about a robot. Note, that the story fits very well Bruner's criteria:

> "In America there was a professor called Peter Brainared and in 1978 he created a robot called Weebo. Weebo could do all sorts of things: she could create holograms, have a data bank of what the professor was going to do, show cartoon strips of what she was feeling like by having a television screen on top of her head which could open and close when she wanted to tell Peter how she felt. And she could record what she saw on television or what people said to her. Weebo looked like a flying saucer about as big as an eleven year old's head also she could fly. Peter Brainared had a girlfriend called Sarah and they were going to get married but he didn't turn up for the wedding because he was too busy with his experiments so she arranged for another one and another one but he still didn't turn up, so she broke off the engagement and when he heard this he told Weebo how much he loved her and she recorded it, went round to Sarah's house and showed her the clip on her television screen to show Sarah how much he loved her and it brought Sarah and Peter back together." (study described in [Bumby & Dautenhahn 99])

Please note that although a central protagonist in the above story is a robot, it is depicted as an intentional agent embedded in a social context [Dennett 87].

4.2 Narratives and Autism

Traditionally Jerome Bruner, Katherine Nelson, Susan Engel (see references above) and other psychologists interested in the nature and development of narratives have a particular viewpoint of narratives in terms of human verbal story-telling. Interestingly, Bruner and Feldman (1993) proposed the *narrative deficit hypothesis of autism*, a theory of autism that is based on a failure of infants to participate in narrative con-

struction through preverbal transactional formats. Children with autism generally have difficulty in communication and social interaction with other people [Jordan 99], and this theory suggest that these deficits could be explained in terms of a deficit in narrative communication skills. As it is discussed later in this article, this work gives important hints on the transactional structure of narratives, a structure that we believe is of wider importance, not limited to the specific context of autism.

What is a narrative transactional format? Bruner and Feldman distinguish different stages. They suggest that the first transactional process is about reciprocal attribution of intentionality, of agency. The characteristic format of preverbal transactions is according to Bruner and Feldman a narrative one, consisting of four stages:

1) canonical steady state
2) precipitating event
3) a restoration
4) a coda marking the end.

An example is the peek-a-book game where 1) mutual eye gaze is established between infant and caretaker, 2) the caretaker hides her face behind an object, 3) the object is removed revealing the face again, and 4) "Boo", marking the end of the game.

Bruner and Feldman suggest that problems of people with autism in the social domain are due to an inability early in their lives to get engaged in 'appropriate' transactions with other people. These transactions normally enable a child to develop a narrative encoding of experiences that allows to represent *culturally canonical forms of human action and interaction*. Normally this leads a child at 2-3 years of age to rework experiences in terms of stories, until she ultimately develops into a skilled story-teller [Engel 95].

As research by Meltzoff, Gopnik, Moore and others suggest, transactional formats play a crucial role very early in a child's life when she takes the first steps of becoming a 'mindreader' and socially skilled individual: reciprocal imitation games are a format of interaction that contributes to the mutual attribution of agency [Meltzoff & Gopnik 93], [Meltzoff & Moore 99]. Immediate imitation creates intersubjective experience [Nadel et al 99]. By mastering interpersonal timing and sharing of topics in such dyadic interactions children's transition from primary to pragmatic communication is supported. It seems that imitation games with caretakers play an important part in a child's development of the concept of 'person' and [Meltzoff & Gopnik 93; Meltzoff & Moore 99], a major milestone in the development of social cognition in humans.

Data by Bruner and Feldman (1993) and others indicates that children with autism seem to have difficulty in organizing their experiences in a narrative format, as well as a difficulty in understanding the narrative format that people usually use to regulate their interactions. People with autism tend to *describe* rather than to *narrate*, lacking the specific causal, temporal, and intentional pragmatic markers needed for story-making. A preliminary study reported by Bruner and Feldman (1993) with high-functioning children with autism indicated that although they understood stories (gave appropriate answers when asked questions during the reading of the story), they showed great difficult in retelling the story, i.e. *composing* a story based on what they know. The stories they told preserved many events and the correct sequence, but lacked the proper emphasis on *important and meaningful events*, events that moti-

vated the plot and the actors. The stories lacked the narrative bent and did not conform to the canonical cultural expectations that people expect in ordinary social interaction. Such a lack of meaning-making makes conversations in ordinary life extremely difficult, although, as Bruner and Feldman note, people with autism show a strong desire to engage in conversations [Bruner & Feldman 93].

Generally, there are different aspects to narrative in communication: expressing or telling stories, recognizing stories (understanding narrative in other agents) and experiencing the world through narratives (being an autobiographic agent) [Nehaniv 99a].

The following example of narratives in robots concentrates on the mechanisms of how a single agent can *express* episodic memory and what could make them narratives.

4.3 Narratives in Robots

The project *Memory-Based Interaction in Autonomous Social Robots* takes an Artificial Life perspective on stories and narratives [Dautenhahn & Nehaniv 98], [Nehaniv & Dautenhahn 98]. The minimal working definition of stories used in the project is as follows: "Stories are sequences of actions, expressed by an autonomous agent (including movements as well as 'speech acts'), which can be related to previous situations in the agent's autobiographical memory" [Dautenhahn & Coles 01]. Note, that in the context of this particular project we use the term 'story' in terms of episodical events. Such stories clearly do not fulfill Bruner's list of criteria for narratives and might therefore be better called *pre-narratives*. A computational framework was developed which supports systematic experimental studies of story-telling in autonomous behavior-based robotic agents (simulated and physical robots).

A particular goal in this project is to study *minimal experimental conditions* of how story-telling might emerge from episodic memory [Coles & Dautenhahn 00], [Dautenhahn & Coles 01]. An initial experimental study [Dautenhahn & Coles 01] investigated memory-based controllers and computational mechanisms of 'story-telling' for robotic agents. We showed that 'story-telling' (i.e. using episodic memory) can be beneficial even to a single agent (cf. [Nehaniv 97]) since it increases the behavioral variability of the reactive agent. Thus, from the point of view of developing Artificial Life *post-reactive* agents [Nehaniv et al 99], we can speculate that minimal mechanisms in the 'first story-telling animal' (not necessarily social) might have survived because the animal was better adapted to a dynamic environment. Later, this capacity could have been used and further developed in a social, communicative context. Note, that for our pre-narratives we do not presuppose any knowledge of the *meaning* or *interpretation* of stories. We did not want to impose meaning by a human designer since meaning implies *meaning for a particular agent*, evaluated from its own (historical) perspective [Nehaniv 99a]. Similarly, *understanding* in this framework means that the agent's stories are grounded in its own experiences rather than imposed by a human designer.

Such kind of research with an experimental computational and robotic test-bed demonstrates a bottom-up approach towards studying narrative and how it can arise and evolve from pre-narrative formats (e.g. episodic memory abilities and formats that are necessary but not sufficient for narratives, as discussed in previous sections) in agents and agent societies. Also, it can provide a means to design and study narra-

tive robots with 'meaningful' narratives that are grounded in the robot's own experiences and means of interacting with the world and other agents (including robots), so as to contribute to the robot's agenda to survive. This approach is different from the common approach to building robots with a body language where non-verbal or scripted narrative behavior is imposed onto the robot purely by design so as to make the robots believable and entertaining for human observers (cf. [Bruce et al 00]).

4.4 Narratives in Animal Behavior?

Stories have an extended temporal horizon, they relate to past and future, they are created depending on the (social) context. Do animals use narrative formats in transactions? Studies e.g. with bonobos, Grey parrots and dolphins on animal language capacities teach the animals a language (using gestures, icons or imitating human sounds), and test the animal's language capacities primarily in interactions with humans [Savage-Rumbaugh et al 86; Pepperberg 99; Herman 01]. In the wild, the extent to which animals use a communication system as complex as human language is still controversial, e.g. dolphins and whales are good candidates for sophisticated communicators. However, looking for verbal and acoustic channels of communication might disguise the *nonverbal*, transactional nature of narratives, as shown in *preverbal* precursor of narratives in the developing child, and possibly evolutionary precursors of (*non-verbal*) narrative that can be found in non-human animals. Michael Arbib (2001) proposes an evolutionary origin of human language in non-verbal communication and body language that can be found in many social species (e.g. mammals, birds). He suggests that imitation (and the primate mirror neuron system [Gallese et al 96]) provided the major mechanisms that facilitated the transition from body language and non-verbal imitation to verbal communication. This work supports the arguments as presented in this paper, namely proposing a) the existence of a strong link between non-verbal, preverbal and verbal communication, and b) the important role of dynamic formats of interactions, such as imitative games, in the development of social communication.

With this focus on interactional structure and non-verbal narratives, how can stories in non-human species look like?

Let us consider Frans de Waal's description of an event of reconciliation in chimpanzees.

> "On this occasion Nikkie, the leader of the group, has slapped Hennie during a passiing charge. Hennie, a young adult female of nine years, sits apart for a while feeling with her hand the spot on her back where Nikkie hit her. Then she seems to forget the incident; she lies down in the grass, staring in the distance. More than fifteen minutes later Hennie slowly gets up and walks straight to a group that includes Nikkie and the oldest female, Mama. Hennie approaches Nikkie, greeting him with soft pant grunts. Then she stretches out her arm to offer Nikkie the back of her hand for a kiss. Nikkie's hand kiss consists of taking Hennie's whole hand rather unceremoniously into his mouth. This contact is followed by a mouth-to-mouth kiss. Then Hennie walks over to Mama with a nervous grin. Mama places a hand on Hennie's back and gently pats her until the grin disappears". ([de Waal 89], pp 39,42)

This example shows that the agent (Hennie) is interacting with an eye to future relationships, considering past and very recent experiences. Hennie, Nikkie and Mama have histories, autobiographic histories as individual agents [Dautenhahn 96], as well as a history of relationships among each other and as members of a larger group. Although the event might be interpreted purely on the basis of behavioristic stimulus-response rules, for many primatologists the interpretation of the event in terms of intentional agents and social relationships is the most plausible explanation.

Interestingly, Hennie's interaction with Nikkie shows the canonical format of narrative transactions among intentional agents described in section 4.2:

1) canonical state: greeting: soft pant grunts
2) precipitating event: Hennie reaches out to Nikkie (attempt at reconciling relationship)
3) restoration: kissing (relationship is restored)
4) end: Hennie is comforted by Mama

The second example we discuss is a different type of primate social interaction, namely tactical deception whereby the agent shifts the target's attention to part of its own body. In this particular case the agent (female Olive baboon) distracts the target (male) with intimate behavior.

> "One of the female baboons at Gilgil grew particularly fond of meat, although the males do most of the hunting. A male, one who does not willingly share, caught an antelope. The female edged up to him and groomed him until he lolled back under her attentions. She then snatched the antelope carcass and ran". (cited in [Whiten & Byrne 88]).

Here, the analysis in terms of transactional narrative formats looks as follows:

1) canonical state: male brings antelope, female waits
2) precipitating event: distraction by grooming
3) restoration: female snatches food and runs away (resolution, female achieves goal)
4) end: female eats meat (not described)

Episodes of animal behavior as described above are different from other instances of animal behavior that possess a certain structure and appear in sequences, such as the chase-trip-bite hunting behavior of cheetahs. Also, the alarm calls of vervet monkeys [Cheney & Seyfarth 90], although serving an important communicative function in a social group and having a component of social learning, are not narrative in nature. It is not the short length of such calls that makes it difficult to interpret them in terms of narrative, it is the fact that their primary function is to change the *behavior* of others as a response to a non-social stimulus, i.e. the sight of a predator, causing an appropriate behavior such as running to the trees after hearing a leopard alarm. The narrative format in animal behavior on the other hand refers to *communicative* and *transactional* contexts where communication is *about* the social field, e.g. group members, their experiences and relationships among them. Narratives are *constructed* based on the current context and the social context (communicator/speaker plus recipients/audience). The primate protagonists described above apparently interacted with respect to the social context, i.e. considering the social network and relationships among group members, with the purpose of influencing and manipulating others. Thus, such kind of non-verbal narratives are fundamentally social in nature.

For a more detailed analysis of narrative formats in animal behavior a lot more work is necessary. For example, the characteristics of the transactional format that Bruner and Feldman suggested (1993) need to be elaborated, possibly revised or replaced, and might need to be adapted to specific constraints of the primate social field [Tomasello & Call 97], so our interpretation can only give a first hint on what aspects one might be looking for when searching for narrative formats in animal communication.

5 The Narrative Intelligence Hypothesis Revisited

If human language and narrative intelligence, rooted in nonverbal narrative intelligence in non-human primates, has evolved to deal with an increasing need to communicate in more and more complex societies, what predictions can be made based on this hypothesis? How could the Narrative Intelligence Hypothesis be tested? What are important research directions based on the importance of narrative in animals and artifacts?

Let us first consider how the NIH might be confirmed or dismissed. As with other hypotheses on the origin of primate/human intelligence and language, animal behavior and communicative abilities are not directly documented in the fossil record, they can only be inferred indirectly from anatomical features (e.g. the vocal system that is necessary to produce a human-like language) and remains that indicate social structures (e.g. remains of nests or resting places, or groups of animals that died together). However, recent primate species that could serve as models of ancestors of the human species might give clues on what groups of primate species one might analyze if wanting to trace the origins of human narrative intelligence. Possible narrative structures confirmed in primate behavior might then be correlated with the complexity of the social field in these species.

With respect to the evolution of human societies, Russel [Russell 93] discusses four levels of social organization which might serve as models for the evolution of human societies: a) the 'shrew'-type pre-primates: solitary, many offspring, insectivores, e.g. *Purgatorius*, a 70-million-year-old fossil, b) the 'mouse-lemur'-type primates: bush-living, nocturnal, strong mother-daughter bonding (stable matrilines), social learning (offspring learns from mother), solitary males and social groups of mothers and daughters, e.g. the 50-million-year-old fossil *Shoshonius cooperi*, c) the ' Lemur catta'-type diurnal lemurs: appearing about 54 million years ago, social groups (troops), dominant females, submissive males, stable matrilines, occasionally consort bonds between single male and female, e.g. *Adapidae*, d) the 'chimpanzee'-type lemur-ape: appearing about 24 million years ago, groups of dominant males and submissive females, stable families of mothers and their offspring, male power coalitions, e.g. *Dryopithecus*. The social organization of recent species of apes shows variations of this pattern: of harem-structures (gorilla), solitary lifestyle (orangutan). Russel discusses how human societies can be interpreted and discussed as variations of such primate social patterns.

The Narrative Intelligence Hypothesis would predict that comparative studies of communicative, and in particular narrative formats of interactions across primates species with different social organizations, e.g. as described above, can identify a

correlation between the complexity of the narrative format and an increasing complexity of the primate social field. Such an increase of social complexity need not be limited to group size, but could also cover all other aspects of social complexity that we discussed previously, such as an increasing number of different types of interactions and roles of group member, and the dynamics of how the social network can change and adapt to changes. Such stages of social organization can be related to behavioral as well as cognitive and mental capacities of primates. The NIH suggests a search for the narrative format in interactions, a format that is so efficiently suited to communicate and deal with the complexity of social life.

What kind of research directions and research methods could the NIH inspire?

Testing with Robotic and Computational Models:
As indicated in section 4.3 artifacts could provide scientific tools to explore and experimentally test the design space of narrative intelligence. Narratives in this sense need to have a 'meaning' for an (intentional) agent. The approach of using artifacts as experimental test beds has been used successfully for many years in the areas of adaptive behavior and artificial life, yielding many interesting results that a) help understanding animal behavior, b) help designing life-like artifacts, in this case artifacts with narrative skills.

Study and Analysis of Animal Narrative Capacities:
Since the Narrative Intelligence Hypothesis does not assume any 'novel' development in the transition from nonverbal (through evolution) or preverbal (development) to verbal narrative intelligence, a detailed study and analysis of the structure and format of animal narrative communication is required in order to develop a proper framework. Many vertebrate species are highly social (e.g. non-human primates, dolphins, whales, elephants, bird species such as crows and parrots) and use non-verbal means of body language in interaction and communication. Narrative intelligence has on the one hand a communicative function (as a means of discourse and dialogue), but it has also an individual dimension (understanding and thinking in terms of narrative). Revealing narrative structure in animal communication might therefore further our understanding about meaningful events in the lives of these animals.

Interesting open research questions (this is not an exhaustive list):

- Relationship between preverbal and verbal narrative intelligence in humans (ontogeny)
- Relationship between nonverbal narrative intelligence in non-human animals and narrative intelligence in humans (phylogeny)
- The format of nonverbal narrative intelligence in animals (species specific? Specific to social organization of animal societies?)
- Can we identify narrative 'modes of thought' in different animal species?

6 Implications for Human Society and Technology

There are many implications of the Social Brain Hypothesis and the Narrative Intelligence Hypothesis for technology development. Human cognitive and narrative capacities are constrained by human evolution. Even technological extensions and enhancements (new media, new means of communication, new interfaces and implants) need to operate within the boundaries set out by biology.

Firstly, for people whose real social networks are smaller than 150, the roles of friends and social partners might be filled by other 'partners', either human beings e.g. actors in movies and soap operas, news presenters or presenters of daily chat shows, fictional characters such as Captain Kirk in Star Trek or Homer Simpson, including computer game characters such as Lara Croft in Tomb Raider. Although many of such 'social relationships' are rather uni-directional (we bond with them but they do not bond with us and do not even know of our existence), they might serve a similar role than real human networks [Dunbar 96]. The boundaries between real and artificial are often nebulous or ambiguous, cf. interactions with chatbots or MUD robots in multi-user on-line environments [Foner 00], or a new generation of embodied conversational agents, e.g. software agents that might serve as real estate agents [Bickmore & Cassell 00]. Today, new interactive game software can create believable illusions that agents truly bond with their users, e.g. the Norns in the computer game Creatures, or robotic pets such as Furbies or Aibo's that are extending such acquaintances even to the physical level. However, this extension of real social networks (see [Turkle 95]) is not without limitations, constrained by the cognitive group size limit of 150 that characterizes human primates social networks. As Dunbar argues (1996) modern information technology might change a number of characteristics of how and with whom and with what speed we communicate, but not influence the size of social networks, nor the necessities of direct personal contact that need to provide trust and credibility to social relationships. Note, that the cognitive group size refers to individually knowing somebody: humans have developed varies means of coping with very large group sizes, e.g. military ranks, castes, stereotypes, (possibly prejudices), etc. Although we might 'know' the names of thousands of people (e.g. as entries in a database) such 'knowing' is not based on individual knowledge.

Language is a dominant means of communication in modern societies human that can do remarkable things seemingly without limits. "Yet underlying it all are minds that are not infinitely flexible, whose cognitive predispositions are designed to handle the kinds of small-scale societies that have characterized all but the last minutes of our evolutionary history." [Dunbar 96].

Building narrative technology, in particular interactive environments is a growing area, ranging from applications in education and therapy to entertainment. In the project AURORA we are developing a robotic agent as a therapeutic tool for children with autism. Here, giving the robot story-telling skills could address issues that are relevant to Bruner and Feldman's narrative deficit hypothesis (see section 4.2). At present the robot we use in the AURORA project is not historically grounded, it reacts based on the here and now ([Dautenhahn 99b], [Dautenhahn & Werry 00], [Werry et al, this volume], [Dautenhahn, in press]), but architectures such as the one we studied for the robotic story-teller (section 4.3) might be applied and studied with respect to their therapeutic effect.

Generally, we can expect that empowering human skills of forming and maintaining social networks might be advanced by supporting the development of narrative skills in children and adults. As we discussed in this article, narratives are not only entertaining and fun, they serve an important cognitive function in the development of social cognition and a sense of self [Dennett 89]. However, as discussed in [Nehaniv 99b], humane technology needs to respect human narrative grounding in order to avoid undesirable and unforeseen effects.

The narratives of the future might reflect our ability to preserve coherence and structure in human societies that consist of increasingly fragmented, temporally and geographically distributed social networks. In shaping this development it is important to investigate the evolutionary heritage of our narrative capacities and the natural boundaries it provides. Also, appreciating the stories other non-human animals tell will allow us to put our familiar stories-as-we-know-them into the broader perspective of stories-as-they-could-be.

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