Interstellar Intersubjectvity

The Significance of Shared Cognition for Communication, Empathy, and Altruism in Space

Dunér, David

Published in:
Extraterrestrial Altruism

DOI:
10.1007/978-3-642-37750-1_10

2014

Document Version:
Peer reviewed version (aka post-print)

Interstellar Intersubjectivity: The Significance of Shared Cognition for Communication, Empathy, and Altruism in Space

By David Dunér

History of Science and Ideas/Centre for Cognitive Semiotics, Lund University

Abstract

What kind of indispensable cognitive ability is needed for intelligence, sociability, communication, and technology to emerge on a habitable planet? My answer is simple: *intersubjectivity*. I stress the significance of intersubjectivity, of shared cognition, for extraterrestrial intelligence and interstellar communication, and argue that it is in fact crucial and indispensable for any successful interstellar communication, and in the end also for the concepts that are focus of this volume, empathy and altruism in space. Based on current studies in cognitive science, I introduce the concept of intersubjectivity as a key to future search for extraterrestrial intelligence, and then explain—leaning on phylogenetic, ontogenetic, and cultural-historical studies of cognition—why intersubjectivity is a basic requisite for the emergence of intelligence, sociability, communication, and technology. In its most general definition, intersubjectivity is the sharing of experiences about objects and events. I then discuss what "intelligence" is. I define it as cognitive flexibility, an ability to adjust to changes in the physical and socio-cultural environment. Next, I discuss sociability and complex social systems, and conclude that we probably can expect that an extraterrestrial civilization which we can communicate with has a high degree of social complexity, which entails a high degree of communicative complexity and high degree of cognitive flexibility. Concerning communication, I discuss intention, attention and

communicative complexity. I also stress three socio-cognitive capacities that characterize advanced complex technology: a sustainable, complex social system, with a regulated system for collaboration, such as ethics; complex communication for collaboration and abstract conceptualization; and a high degree of distributed cognition. Finally, if we conclude that intersubjectivity is a fundamental requisite, we then have some options for future interstellar communication. We should target Earth analogues, monitor them, and finally initiate an interstellar intersubjective interaction.

Keywords: altruism, astrobiology, cognition, cognitive science, cultural evolution, empathy, evolution, history of technology, intelligence, interstellar communication, intersubjectivity, joint attention, philosophy of mind, sociability

1. Introduction

When we read texts like this one, when we write, or talk to each other, we interact with someone with intentions, we socialize, have joint attention, we try to reach the other's inner world. What makes this endeavor possible is that we to some extent shared experiences. What we need is intersubjectivity.

When we monitor the skies, listen to the stars, or analyze electromagnetic waves from outer space in the search for extraterrestrial intelligence, we are searching for something that we can understand, can communicate with, that has intentions, is self-conscious and social, has advanced civilization and technology. In return, in interstellar communications, we have to show that we are alive, intelligent and self-conscious. We must recognize that they have attentions and intentions, and they have to recognize that we have it. What is needed is intersubjectivity.

Interstellar message construction and the analysis and decoding of extraterrestrial signals are about searching for "something" or "someone" we can exchange information with. That is, this transmitter or receiver should be "something" that we can recognize as "intelligent". However, it is not enough to say that it has technology to transmit electromagnetic waves. It should also be able to understand and decode our messages, believing that there are intentions behind them, that there are meanings hidden in them; thus, it should have an ability to communicate. So the "thing" we are searching for is in some respects something similar to us, something that we recognize as intelligent and with which we can communicate and exchange knowledge and experiences: i.e., a social and communicating intelligent being with advanced technology. At least four characteristics of such an extraterrestrial life form have thus been presumed in our search: intelligence, sociability, communication, and technology. These characteristics, I would argue, are interrelated and depend on more fundamental cognitive skills.

So the question here is what kind of indispensable cognitive ability is needed for intelligence, sociability, communication, and technology to emerge on a habitable planet? My answer is simple: *intersubjectivity*. In this chapter, I will stress the significance of intersubjectivity, of shared cognition, for extraterrestrial intelligence and interstellar communication, and argue that it is in fact indispensable for any successful interstellar communication, and in the end also for the concepts that are focus of this volume, empathy and altruism in space. Empathy, the knowing of other feelings, and altruism, the knowing of other needs leading to a subsequent unselfish action, as well as intelligence, sociability, communication, and technology, rest on intersubjective abilities of the terrestrial minds, and presumably also the extraterrestrial minds in Universe.

Based on current studies in cognitive science, I will introduce the concept of

intersubjectivity as a key to future search for extraterrestrial intelligence, and then explain, leaning on phylogenetic, ontogenetic, and cultural-historical studies of cognition, why intersubjectivity is a basic prerequisite for the emergence of intelligence, sociability, communication, and technology. Finally, I will propose an interstellar intersubjective interaction for future detections of Earth analogues.

The following argument rests on the belief that we need to focus on the cognitive foundations of interstellar communication, and that cognition and communication are results of the biocultural coevolution. The mathematical, logical and technological constructions of interstellar messages are of limited use if we do not take into account the cognitive basis of intelligence in space, the emergence and evolution of cognitive capacities, how interstellar messages can be cognitively understood, and the cognitive and societal requisites for a sustainable advanced technology. From a general cognitive perspective, I aim to propose new strategies for future interstellar communication. Elsewhere I have discussed the significance of cognitive science as a tool to understand the cognitive challenges the human mind faces in space, and the cognitive foundations of interstellar communication (Dunér 2011a; Dunér 2011b; Dunér 2011c; Dunér 2012; Dunér [forthcoming]). In this chapter I will explore how and in what way intersubjectivity is fundamental for intelligence, sociability, communication, and technology to evolve in space.

2. Intersubjectivity

In contemporary cognitive science, intersubjectivity has become a key concept for understanding not only empathy and altruism, but also intelligence, sociability, and communication. (Gillespie 2009; Hrdy 2009; Gillespie and Cornish 2010; Tylén et al. 2010;

Fusaroli, Demuru, and Borghi 2012; Gentilucci et al. 2012) In its most general definition, intersubjectivity can be explained as the "*sharing of experiences* about objects and events". (Brinck 2008, 116) To be more precise, Zlatev et al. (2008, 1) describe intersubjectivity as "the sharing of experiential content (e.g., feelings, perceptions, thoughts, and linguistic meanings) among a plurality of subjects." The intersubjectivity originates then from a sharing of experiences through actions, and these shared experiences can basically be of three kinds: emotions, attention, and intention. (Stern 1985) Through a process of observations and imitations, the individuals share object-directed actions. According to Peter Gärdenfors, intersubjectivity includes five capacities: representing other beings' emotions (empathy), attention, desires, intentions, and beliefs and knowledge. These capacities have emerged gradually in that order through an evolutionary process. (Gärdenfors [forthcoming]) Empathy, the ability to share others' emotions, according to Stephanie Preston and Frans de Waal (2002), is available to most mammalian species and some birds, which indicates that empathy has old evolutionary roots. Higher order intersubjective skills that we find among humans, such as representing beliefs and knowledge of other beings, are particularly relevant for this present study concerning communication with extraterrestrial intelligence.

The ability to share and represent others' mentality, i.e. intersubjective ability, is an important part of our inner worlds (Thompson 2001; Zlatev et al. 2008). In the phenomenological tradition, empathy and intersubjectivity play a significant role in the experiencing of another person as a subject and the world as a shared world. (Husserl 1973; Stein 1917; Gallagher 2004; Zahavi 2001) Empathy, the representing of other human beings' emotions, motives, intentions and desires, bodily expressions of emotions, beliefs and knowledge, are impossible without a rich inner world. Other species on Earth have

varying degrees of cognitive skills, including awareness of their own subjectivity, their own existence and mental processes, but they seem not to have to the same extent as the species *Homo sapiens sapiens* an awareness of other minds, of other beings' subjectivity. It seems that to be human, or in other words, to be intelligent, is not only to be aware of our own thoughts, but also be aware of others' thoughts, feelings, intentions, etc. According to Zlatev et al. (2008) the quintessence of the human mind is to be a shared mind. Intersubjectivity is what makes us human. I would add that beings, which we would recognize as intelligent in space, would have intersubjective skills, be aware of themselves and of other minds, and be able to share experiences, actions, information and mental content. If they are conscious of other minds they would also be self-conscious, be able to ponder on their own thoughts and existence. We can probably conclude that an extraterrestrial being technologically capable of transmitting and receiving interstellar messages has intersubjective skills. That said, this does not mean that they actually will think like us. There are species-specific capacities for intersubjectivity, based on biological factors, but also as a consequence of societal, ecological and cultural factors. Most likely these extraterrestrial intelligent species would have other bodies, social organization and cultural history.

Even when intersubjective ability is present, an interchange of information will not be easy. Due to our totally different biological and cultural attributes, future encounters with aliens will face severe problems concerning intersubjectivity, in coordinating our inner worlds, feeling empathy, etc. A human and an extraterrestrial will probably also have trouble perceiving the same target, aligning their attention, adjusting their actions, and imitating each other. Because of our divergent evolutions, empathy and intersubjectivity toward extraterrestrials would probably be even more problematic than in the case of inter-

species communication on Earth. What we can hope for is that we might be capable of sharing attention. Among the shared experiences (emotions, attentions, intentions), it is probably primarily sharing attention, joint attention or attentional intersubjectivity that we can hope for. It would be more difficult to understand each other's emotions and intentions, which require more knowledge about the context and history of the other.

3. Cognition

The field of *astrocognition* deals with cognitive processes in space, the evolution of cognitive abilities, and cognition in extraterrestrial environments. (Dunér 2011a; Osvath [forthcoming]) If we are discussing the existence of extraterrestrial intelligence in space, I maintain, we seriously have to take into account the research within cognitive science and affiliated research areas in order to get satisfactory answers to the question: What is needed for higher cognitive skills to evolve? What physical, biological, societal, cultural and other environmental factors shape cognition? What cognitive abilities are needed for a living organism to be able to manipulate its environment or, in another words, to develop technology?

3.1. Cognitive flexibility

What is intelligence? In the search for extraterrestrial intelligence, we should at least have some ideas of what kind of phenomena we are looking for. (Regis 1985) I do not think we need to have, or even could have, an Aristotelean definition, a finite set of necessary and sufficient qualities, because we do not know what we will encounter and an openness in our definition would be a necessary strategy when encountering the unknown. Instead, in line with a prototype theory (Rosch 1975; Rosch 1978), we should discuss what kind of

qualities we are looking for, qualities that we can recognize. I think we should not avoid this question, as it is sometimes in the interstellar communication literature. The famous Drake equation for estimating the number of civilizations in our galaxy with which communication is possible, does not define what we mean by that "intelligence" we are searching for. Rather, it has an operative definition and just looks for a civilization able to transmit electromagnetic waves. "Intelligence" is, in that sense, "the ability to transmit electromagnetic waves". This is of course not what we mean when we recognize something as "intelligent" in ordinary life. Nor is it sufficient. A satellite can contact us and receive message from us, but it is not intelligent. Rather, it is a cultural product or extended tool of an intelligent being. If we want to exchange information with an extraterrestrial civilization, it is not enough that the "intelligent" being is able to construct advanced devices; it should also be able to communicate, to share experiences through a medium. This kind of intelligent being needs to have intersubjective skills.

The definition of intelligence has been the subject of a lively debate (Sternberg 2002) and has often been connected to problem solving. Intelligence as the ability to solve problems, to make rational choices, to reason logically, to handle the constraints and limitations of time, space and materials, is not enough to explain the development of technology for interstellar communication. The social constraints are missing. Intelligence is an adaption to the physical *and* social environment. As a broader concept, cognition includes not just the abilities that we call rational, logical or intelligent. An important part of what it is to be intelligent is to have emotional skills, a capacity to emotionally appraise the relevant environment with attraction, disgust, etc., and to respond to socializing, bounding, coupling, etc., in a social group. Emotions are shortcuts through competing options, a faster way to decide, instead of calculating all of them. (Frank 1988; Damasio

1994) As Darwinian creatures, extraterrestrials would probably have emotions and feelings, longing for some things, dislike other things, just like us.

I would pinpoint just two features (among many other possible ones) that we find in that we call "intelligent". Firstly, it can imagine things not existing—things, events, etc., not present in time or space right in front of the thinking subject. An intelligent being can test various options or "simulate" events in its mind, instead of doing it in the world outside the brain. Secondly, an intelligent being is also able to engage in intersubjective interactions, understand other minds, imagine and envision what they will do, what they feel and reason. To be intelligent is to have intersubjective skills, to be able to understand and make interferences about other minds. If the extraterrestrial being that we encounter is lacking these two abilities, it would probably not have complex communication and advanced technology, and we would not be able to communicate with it.

To conclude, in the most general sense I would say that "intelligence" is cognitive flexibility, an ability to adjust to changes in the physical and socio-cultural environment. Intelligence can be seen as evolved mental gymnastics required to survive and reproduce within a specific environment. This includes the capability of representing activities and being able to make inner models of reality and other minds. "Intelligence", and in our case "extraterrestrial intelligence", is a rather misleading and narrow concept, too connected to problem solving and rational reasoning, and does not include other mental abilities that are indispensable for a life form to have civilization, culture, and technology. Thus, instead of searching for extraterrestrial intelligence, we should search for extraterrestrial cognitive flexibility, especially extraterrestrial intersubjectivity.

3.2. The evolution of cognition

It is evident that cognitive flexibility has evolutionary benefits and can be regarded as a good strategy for the adaptation to a changing environment. “Intelligence is an adaptation”, Jean Piaget wrote, “To say that intelligence is a particular instance of biological adaptation is thus to suppose that it is essentially an organization and that its function is to structure the universe just as the organism structures its immediate environment”. (Piaget 1963) The mental life of an organism is an accommodation to the environment.

Intelligence or cognitive flexibility has emerged through an evolutionary process due to its benefits for survival, orientation and adaptation to a variable environment in a Darwinian struggle for existence. Intelligence is thus the ability to respond to changes in the environment with flexibility and success, and a plasticity of learning, i.e. be able to learn from experience. As we know it, we can presuppose that the phenomenon we call “life” and are searching for in outer space, has experienced a Darwinian evolution, including variation, heredity, and selection. With their senses, Darwinian creatures explore their environment, orientate in it and search for sources, under a selection pressure leading to different capacities for its specific ecological niche. (Gibson 1979; Gärdenfors 2003) This cognitive flexibility, it has to be emphasized, is also a fruit of the pressure from the socio-cultural environment. In other words, intelligence, or rather cognitive flexibility, is a result of the biocultural coevolution of the embodied minds that are interacting with their physical and socio-cultural environment. Extraterrestrial minds, like terrestrial minds, have adapted to their specific environment and the specific social interactions between the minds of their species.

Living creatures have to tackle a variable and changing environment, cope with the abundance of information in the environment, sift through the mass of data, make decisions of what is relevant or not, and find out how these pieces of data relate to each other.

(Thornton, Clayton and Grodzinski 2012) In complex environments, it is advantageous not just to take statistical co-occurrences into account but also to try to find general rules and then be flexible and able to solve various problems in different contexts, and further to be able to make mental representations or models of how the world works. By simulating events in their brains, living creatures prepare for actions not yet occurred.

There are reasons to believe that under the right circumstances this environmental pressure will lead to more complex and flexible cognitive abilities. We cannot, though, presuppose that intelligence is a necessary outcome of evolution. Ernst Mayr (1985) expected the probability of intelligent life to evolve to be very low. The benefits of acquiring improved cognitive abilities have to be balanced against the costs of having an energy-consuming brain. But on Earth we find that intelligence seems, like vision and other abilities, to have emerged several times in the course of evolution and in separate evolutionary lines, i.e. convergent or parallel evolution. (Seed, Emery and Clayton 2009; Osvath [forthcoming]) The more intelligent or cognitive flexible species on Earth, such as primates, dolphins, and corvids, seem to have some qualities in common: First, they are social and have a high degree of social complexity; and second, they are "all-round," multi-adaptable to very different environments and diets. (Osvath [forthcoming])

If we can come closer to an understanding of the processes behind the rapid brain evolution that began a few million years ago on Earth—the encephalization in the Phanerozoic (Carter 2012)—we can use this knowledge to formulate astrocognitive theories. The evolution of human intelligence is part of a general process of greater encephalization (Bogonovich 2011), or the increase brain size relative body size, over time. The social-brain hypothesis (Dunbar 1996; Dunbar 1998) says that there is a correlation between the size of an animal's social group and the size of its brain, leading to the

conclusion that social behavior drives encephalization.

The complex social structure of the group is probably a very important drive for the emergence of intelligence. The brain has increased in capacity in order to tackle different kinds of social relations. The difference between humans and other primates is the state of the socio-cognitive capabilities. Humans engage with others in joint activities that share goals and attention, which facilitate the use of linguistic symbols and the creation of cultural norms. (Tomasello et al. 2005; Herrmann et al. 2007; Thornton, Clayton and Grodzinski 2012) But must we suppose that the extraterrestrials also are social creatures? Could it be possible that the intelligent "it" we are communicating with is a solitary phenomenon, a "Solaris", an end of an evolutionary process? Not likely. For the selective evolutionary process to give rise to higher cognitive flexibility, we have to suppose a variation of distinct genetic units that are flexible enough to quickly adapt to environmental changes.

The biocultural coevolution, in respect to long-term processes and different environmental pressures, will probably make extraterrestrial cognitive abilities and intelligence very different from ours. But if there are intelligent (or rather cognitive flexible) beings in space, we can then probably suppose that they are social and multi-adaptable to different environments, that through the course of their biocultural coevolution have acquired capacities to handle and orientate themselves in their environment, both in their physical environment, but perhaps even more importantly in their social environment. They need to be able to handle complex social relations, to understand other individuals' feelings, thoughts, attentions, intentions, etc. In short, they need intersubjectivity. At least among themselves they would most likely show various degrees of empathy and altruistic behavior in order to orient themselves as social beings in the group. The question is then,

would they show empathy towards other forms of life?

4. Sociability

Intelligent species are social species. Human society is a complex environment that requires cognitive flexibility in order to survive. Individuals need to understand and keep a check on what the others' are doing, thinking and feeling. In return, sociability and the social context enhance the adaption to the physical environment, and make the individuals less vulnerable to a hostile environment. The sociability is advantageous to the individuals themselves as well as the group in its entirety. These social skills cannot subsist without a cognitive capacity to understand, feel and share experiences of other minds.

4.1. Cultural evolution

Characteristic of this human social interaction is the ability to learn from others, i.e. *culture*, the transmission of learned behavior and knowledge that is not biologically encoded, or in other words, the ability to transfer information from generation to generation that does not use the genetic code for the transfer but is learned, taught, and transferred by a multitude of communicative and cultural devices and artifacts, like language, signs, pictures, sounds, objects, etc. Culture presupposes enduring joint beliefs or common knowledge. Significant for human cognition is the infant's prolonged period of dependency on its parents, in order to learn skills, behaviors, attitudes, knowledge about the environment, etc., that are not contained in the genetic code, but are indispensable for a flexible and less-vulnerable existence as an adult. Culture is also dependent on an alloparental care, a system where individuals others than biological parents take the parental role, which can be regarded as an altruistic behavior for the benefit of new generations. What makes us human is to a large

extent our propensity for imitation and seeing motivations of others. (Calcagno and Fuentes 2012) That is our ability to see things from the perspective of our fellows.

We probably have to assume that social and cultural skills, and in the end a complex social system, play a significant role if we want to explain the evolution of intelligence, communication, and advanced technology in space. Theories discussing the cultural evolution in space are very much needed. (Dick 2003; Vakoch 2009) Biological theories of the evolution of cognition are of course important, as I have maintained earlier in this chapter, but we should also discuss, the "post-biological" cultural evolution leading to technological civilizations. The social, cultural, educational skills are fundamental prerequisites for the survival and technological development of an extraterrestrial civilization. We can expect that an extraterrestrial intelligence has developed intricate social interactions, a complex social system, that enhances their chances of survival, not just for the individuals, but more importantly for the entire biosphere. And furthermore, if we succeed in interstellar communication, we will in fact socialize with extraterrestrial social beings, and this will demand that we both have advanced social skills and a flexibility to handle and understand very different ways of organizing the social interactions.

4.2. Complex social systems

Humans and other intelligent species on Earth have more or less complex social networks. There are reasons to believe that social complexity has been the driving force behind the emergence of intelligence, brain size and communicative complexity. Complex social worlds are like selective environments, driving species towards increased cognitive processing ability, that in its turn leads to higher social complexity, and when social

complexity increases, it give rise to a greater selection pressure on individuals for cognitive skills, that feedback producing even more social complexity and so on. (Bogonovich 2011)

In Complex social systems "individuals frequently interact in many different contexts with many different individuals, and often repeatedly interact with many of the same individuals over time." (Freeberg, Dunbar and Ord 2012, 1785; Freeberg, Ord and Dunbar 2012) A complex society contains a large number of interacting individuals. These individuals are of different types and take different social roles. Furthermore, the interaction between individuals has a high degree of diversity. A large number of individuals interact in many different contexts and often with the same individuals.

An "advanced" society, or a civilization with advanced technology, is a complex social system. We can probably expect that an extraterrestrial civilization, which we can communicate with, has a high degree of social complexity, which entails a high degree of communicative complexity and high degree of cognitive flexibility. Such a socially complex extraterrestrial civilization would have 1) many individuals rather than few; 2) a high rather than low density; 3) many different member roles rather than few roles; and 4) an egalitarian structure rather than a hierarchical structure.

These four characteristics of social complexity will enhance the emergence of advanced technology. Many individuals entail greater collective brain power. A high density entails more frequent and faster interactions between individuals. Many different member roles entail a distributed and specialized cognitive processing. And finally, egalitarian societies have greater diversity of directional relations and more reversals and agonistic interactions. In hierarchies, there are fewer relationships between individuals, and the directional relations are severely limited. Because of this greater diversity in relations, the communicative complexity of egalitarian societies is greater than in despotic systems.

It is more likely that a long-lasting advanced extraterrestrial society is egalitarian than despotic. Firstly, an egalitarian society with distributed decision-making is better adapted to the physical constrains of the universe. To be dictator in the huge time and space-frames of the universe is rather difficult. Hierarchical systems are impractical in space, where the huge distances will make orders from despot to subordinates take a very long time to arrive, in contrast to egalitarian, distributed decision-making. In the history of colonial empires on Earth we find many examples of the difficulties of holding power and the empire together over longer distances. A society with distributed decision-making is more flexible, better able to change and less vulnerable to disturbances in the communication network. Secondly, if an extraterrestrial civilization has survived for a longer period of time, it must have found ways of dealing with agonistic behavior and conflicts (cf. Pinker 2011), and have developed reliable collaborative systems for overcoming physical and societal threats. In order to deal with destructive behavior, these civilizations must have advanced intersubjective skills to understand other subjects, must have a high degree of communicative complexity to sustain and strengthen the intersubjective interactions between its members, including long experience of communicating with a diversity of groups and species, and must have arrived at some sort of reliable "ethics" or regulation system for behavior.

5. Communication

Communication is in its quintessence social, something communal rather than private. Some authors have supposed that social complexity leads to communicative complexity. According to the "social complexity hypothesis" for communication, "groups with complex social systems require more complex communicative systems to regulate interactions and

relations among group members." (Freeberg, Dunbar and Ord 2012, 1785) If we receive a complex message, or a complex artificial signal, from outer space, we then have reasons to believe that the transmitting civilization has a complex social structure (and accordingly also intelligence).

Interstellar communication is, like spoken human languages, intersubjective, as a system for sharing information and for socializing. Communication can be regarded as a sharing of mental states, and the expression as information about a mental state. (Østergaard 2012) The semantics is based on a "meeting of minds", as Gärdenfors puts it: "the meanings of expressions do not reside either in the world or (solely) in the mental schemes of individual users, but emerge from *communicative interactions* between the language users." (Gärdenfors [forthcoming]) The evolution of semantics could be seen as a coevolution of intersubjectivity, cooperation, and communication. (Gärdenfors 2008a, 2008b) In linguistics and cognitive science, probably no-one would deny that intersubjectivity plays a critical role in the acquisition of language, but it has still not been discussed in the context of interstellar communication.

Elsewhere I have discussed the cognitive foundations of interstellar communication (Dunér 2011b), and maintained that communication is based on cognitive abilities embodied in the organism that has developed through an evolutionary and socio-cultural process by interacting with its specific environment. (See also Arbib [forthcoming]; Holmer [forthcoming]) In the following I will dig into this further, and discuss one of the most crucial cognitive abilities for language acquisition, i.e. intersubjectivity. Communication presupposes shared knowledge, or perhaps better, shared experiences.

5.1. Intention

I want you to react in a certain way. That is why I send this message. And I have, like we all have in ordinary everyday communication between humans, some ideas of what kind of response our messages might get. There are intentions behind our messages. A communicative intention means that the sender's utterance is meant to produce a particular response, and that the receiver recognizes that the sender intends. (Grice 1989 [1957])

By sending a message, the sender has some idea about how other minds will receive it. The problem is, when we transmit a message to an extraterrestrial civilization, we do not know if they will respond to it. Neither do we have any idea of how they will respond. Intersubjectivity is lacking. We want to achieve something more than just sending a message and not knowing if it is received. My intention in writing this chapter is not just to send a message to an unknown addressee, but to elicit a response, even though I am well aware of that few of us are lucky enough to get response. Thus, at least a third order intention is what is needed in true interstellar communication—in other words, we should know that they know that we know them, by transmitting a message saying: "We are doing this communicative act to you, just you," that they believe is an intentionally sent message aimed to generate a response.

5.2. Attention

All successful communication requires intersubjectivity, an idea of the interlocutor's mental state. The communicating subjects need to know what the other is referring to. The interpreter has to make assumptions about the state of the interlocutor's knowledge, attention, feelings, etc., and then adjust to what he or she thinks the other thinks. These intersubjective interactions are based on common experiences or shared actions. When communicating, communicators need to have shared devices for sharing and manipulating

attention. In conversations between humans, we constantly monitor each other's attentional status. There are strong arguments, according to Michael Tomasello (2005), that an infant can understand a symbolic convention only if it understands its communicating partner as an intentional agent with whom one may share attention toward something. A linguistic symbol can in that case be said to be a marker for an intersubjective and shared understanding of a situation. Sign use is in other words social, intersubjective, a sharing of meanings. Imitation and shared attention proceeds, phylogenetically and ontogenetically, other more complex communication systems involving iconic and symbolic signs. (cf. Kita 2003; Oller and Griebel 2008; Andrén 2010; Lenninger 2012)

To achieve mutual understanding in interstellar communication, we need to establish an intersubjectivity that could lead to the possibility of entering the others' inner thoughts and views of reality. It is crucial to find out whether the others are, like ourselves, intentional agents, so that we in that case could relate to their world, and have perspectives on our worlds that can be followed, directed, and shared.

5.3. Complex communicative systems

In order to reach more complex communication, we first need not just attention, imitation and iconic signs, but also have to use symbolic signs—conventional or arbitrary signs that are detached representations and, as such, dependent on culture and human interaction. If the extraterrestrials are intelligent, they probably have some kind of symbolization abilities and abstract thinking detached from the environment, with which they can reason about things not existent, things that are not right in front of them, facing their senses, in a specific moment in time. In other words, to reach a higher degree of communicative complexity, they need signs where the expression is separated from the content. Symbolic

signs are characterized by this constraint, as Göran Sonesson has shown, makes it nearly impossible to use symbols for interstellar communication. (Sonesson [forthcoming]) Even if we agree with the content (for example about mathematics, physics, chemistry, etc.), we could have very different ways of expressing this content. So, even though we cannot decode and understand their symbolic messages, they must show that they have it. Secondly, complex communicative systems contain "a large number of structurally and functionally distinct elements […] or possess a high amount of bits of information." (Freeberg, Dunbar and Ord 2012, 1787) A complex communicative system shows a large repertoire of distinct signals.

To conclude, in the presumably artificial signals from outer space we have to look for: 1) symbolic signs, and 2) signaling complexity. These two characteristics of complex communicative abilities can indicate that we are receiving a message from an extraterrestrial intelligent civilization.

6. Technology

Advanced technology can be defined heuristically as technology for interstellar communication. Technology in general could be described as ways of manipulating the environment, using objects in the environment outside the body in order to strengthen the genetically given capacities, such as body strength, perception, and cognition.

Technology is not just applied science. It is a misconception that technology is an application of scientific theories, a product of the rational, inventive mind. An innovation needs a larger innovation system, including many people with different roles, technicians, designers, investors, lawyers, marketers, etc. It is not enough to have a new bright idea. To become an innovation, the technological invention has to be used, to be an answer to the

needs of a society. Technology is to a large extent a social phenomenon, a product of the cultural evolution. One of the most challenging factors in the Drake equation is f_c, the fraction of intelligent civilizations that develop technology for interstellar communication. (Sagan 1973) This factor actually concerns the cultural evolution of technical civilizations; or, to put it in another way, what is needed for an intelligent life form to evolve advanced technology? To answer this question we have to turn to studies in the evolution of cognition, how hominids began using and manipulating their environment, and to studies in the history of technology, how the cultural evolution of *Homo sapiens sapiens* made it possible to achieve higher technology. (Donald 1991; Tomasello 1999; Steels 2004; Richerson and Boyd 2005) The rise of civilization involved closeness, interaction of many individuals, exchanges of ideas, products, and experiences that paved the way for a technological society.

In order to achieve advanced technology extraterrestrial life forms need to have complex social structure, complex communicative skills, high degree of distributed cognition, sustainable society, and well-developed intersubjective abilities. Technology is not a matter of science, rational reasoning alone; intersubjective skills are completely indispensable.

6.1. Advanced technology

If we are searching for extraterrestrial civilizations (Vakoch and Harrison 2011) with advanced technology, i.e. technology for interstellar communication or other devices for reaching beyond their home planet, we also have to discuss what makes advanced technology possible. I would like to stress three socio-cognitive capacities that characterize advanced complex technology and that are crucial for the development of it: 1) a sustainable complex social system, with a regulated system for collaboration, such as

ethics; 2) complex communication for collaboration and abstract conceptualization; and 3) a high degree of distributed cognition. All these three capacities require intersubjective skills.

Cooperation is what makes higher technology possible. Cooperation in its turn requires some fundamental cognitive and communicative functions. (Leimar and Hammerstein 2001; Bowles and Gintis 2003; Richerson, Boyd and Henrich 2003; Fehr and Fischbacher 2004; Stevens and Hauser 2004; Kappeler and van Schaik 2006; Lehmann and Keller 2006; Gärdenfors 2008b; Tomasello 2009; Cheney and Seyfarth 2012) All the three factors mentioned above (complex social system, complex communicative system, and distributed cognition) enhance such cooperative behavior towards higher technology. In many cases basic cooperation—for example, flocking behavior and the way of increasing cooperation by separating members of the in-group from the out-group among non-human animals on Earth—requires just limited cognitive capacities and no communicative skills. More advanced forms of cooperation, as we find among humans, as Gärdenfors (2012, 165) argues, "presuppose a high awareness of future needs, a rich understanding of the minds of others, and symbolic communication."

First, concerning a sustainable complex social system: Cooperation about detached non-present goals requires advanced coordination of the inner worlds of the individuals. In order to achieve advanced technological skills, the individuals have to cooperate in joint activities where they are sharing goals and attentions. By coordinating their roles when working towards a specific goal, they achieve a joint intention. To this we can add that they must be able to engage in prospective planning, to anticipate the future, i.e. have the capacity to represent future needs, a prospective thinking or "mental time travel" (Suddendorf and Corballis 1997; Roberts 2007). An extraterrestrial civilization capable of transmitting

messages for a long period of time, and which has perhaps more advanced technology than we do, must have survived and be capable of avoiding disasters and crises in their history, such as those that we face — nuclear war, global warming, pollution, decreasing biodiversity, etc. This indicates that they have a functioning social structure that can handle and avoid crises, a complex social system that regulates risks and destructive behavior. It is easier to develop advanced technology for destruction than an ethics for survival. It is easier to understand the laws of physics and chemistry than to understand and predict the human mind and the complex social and cultural interactions of humans. The question of the L-factor, the life-span of advanced technological civilizations, deals with this bottleneck. (Sagan 1973; Shostak 2009; Denning 2011) Longevity, sustainability and technological growth as well as regulatory systems for behavior (ethics) are linked together. Civilizations develop technology for destruction before they develop a sustainable ethics. If a civilization has advanced technology, which needs cooperation between large numbers of individuals, they have to be able to trust each other; some sort of ethical consent has been established.

Second, a complex communicative system is needed in order to handle the social complexity, to facilitate collaboration, to transfer information between the individuals, which in its turn are indispensable for the development of technology. The communicative system must enable the users to construct abstract concepts and symbols, to generalize, to discuss things and events not existent, that have ceased to exist, and have not yet have come into being.

A third factor important for the emergence of higher technology is distributed cognition, the ability to use external objects and minds to enhance thinking. The ability to construct external cognitive artifacts is significant in human cognition. (Norman 1991; Norman 1993;

Malafouris and Renfrew 2010; Malafouris 2012) These organism-independent artifacts compensate for the limitations of the biological memory. As such, they are part of our distributed cognition. Gradually through human cultural history, the externalization and materialization of memory have increased, from the art of writing, to the printing press and Internet. (Cf. Donald 1991; Donald 2008) We have invented more devices strengthening our inborn sensory equipment and more devices for thinking. We are using our environment to think, and distributing our thinking to physical objects, but also to other minds. A diversified, specialized distributed cognition has some radical advantages for developing complicated and thought challenging technology. Constructing advanced technology involves a large number of people. The famous Manhattan Project that led to the first atomic bomb included more than 130,000 people. A technologically-advanced civilization cannot rest on the brain power of a few individuals, but needs as many as possible sharing their knowledge, cooperating, and completing different specialized tasks.

To conclude, if there are intelligent beings able to communicate with advanced technology, they would probably have a complex social system, complex communications, and a high degree of distributed cognition, and needless to say, intersubjectivity.

7. Conclusion

If we succeed in transcending the insurmountable moats of the immense distances of light years between the stars, we will confront the next problem, the cognitive and semiotic problem of interstellar communication. Interstellar communication is a dyadic interaction. The question is if this interaction will be an asymmetrical and hierarchical relationship. This is what Stephen Hawking and others have feared. In other words, are there different ethical standards, different scopes of inclusion in the ethical community (Persson 2012), are

the an asymmetry in respect to knowledge, science and technology? Recent phylogenetic, ontogenetic, and cultural-historical studies clearly show that intersubjectivity is an indispensable requisite for the evolution of human intelligence, sociability, and communication, as well as advanced technology. If so, then intersubjectivity is important for any future interstellar communication. In the following, I will explain how this knowledge can be used in an interaction with a future extraterrestrial interlocutor.

7.1. Future candidates

Earlier I suggested that an interstellar message should not be a general, abstract message, but a concrete message tied to the spatiotemporal setting. (Dunér 2011b) In this chapter I also suggest that we should search, for heuristic reasons, for an extraterrestrial being similar to us. To begin with, to enhance the feasibility of communication with an extraterrestrial intelligence, we should choose a habitable planet with similar physical appearance. In this section, I will give some suggestions of how we can focus our search, and what targets we could select as future candidates for communication.

Our chances for functioning communication increases if we search for and construct messages aimed for an intelligent extraterrestrial species similar to us, a social creature adapted to an equivalent physical environment. This would probably also enhance our ability to recognize the signal as an artificial message. What I propose is not an analogical argument, suggesting that they necessarily are like us. Intelligent beings in outer space might be very different. Searching for extraterrestrial cognitive flexibility could instead be seen as a heuristic approach. The probability for a fruitful exchange would be greater if we formulate our message for a species that has evolved under similar circumstances, and is similar to us. In addition (Dunér 2011b), we should not only tie the message to the

spatiotemporal situation, and formulate a non-symbolic message, but also try to communicate with something similar to us in order to increase the possibility to mutual comprehension.

I would suggest three steps in a road map towards an interstellar intersubjective interaction. First, we should search for Earth analogues, i.e. Earth-like exoplanets within the habitable zone (Kane and Gelino 2012) around solar-type stars (a G2 main sequence star of 4.5 Gyr of age)—in other words, exoplanets with similar magnitude, physical and orbital characteristics (period, eccentricity, inclination, etc.), gravitation, atmosphere, chemistry, temperature, etc., as Earth. Hopefully, such candidates would be detected in the near future. (Fridlund et al. 2010.) If we believe that cognition is somehow and to some extent related to and adapted to the physical environment, we could expect that similar environmental pressures would lead to similar cognitive adaptions. That is why Earth analogues would be particularly interesting. The extraterrestrial intelligent beings' perceptual system and cognition have adapted to regularities in their physical environment such as planetary motion, gravitation, light, radiation, atmospheric conditions, chemistry (water, minerals), etc. The organisms are adapted to their specific environment; their sensory equipment has evolved in order to facilitate the orientation in and interaction with it. This environment-specific sensory ability leads to environment-specific cognitive abilities and conceptualization of the world. In other words, different environments mean different sensory modalities, which in its turn mean different conceptualizations of the world. (Jonas and Jonas 1976) The possibility of sharing experiences with an extraterrestrial intelligence will be enhanced if we share similar physical environments, and thus similar selection pressures. If we are very different from each other, with brains adapted to completely different environments, we would to some extent have different

views of the “reality”. The “reality” is not objective, in the sense that our view of it is independent of our bodily constitution, our senses, cognition, etc. The sensory impressions from the “reality” must in some way be processed before it becomes something we can think about. The view that there is only one “reality”, might be too simplistic, defending that there is a “reality” that is objective and intelligible, where the laws of physics and mathematics are objective, transcendental and universal, everywhere the same, no matter who is actually perceiving the “reality” that transcends our existence as embodied, perceiving, thinking beings living in the world. As Douglas Vakoch (2011) captivating mountain metaphor, different civilization might have taken different paths to the summit. There is not one single way of conceptualizing the world. “Science” or conceptual representations of the “reality” might have taken very different paths in different contexts. In line with this challenge to the universality principle of science (Rescher 1985), I think that the reason for this divergence is the human embodiment, the enactive mind’s interaction with the environment, which means that our views and conceptualization of the world cannot be separated from our idiosyncratic biology, ecology, and culture—whom we are, where we are, and where we come from. By communicating with an extraterrestrial intelligent civilization and getting their view on reality, we will find out if our “objective” view of reality is shared with thinking beings other than our own species.

Second, we should monitor these Earth analogues for a period of time, analyzing their 1) electromagnetic leakage, and 2) the absorption spectrum of its atmosphere. First of course we turn our radio telescopes towards these candidates and listen. If electromagnetic leakage be detected, we have to determine if it might be artificial, i.e. a voluntarily transmitted message of a cognitive flexible life form; and second we have to develop methods for detecting communicative or signaling complexity, i.e. search for a great diversity of

elements of the signaling system. The second monitoring strategy would be absorption spectroscopy. (Kaltenegger et al. 2010) First of all, of course, would be to look for biomarkers, and by analyzing the chemistry and composition of these candidates' atmospheres, we might detect signs that reveal the environmental conditions of that exoplanet. Life on Earth exists in equilibrium with the rest of the planet in, for example, the case of the biomarkers oxygen and methane. A non-periodic rapidly-changing chemical equilibrium might indicate a decline in habitability. Granted, of course, that we know what the normal conditions are like at the monitored planet, we could accordingly develop methods for determining the sustainability and stability of its atmosphere, if there are signs of environmental disasters, rapid climate change, greenhouse effects, low biodiversity, radioactive leakage and other indications of unfriendly circumstances for life. In other words, we need methods of detecting artificial, unstable pollution in the spectrum of their planetary atmosphere or other "technomarkers" that are indicators of artificial non-periodic chemical processes. If we can find out if they have a sustainable and stable atmosphere (at least not polluted in a similar way as our planet)—this could indicate that they either has not evolved advanced technology yet or they have gone through the bottlenecks of their civilization. In both cases they should be rather benign. If so, we should not fear to continue to step three, to construct an interstellar intersubjective interaction directed to just them, tightly connected to the situation in time and space. On the other hand, if it turns out that they have an artificially affected unstable environment, this can indicate that they have rather primitive altruism. Silence, might then be recommended.

7.2. Interstellar intersubjective interaction

Instead of formulating an abstract, universal, symbolic message, I suggest that we do

something together. To be more precise, I propose interaction tightly connected to the spatiotemporal setting, i.e. trying to establish *joint attention* (Tomasello 1999; Moore and Dunham 1995) by context-specific signals. We would then develop a mutual referential behavior, directed gaze or mutual gaze, by pointing to an object or spatial location, for example with a laser pointer, and checking if the recipient attends to the same object or location. In its turn, the recipient checks if the pointer notices the recipient's attention. The option is thus to try to tune in our spatial organizations, and together observe things observable to both terrestrials and extraterrestrials. For example, we can use certain astronomical landmarks or periodic events in their neighborhood, or in our own near environment, to which we can direct our joint attention—for example, as has been earlier suggested with reference to known pulsars in the neighborhood, as the Pioneer plaque represented the sun's relationship to 14 known pulsars. Or the nearby Andromeda Galaxy, which, as Carl Sagan noted, would be the only object that both the recipients and we could see first-hand. Even better, I would say, is to choose closer targets for joint attention that cannot be confused. Everett M. Hafner proposed transmissions simulating astronomical objects—for example the fluctuation of the sun's cycle back and forth between the stars (Hafner 1969; Vakoch 1998). The sounds of geological activity, such as volcanoes, earthquakes, thunder, and ocean waves, included in the Voyager recording (Vakoch 2009), are something we both might experience if we both hear in the same frequency range under same atmospheric conditions. By using such indexical references toward some concrete phenomena in the physical environment, we do not need to presuppose a universal science that we should have in common, and do not have to point to our models of the phenomena. Instead, we firmly connect our interaction in physical reality. If we succeed in this, we will have taken a crucial step toward an interstellar intersubjectivity.

Joint attention or "attentional intersubjectivity" is the case when "two or more subjects simultaneously focus their attention on the same target". (Brinck, Zlatev and Andrén 2006, 1; Brinck 2001) The target can be an object, an entity that has a position in space and time, or in a wider sense, events in space and time. A target can also be a spatial location (for example, a place to go to), or a direction (for example, the way to go). What characterizes a target is that it is an object for an undivided attention of one or both subjects. This attention can be symmetric (the target is noticed by both subjects) or asymmetric (the target is initially noticed by just one of the subjects and then the other subject aligns its attention). According to Brinck, Zlatev and Andrén (2006, 4), there are three levels of attentional intersubjectivity of increasing complexity: synchronous, coordinated, and reciprocal. Synchronous attentional intersubjectivity occurs when participants are "performing similar individual actions relative to a single target in the same spatiotemporal context". This is not a social behavior, because their individual actions are performed independently of each other. Co-ordinated attentional intersubjectivity occurs when the subjects are "adjusting their actions relative to a single target." This behavior is social and can be interactive, i.e. their actions directly affect the other. Finally, reciprocal attentional intersubjectivity is when subjects are "mutually matching their actions relative to a single target". This behavior is a more complex interactive behavior.

This is what we can hope for in an interstellar intersubjective interaction, an attentional intersubjectivity of various sorts following the typology of Brinck, Zlatev and Andrén (2006). A simple case could be an asymmetric synchronous attentional intersubjectivity: We, the terrestrial intelligence, *T*, focus our attention on the target, *t*. The extraterrestrial intelligence, *E*, is attracted by our attention focusing. *E* then follows our orientation to *t*, with the result that both of us focus our attention on *t*. (See fig.) The case could also be the

other way around where *E* initiates the attentional intersubjective episode: that *E* focuses its attention on *t*; we notice that *E* focus their attention on *t*; and we follow their orientation to *t*. Even better would be a social coordinated attentional intersubjectivity: We focus our attention on *t*, and ostensively focus on *t* and engage in referential behavior towards *t*. Then *E* notices our referential behavior, which leads to *E* following our attention and referential behavior and notices *t*. The goal would be to engage in a reciprocal attentional intersubjectivity, where *E* attends not just to our attention to *t* and vice versa, but to a third-order attention (Zlatev 2008) in which *E* attends to our attending to *E*'s attention and vice versa. By a referential behavior towards a target that only they can see from their position, and which is hidden to us—for example an eclipse or a transit of a planet between their planet and their star, which they will know that we know what they observe.

The benefit of this interstellar intersubjective interaction is that it will create 1) a common experience about an object or event. We both will have an unambiguous conception of the very same object, a common reference, that we both have turned our attention to, and we both will know that the other know what that object is. From this shared experience, we can begin a conversation about the object we direct our attention to; we can compare our views, learn from the other's view, and find what we have in common or not. Interstellar intersubjective interaction would hopefully be an unambiguous starting point for future interstellar communication. An interstellar intersubjective interaction will have the further advantage of focusing on 2) the prelinguistic semiotic stages in the phylogenetic and ontogenetic development of communication, an intersemiotic communication of attentional intersubjectivity, of iconic and indexical signs, rather than the more complex sign use, such as using abstract, arbitrary and detached symbolic messages. 3) The interaction will not be an information transfer as such, and thus be a rather

"ecological" encounter that just triggers a response. Finally, 4) the content of the message will not be some presupposed universal abstract conception or "fact," but solely the intention to communicate.

7.3. Altruism

In this chapter, I have argued that there is a certain cognitive ability, namely intersubjectivity, that is fundamental for intelligence, sociability, communication, and technology. Intersubjectivity is a sine qua non for interstellar communication. We can expect that if we find a civilization with advanced technology, its members would have some sort of intersubjective skills. If they have intersubjectivity, they would also show empathetic and altruistic behaviors towards at least some of their conspecifics. Some basic *reciprocal altruism* (Trivers 1971; Trivers 2006)—"scratch my back and I'll scratch yours"—would be expected, a strategy for cooperation that needs the ability to recognize individuals and a memory of previous outcomes. But among humans we find much more advanced forms of altruism, such as *indirect reciprocity* (Leimar and Hammerstein 2001; Nowak and Sigmund 2005), in which a person can help another person, without expecting help from that person, but from someone else. Humans also use commitments, contracts, and conventions in cooperation. The question is, will we be included in their altruistic domain? If they have survived, have been able to develop a sustainable environment, a stable society, and an ethics, they might have achieved an empathetic and altruistic behavior towards other life forms, a behavior that can handle agonistic and destructive behavior, inequalities and asymmetry. An altruistic or "ecological" behavior might be to leave the other less- developed civilization alone, not engage in interstellar communication, and let the other develop without interference. They might say to themselves that our

species is not ready for intergalactic integration, as has been suggested as a solution to the Fermi paradox, the so-called "zoo hypothesis". (Ball 1973; Baxter 2001; cf. Haqq-Misra and Baum 2009) We can be rather sure that if a message comes through, it will change the other culture. From our own history, we learn that cultural encounters and information transfers always include an asymmetric relation due to different experiences. And that is what communication is about, to share experiences.

Another question is this: are we in our present state are able to send an altruistic message? Mathematical and scientific messages do not entail signs of altruism, and the level of our civilization shows obvious problems in altruistic behavior. So it can be argued that is not we (and Hawking), but the extraterrestrials, who should be afraid. We cannot just claim that we are altruistic—we have to show it, we have to prove it—and that we cannot, I am afraid, in the present time, with agonistic behavior, environmental problems, decreasing biodiversity, etc. Even though our situation might be improving, we are not there yet. This terrestrial intersubjective altruism is something we can work on, whether or not any extraterrestrial intelligent civilization exists.

The author:

David Dunér is associate professor of history of science and ideas at Lund University, Sweden, and researcher at the Centre of Cognitive Semiotics, Lund University. His research concerns the development of science, medicine, mathematics, and technology in the scientific revolution and onwards. His latest book is *The Natural Philosophy of Emanuel Swedenborg: A Study in the Conceptual Metaphors of the Mechanistic World-View* (Dordrecht: Springer, 2013). He is studying the history of astrobiology, and was guest editor of the special issue "The History and Philosophy of Astrobiology" of *Astrobiology*

12(10), October 2012. His astrobiological research concerns "astrocognition," the study of cognition in space, "Astrocognition: Prolegomena to a Future Cognitive History of Exploration." In *Humans in Outer Space – Interdisciplinary Perspectives*, edited by Ulrike Landfester et al. (Wien: Springer, 2011), and the semiotic and cognitive foundations of interstellar communication, "Cognitive Foundations of Interstellar Communication." In *Communication with Extraterrestrial Intelligence*, edited by Douglas A. Vakoch (Albany NY: State University of New York Press, 2011).

Acknowledgements: Special thanks to Göran Sonesson, Per Lind and Erik Persson for valuable comments on my chapter, and to Dainis Dravins, Peter Gärdenfors, Mathias Osvath, and Jordan Zlatev who generously shared their knowledge and articles in preparation. Finally, thanks to all participants of the seminar at the Centre for Cognitive Semiotics, Lund University, for exciting discussions about cognition seen from a true universal perspective.

References

Andrén, Mats. 2010. *Children's Gestures from 18 to 30 Months*. PhD diss. Lund: Travaux de l'institut de linguistique de Lund.

Arbib, Michael A. [forthcoming]. "Evolving an Extraterrestrial Intelligence and its Language-Readiness." In *The History and Philosophy of Astrobiology: Perspectives on the Human Mind and Extraterrestrial Life*, edited by David Dunér. Newcastle upon Tyne: Cambridge Scholars Publishing.

Ball, John A. 1973. "The Zoo Hypothesis." *Icarus* 19:347–349.

Baxter, Stephen. 2001. "The Planetarium Hypothesis: A Resolution of the Fermi Paradox."

Journal of the British Interplanetary Society 54(5/6):210–216.

Bogonovich, Marc. 2011. “Intelligence’s Likelihood and Evolutionary Time Frame.” *International Journal of Astrobiology* 10(2):113–122.

Bowles, Samuel, and Herbert Gintis. 2003. “The Origins of Human Cooperation.” In *The Genetic and Cultural Origins of Cooperation*, edited by Peter Hammerstein, 429–443. Cambridge MA: Massachusetts Institute of Technology Press.

Brinck, Ingar. 2001. “Attention and the Evolution of Intentional Communication.” *Pragmatics and Cognition* 9(2):255–272.

Brinck, Ingar. 2008. “The Role of Intersubjectivity in the Development of Intentional Communication.” In *The Shared Mind: Perspectives on Intersubjectivity*, edited by Jordan Zlatev et al., 115–140. Amsterdam: Benjamins.

Brinck, Ingar, Jordan Zlatev, and Mats Andrén. 2006. “An Applied Analysis of Attentional Intersubjectivity.” In *Deliverables of Stages in the Evolution and Development of Sign Use* 7, 1–21. Lund: Lund University. Accessed November 1, 2012. http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=931481&fileOId=2303466

Calcagno, James M., and Agustín Fuentes. 2012. “What Makes Us Human?: Answers from Evolutionary Anthropology.” *Evolutionary Anthropology* 21:182–194.

Carter, Brandon. 2012. “Hominid Evolution: Genetics Versus Memetics.” *International Journal of Astrobiology* 11:3–13.

Cheney, Dorothy L., and Robert M. Seyfarth. 2012. “The Evolution of a Cooperative Social Mind.” In *Oxford Handbook of Comparative Evolutionary Psychology*, edited by Jennifer Vonk, and Todd K. Shackelford, 507–528. Oxford: Oxford University Press.

Damasio, Antonio R. 1994. *Descartes’ Error: Emotion, Reason, and the Human Brain*.

New York: G.P. Putnam.

Denning, Kathryn. 2011. "'L' on Earth." In *Civilizations Beyond Earth: Extraterrestrial Life and Society*, edited by Douglas A. Vakoch, and Albert A. Harrison, 74–86. New York: Berghahn Books.

Dick, Steven J. 2003. "Cultural Evolution, the Postbiological Universe and SETI." *International Journal of Astrobiology* 2(1):65–74.

Donald, Merlin W. 1991. *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. Cambridge MA: Harvard University Press.

Donald, Merlin W. 2008. "A View from Cognitive Science." In *Was ist der Mensch?*, edited by Detlev Ganten, Volker Gerhardt, Jan-Christoph Heilinger, and Julian Nida-Rümelin, 45–49. Berlin: de Gruyter.

Dunbar, Robin. 1996. *Grooming, Gossip and the Evolution of Language*. Cambridge MA: Harvard University Press.

Dunbar, Robin. 1998. "The Social Brain Hypothesis." *Evolutionary Anthropology* 6(5):178–190.

Dunér, David. 2011a. "Astrocognition: Prolegomena to a Future Cognitive History of Exploration." In *Humans in Outer Space – Interdisciplinary Perspectives*, edited by Ulrike Landfester, Nina-Louisa Remuss, Kai-Uwe Schrogl, and Jean-Claude Worms, 117–140. Wien: Springer Verlag.

Dunér, David. 2011b. "Cognitive Foundations of Interstellar Communication." In *Communication with Extraterrestrial Intelligence*, edited by Douglas A. Vakoch, 449–467. Albany NY: State University of New York Press.

Dunér, David. 2011c. "Die Evolution kognitiver Prozesse im Universum." *Sagenhafte Zeiten* 13(6):14.

Dunér, David, ed. 2012. “Introduction: The History and Philosophy of Astrobiology.” In “The History and Philosophy of Astrobiology.” Special issue of *Astrobiology* 12(10):901–905.

Dunér, David, ed. [forthcoming]. *The History and Philosophy of Astrobiology: Perspectives on the Human Mind and Extraterrestrial Life*. Newcastle upon Tyne: Cambridge Scholars Publishing.

Fehr, Ernst, and Urs Fischbacher. 2004. “Social Norms and Human Cooperation.” *Trends in Cognitive Science* 8:185–190.

Frank, Robert H. 1988. *Passions within Reason: The Strategic Role of the Emotions*. New York: Norton.

Freeberg, Todd M., Robin I. M. Dunbar, and Terry J. Ord. 2012. “Social Complexity as a Proximate and Ultimate Factor in Communicative Complexity.” *Philosophical Transactions of Royal Society. Series B: Biological Sciences* 367:1785–1801.

Freeberg, Todd M., Terry J. Ord, and Robin I. M. Dunbar. 2012. “The Social Network and Communicative Complexity: Preface to Theme Issue.” *Philosophical Transactions of Royal Society. Series B: Biological Sciences* 367:1782–1784.

Fridlund, Malcolm, et al. 2010. “The Search for Worlds Like Our Own.” *Astrobiology* 10(1):5–17.

Fusaroli, Riccardo, Paolo Demuru, and Anna M. Borghi. 2012. “The Intersubjectivity of Embodiment.” *Journal of Cognitive Semiotics* 4(1):1–5.

Gallagher, Shaun. 2004. “Situational Understanding: A Gurwitschian Critique of Theory of Mind”. In *Gurwitsch’s Relevancy for Cognitive Science*, edited by Lester Embree, 25–44. Dordrecht: Springer.

Gärdenfors, Peter. 2003. *How Homo Became Sapiens: On the Evolution of Thinking*.

Oxford: Oxford University Press.

Gärdenfors, Peter. 2008a. “Evolutionary and Developmental Aspects of Intersubjectivity.” In *Consciousness Transitions – Phylogenetic, Ontogenetic and Physiological Aspects*, edited by Hans Liljenström, and Peter Århem, 281–385. Amsterdam: Elsevier.

Gärdenfors, Peter. 2008b. “The Role of Intersubjectivity in Animal and Human Cooperation.” *Biological Theory* 3(1):1–12.

Gärdenfors, Peter. 2012. “The Cognitive and Communicative Demands of Cooperation.” In *Games, Actions and Social Software: Multidisciplinary Aspects*, edited by Jan van Eijck, and Rineke Verbrugge, 164–183. Berlin and Heidelberg: Springer.

Gärdenfors, Peter. [forthcoming]. “The Evolution of Semantics: Sharing Conceptual Domains.” In *Evolutionary Emergence of Language*, edited by Rudolf Botha. Oxford: Oxford University Press.

Gentilucci, Maurizio, Claudia Gianelli, Giovanna Cristina Campione, and Francesca Ferri. 2012. “Intersubjectivity and Embodied Communication Systems.” *Journal of Cognitive Semiotics* 4(1):124–137.

Gibson, James J. 1979. *The Ecological Approach to Visual Perception*. Boston MA: Houghton Mifflin.

Gillespie, Alex. 2009. “The Intersubjective Nature of Symbols.” In *Symbolic Transformations: The Mind in Movement through Culture and Society: Cultural Dynamics of Social Representation*, edited by Brady Wagoner, 23–37. London: Routledge.

Gillespie, Alex, and Flora Cornish. 2010. “Intersubjectivity: Towards a Dialogical Analysis.” *Journal for the Theory of Social Behaviour* 40:19–46.

Grice, Paul. 1989 [1957]. “Meaning.” In *Studies in the Way of Words.* Cambridge MA:

Harvard University Press.

Hafner, Everett M. 1969. “Techniques of Interstellar Communication.” In *Exobiology: The Search for Extraterrestrial Life*, edited by Martin M. Freundlich, and Bernard M. Wagner, 37–62. Washington DC: American Astronautical Society.

Haqq-Misra, Jacob D., and Seth D. Baum. 2009. “The Sustainability Solution to the Fermi Paradox.” *Journal of the British Interplanetary Society* 62(2):47–51.

Herrmann, Esther, Josep Call, María Victoria Hernàndez-Lloreda, Brian Hare, and Michael Tomasello. 2007. “Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis.” *Science* 317:1360–1366.

Holmer, Arthur. [forthcoming]. “Greetings Earthlings!: On Possible Features of Exo-language.” In *The History and Philosophy of Astrobiology: Perspectives on the Human Mind and Extraterrestrial Life*, edited by David Dunér. Newcastle upon Tyne: Cambridge Scholars Publishing.

Hrdy, Sarah Blaffer. 2009. *Mothers and Others: The Evolutionary Origins of Mutual Understanding.* Cambridge MA: Belknap Press of Harvard University Press.

Husserl, Edmund. 1973. *Zur Phänomenologie der Intersubjektivität*, 3 vols., edited by Iso Kern. Haag: Nijhoff.

Jonas, Doris, and David Jonas. 1976. *Other Senses, Other Worlds*. New York: Stein and Day.

Kaltenegger, Lisa, et al. 2010. “Deciphering Spectral Fingerprints of Habitable Exoplanets.” *Astrobiology* 10(1):89–102.

Kane, Stephen R., and Dawn M. Gelino. 2012. “The Habitable Zone and Extreme Planetary Orbits.” *Astrobiology* 12(10):940–945.

Kappeler, Peter M., and Carel P. van Schaik, eds. 2006. *Cooperation in Primates and*

Humans: Mechanisms and Evolution. Berlin: Springer.

Kita, Sotaro, ed. 2003. *Pointing: Where Language, Culture and Cognition Meet*. Mahwah NJ: Laurence Erlbaum.

Lehmann, Laurent, and Laurent Keller. 2006. "The Evolution of Cooperation and Altruism: A General Framework and a Classification of Models." *Journal of Evolutionary Biology* 19(5):1365–1376.

Leimar, Olof, and Peter Hammerstein. 2001. "Evolution of Cooperation through Indirect Reciprocity." *Proceedings of the Royal Society of London. Series B: Biological Sciences* 268(1468):745–753.

Lenninger, Sara. 2012. *When Similarity Qualifies as a Sign: A Study in Picture Understanding and Semiotic Development in Young Children*. PhD diss. Lund: Lund University.

Malafouris, Lambros. 2012. "Linear B as Distributed Cognition: Excavating a Mind not Limited by the Skin." In *Excavating the Mind: Cross-sections through Culture, Cognition and Materiality*, edited by Niels Johannsen, Mads Jessen, and Helle Juel Jensen. Aarhus: Aarhus University Press.

Malafouris, Lambros, and Colin Renfrew, eds. 2010. *The Cognitive Life of Things: Recasting the Bounderies of the Mind*. Cambridge: The McDonald Institute Monographs.

Mayr, Ernst. 1985. "The Probability of Extraterrestrial Intelligent Life." In *Extraterrestrials: Science and Alien Intelligence*, edited by Edward Regis Jr., 23–30. Cambridge: Cambridge University Press.

Moore, Chris, and Philip J. Dunham. 1995. *Joint Attention: Its Origins and Role in Development*. Hillsdale NJ: Lawrence Erlbaum.

Moran, Dermot. 2004. “The Problem of Empathy: Lipps, Scheler, Husserl and Stein.” In *Amor Amicitiae: On the Love that is Friendship*, edited by Thomas A. Kelly, and Phillip W. Rosemann, 269–312. Leuven, Paris, and Dudley MA: Peeters.

Norman, Donald A. 1991. “Cognitive Artifacts.” In *Designing Interaction: Psychology at the Human-Computer Interface*, edited by John M. Carroll, 17–38. Cambridge: Cambridge University Press.

Norman, Donald A. 1993. “Cognition in the Head and in the World.” *Cognitive Science* 17:1–6.

Nowak, Martin A., and Karl Sigmund. 2005. “Evolution of Indirect Reciprocity.” *Nature* 437(7063):1291–1298.

Oller, D. Kimbrough, and Ulrike Griebel, eds. 2008. *Evolution of Communicative Flexibility: Complexity, Creativity, and Adaptability in Human and Animal Communication*. Cambridge MA: Massachusetts Institute of Technology Press.

Østergaard, Svend. 2012. “Imitation, Mirror Neurons and Material Culture.” In *Excavating the Mind: Cross-sections through Culture, Cognition and Materiality*, edited by Niels Johannsen, Mads Jessen, and Helle Juel Jensen. Aarhus: Aarhus University Press.

Osvath, Mathias. [forthcoming]. “Astrocognition: A Cognitive Zoology Approach to Potential Universal Principles of Intelligence.” In *The History and Philosophy of Astrobiology: Perspectives on the Human Mind and Extraterrestrial Life*, edited by David Dunér. Newcastle upon Tyne: Cambridge Scholars Publishing.

Persson, Erik. 2012. “The Moral Status of Extraterrestrial Life.” *Astrobiology* 12(10):976–984.

Piaget, Jean. 2001 [1963]. *The Psychology of Intelligence*. New York: Routledge.

Pinker, Steven. 2011. *The Better Angels of Our Nature: The Decline of Violence in History*

and its Causes. London: Allen Lane.

Preston, Stephanie D., and Frans B. M. de Waal. 2002. "Empathy: Its Ultimate and Proximal Bases." *Behavioral and Brain Sciences* 25(1):1–72.

Regis Jr, Edward, ed. 1985. *Extraterrestrials: Science and Alien Intelligence*. Cambridge: Cambridge University Press.

Rescher, Nicholas. 1985. "Extraterrestrial science." In *Extraterrestrials: Science and Alien Intelligence*, ed. Edward Regis Jr, 83–116. Cambridge: Cambridge University Press.

Richerson, Peter J., and Robert T. Boyd. 2005. *Not by Genes Alone: How Culture Transformed Human Evolution*. Chicago: University of Chicago Press.

Richerson, Peter J., Robert T. Boyd, and Joseph Henrich. 2003. "Cultural Evolution of Human Cooperation." In *Genetic and Cultural Evolution of Cooperation*, edited by Peter Hammerstein. Dahlem workshop reports 90, 357–388. Cambridge MA: Massachusetts Institute of Technology Press.

Roberts, William A. 2007. "Mental Time Travel: Animals Anticipate the Future." *Current Biology* 17(11):R418–R420.

Rosch, Eleanor. 1975. "Cognitive Representations of Semantic Categories." *Journal of Experimental Psychology: General* 104:192–233.

Rosch, Eleanor. 1978. "Principles of Categorization." In *Cognition and Categorization*, edited by Eleanor Rosch, and Barbara B. Lloyd, 27–48. Hillsdale NJ: Erlbaum.

Sagan, Carl, ed. 1973. *Communication with Extraterrestrial Intelligence (CETI)*. Cambridge MA: Massachusetts Institute of Technology Press.

Seed, Amanda M., Nathan J. Emery, and Nicola S. Clayton. 2009. "Intelligence in Corvids and Apes: A Case of Convergent Evolution?" *Ethology* 115:401–420.

Shostak, Seth. 2009. "The Value of "L" and the Cosmic Bottleneck." In *Cosmos and*

Culture: Cultural Evolution in a Cosmic Context, ed. Steven J. Dick, and Mark L. Lupisella, 399–414. Washington DC: NASA History Series.

Sonesson, Göran. [forthcoming]. "Preparations for Discussing Constructivism with a Martian." In *The History and Philosophy of Astrobiology: Perspectives on the Human Mind and Extraterrestrial Life*, edited by David Dunér. Newcastle upon Tyne: Cambridge Scholars Publishing.

Steels, Luc. 2004. "Social and Cultural Learning in the Evolution of Human Communication." In *Evolution of Communication Systems*, edited by D. Kimbrough Oller, and Ulrike Griebel, 69–90. Cambridge MA: Massachusetts Institute of Technology Press.

Stein, Edith. 1917. *Zum problem der Einfühlung*. Halle: Buchdruckerei des Waisenhauses.

Stern, Daniel N. 1985. *The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology*. New York: Basic Books.

Sternberg, Robert J. 2002. "The Search for Criteria: Why Study the Evolution of Intelligence." In *The Evolution of Intelligence*, edited by Robert J. Sternberg, and James C. Kaufman, 1–7. Mahwah NJ: Lawrence Erlbaum Associates Publishers.

Stevens, Jeffrey R., and Marc D. Hauser. 2004. "Why Be Nice?: Psychological Constraints on the Evolution of Cooperation." *Trends in Cognitive Sciences* 8(2):60–65.

Suddendorf, Thomas, and Michael C. Corballis. 1997. "Mental Time Travel and the Evolution of Human Mind." *Genetic, Social and General Psychology Monographs* 123(2):133–167.

Thompson, Evan, ed. 2001. *Between Ourselves: Second-person Issues in the Study of Consciousness*. Thorverton: Imprint Academic.

Thornton, Alex, Nicola S. Clayton, and Uri Grodzinski. 2012. "Animal Minds: From

Computation to Evolution." *Philosophical Transactions of Royal Society. Series B: Biological Sciences* 367:2670–2676.

Tomasello, Michael. 1999. *The Cultural Origins of Human Cognition*. Cambridge MA: Harvard University Press.

Tomasello, Michael. 2005. "Uniquely Human Cognition is a Product of Human Culture." In *Evolution and Culture: A Fryssen Foundation Symposium*, edited by Stephen C. Levinson, and Pierre Jaisson, 203–217. Cambridge MA: Massachusetts Institute of Technology Press.

Tomasello, Michael. 2009. *Why We Cooperate?* Cambridge MA: Massachusetts Institute of Technology Press.

Tomasello, Michael, Malinda Carpenter, Josep Call, Tanya Behne, and Henrike Moll. 2005. "Understanding and Sharing Intentions: The Origins of Cultural Cognition." *Behavioral and Brain Sciences* 28:675–691.

Trivers, Robert L. 1971. "The Evolution of Reciprocal Altruism." *The Quaterly Review of Biology* 46(1):35–57.

Trivers, Robert L. 2006. "Reciprocal Altruism: 30 Years Later." In *Cooperation in Primates and Humans: Mechanisms and Evolution*, edited by Peter M. Kappeler, and Carel P. van Schaik, 67–83. Berlin: Springer.

Tylén, Kristian, Ethan Weed, Mikkel Wallentin, Andreas Roepstoorf, and Chris D. Frith. 2010. "Language as a Tool for Interacting Minds." *Mind and Language* 25:3–29.

Vakoch, Douglas A. 1998. "Constructing Messages to Extraterrestrials: An Exosemiotic Perspective." *Acta Astronautica* 42(10–12):697–704.

Vakoch, Douglas A. 2009. "Encoding Our Origins: Communicating the Evolutionary Epic in Interstellar Messages." In *Cosmos and Culture: Cultural Evolution in a Cosmic*

Context, edited by Steven J. Dick, and Mark L. Lupisella, 415–439. Washington DC: NASA History Series.

Vakoch, Douglas A. 2011. "Asymmetry in Active SETI: A Case for Transmission from Earth." *Acta Astronautica* 68:476–488.

Vakoch, Douglas A., and Albert A. Harrison, eds. 2011. *Civilizations Beyond Earth: Extraterrestrial Life and Society*. New York: Berghahn Books.

Zahavi, Dan. 2001. "Phenomenology and the Problem(s) of Intersubjectivity." In *The Reach of Reflection: Issues for Phenomenolgy's Second Century*, edited by Steven Crowell, Lester Embree, and Samuel J. Julian, 265–278. [S.l.]: Electron Press.

Zlatev, Jordan. 2008. "The Co-evolution of Intersubjectivity and Bodily Mimesis." In *The Shared Mind: Perspectives on Intersubjectivity*, edited by Jordan Zlatev et al. Amsterdam: Benjamins.

Zlatev, Jordan, Timothy P. Racine, Chris Sinha, and Esa Itkonen, eds. 2008. *The Shared Mind: Perspectives on Intersubjectivity*. Amsterdam: Benjamins.

Zlatev, Jordan, Timothy P. Racine, Chris Sinha, and Esa Itkonen. 2008. "Intersubjectivity: What Makes Us Human?" In *The Shared Mind: Perspectives on Intersubjectivity*, edited by Jordan Zlatev et al. Amsterdam: Benjamins.