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**Cognitive Foundations of Interstellar Communication**

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*Published in:*
Communication with Extraterrestrial Intelligence

2011

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

[Link to publication](#)

*Total number of authors:*
1

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Unspecified

# Cognitive Foundations of Interstellar Communication

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## 1. The problem of interstellar communication

This is a message, a message addressed to you constructed in a code-system called English marked with Roman letters in ink on sheets of cellulose, or as liquid crystals on the screen. It is here and now, perceived by the senses, interpreted by a being with a brain, body and history, living in the world.

By using this code-system I evidently hope to make myself understood, to awaken in the mind of the receiver similar thoughts and ideas that I have when I formulate this message. Ultimately—above and beyond the mere question of language skills—this hope of mine stems from the fundamental fact that we share the same human cognitive abilities that are a function of our common evolutionary history here on Earth, the planet Tellus. But if we extend this communicational situation beyond Earth, however, the question naturally arises: *How could communication be possible between intelligent beings of different environments that differ physically, biologically, and culturally, and have developed through separate evolutionary lines?* This is the problem of interstellar communication. It is right, as Michael Arbib wrote, that "we

are in fact at this very time receiving messages from intelligent civilizations, messages transmitted hundreds or even thousands of years ago" (Arbib 1979, 25; cf. Finney and Bentley 1998). Arbib had the writings of Newton, Euclid and others in mind. Even though these messages do not contain all facts needed for the right interpretation of them, they are in fact possible to understand. The explanation for this, I would say, is that we all share the same history, the same evolutionary and cognitive set-up. And this we cannot count on in respect to extraterrestrial cognition. The problem of interstellar communication is far more complicated. These circumstances—that we will have no kinship, that we will not share similar bodies or cultures, or even similar physical realities—will have far-reaching consequences for how we will be able to construct and interpret messages from distant civilizations.

## 2. Recasting the objective

The usual strategy to overcome the problem of interstellar communication has been to try to construct a message that is: *A universal symbolic information transfer that is independent of context, time and human nature.* This can be called "the universal-transcendental interstellar message objective". My point here is that this strategy and its requirements are not reconciled with what we presently know about cognition, communication, and evolution. Particularly, it presupposes the universality it aims at, and thereby ignores the facticity of evolution, and the situatedness and embodiment of symbolization. It ignores the context, that the living organisms—and consequently their cognition and communication—are planet-bound, tied to and constrained by certain physical conditions. It leaves out time and history—the evolution, the phylogenetic, ontogenetic, and cultural-historical time—in which the organisms are evolving.

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And finally it ignores the nature of the communicators—that they have bodies and brains evolved in interaction with their environment.

For these reasons, I propose a different strategy that in my view does justice to the known facts about cognition, communication and evolution. In this article I put forward instead an "embodied-situated interstellar message objective"; that is, a search for: *A local, embodied, situated, and concrete non-symbolic interaction.* I will later on in this paper explain more in detail why it is problematic—if you would like to be understood in the cosmos—to exclude the context, the situation, space, time and human nature, and also why symbols (or conventional signs) and information transfers are probably less effective ways of starting a communicative interaction. But first I will say something on the often unproblematized assumption of universality.

## 3. Assets for solving the problem

There are three different fields of research that I think are inevitable for any future interstellar message construction: cognitive science, semiotics, and history. Firstly, regarding cognitive science, I build on the basic observation that our cognitive and communicational skills are embodied, situated in and adapted to our terrestrial environment. In short, cognitive science studies how the external world is represented, how we use cognitive tools for our thinking—such as language, image schemas, mental maps, metaphors, and categories—but also how we use and interpret, for example, drawings and images to enhance communication. It is about perception, attention, memory, learning, consciousness, reasoning and other things that we include in what is called "thinking". Elsewhere I have discussed that cognitive science can play a vital role in our

studies of extraterrestrial intelligence, and reveal new perspectives on human encounters with the unknown. The field of "astrocognition" can be defined as the study of human cognitive processes in extraterrestrial environments (Dunér in press).

Secondly, the time-honored insights of classical hermeneutics, which theorize on the many aspects of symbol formation, the transfer of meaning and the decoding of messages, cannot be neglected in the quest for interstellar symbolization. What research fields are actually dealing with communication and meaning? It is the humanities, the arts, anthropology, history, and other studies of the human being as creators of and searchers for meaning. Inasmuch as interstellar communication is thought to be an exercise in coding and decoding signs, the relevance of these insights, especially in semiotics, should be obvious. Douglas Vakoch is one of the few who have observed the potentiality in an exosemiotic perspective (Vakoch 1998). Another is Göran Sonesson, who has delivered a sharp semiotic analysis of the problem (Sonesson 2007). It could be argued that the problem of intersteller communication is not just a problem within natural science primarily, but a true humanistic problem in its true sense; a human problem. It is we humans who will send and receive, code and decode the messages.

Finally, I focus on history, understood, on the most basic level, as the interaction of organisms with their environment over time. Our cognition and communication are a result of time, of history; both evolutionary history and socio-cultural history. Communication is not something pregiven, but rather evolves in interplay with the environment; a process during millions of years. The latter factors of Drake's equation are in fact social, historical problems, and are probably the most difficult to answer for the moment: $f_c$—the fraction of intelligent sites that develop a technological communicating civilization; and L—the longevity of a communicative

civilization (Sagan 1973; McConnell 2001; Tarter 2001; Shostak 2009). We know just one such civilization and we have not seen the end of it. We need to place interstellar communication in time, the fourth dimension.

These fields, I suggest, contain vital tools for any future interstellar message construction. In fact, without firm insights into these fields I think the problem of interstellar communication will be hard to solve. These, together with science, mathematics, and technology, will give us the indispensable, collective human mental powers for deciphering interstellar messages. Before I go on to the cognitive foundations of communication, I have to say something about the often unproblematized assumption of universality that has commonly been taken for granted as a necessary requirement in interstellar message construction.


## 4. The universality principle reconsidered

Behind the universal-transcendental objective is a standard assumption that there are some universal facts and laws, especially of a scientific and mathematical nature, that are the same throughout the universe (DeVito and Oehrle 1990; Vakoch 2009a). From our knowledge about the universe we infer that these laws we have found are valid for the whole universe, by a way of analogical reasoning that what is true here might be true there. It could also be said to assume a reality that transcends the physical reality of here and now, reminding us of a Platonic world of ideas that exists independently of the world of matter in which man lives and functions. The question here is not if there are universal facts that are the same for all observers—it might be true—but rather if we can know that we have come to the indisputable final, universal facts (the epistemological problem), and whether we actually can use our assumed universal propositions

of reality for our purposes and as a foundation for an interstellar message that aims to be possible to decode and be understood by an extraterrestrial intelligence (the semiotic problem). The problem concerns, as it did for George Sefler and Nicholas Rescher, the postulating of our models of reality as universally commensurable (Sefler 1982; Rescher 1985; Vakoch 1998). There are however critics, such as the physicist Andrei Linde, of the idea that the universe and the laws of physics are everywhere the same (Michaud 2007). Our traditional "universal" laws of physics might be just local bylaws with limited range.

Against the assumption that our present-day understanding of universality could be a starting point is, firstly, a historical-epistemological argument. Can we know that the universal a posteriori statements we come to by inductive reasoning are true everywhere and whenever? Throughout the history of science, man has time after time been surprised over reality. That which we once thought was a universal fact turned out to be false. A classical example is how the Newtonian gravitational theory was once thought to be universal but later on found to be just a special case of Einstein's relativity theory. Many such examples can be found in the history of science. The whole history of science could be said to be a history of surprises that violate our first assumptions of a universal and uniform world. Reality is more complex and diversified than we originally imagine. It is more reasonable—in respect to extraterrestrial intelligence—to expect diversity than uniformity in understanding and representing the world. Diversity is what we should expect, not least concerning different ways of communicating ideas in the universe.

Secondly, there are cognitive arguments against postulating human science and mathematics as a foundation for universality. Our universe is seen from our point of view, from our planet, through our species-unique senses and cognition. It is an anthropocentric and terrestrial view.

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Our understanding of the universe depends on our terrestrial brain. Science and mathematics are products of the evolution of human species-unique cognitive skills, of human embodiment and sensorimotor interaction in the gravitational field specific to our Earth, and a particular cultural evolution. Basic mathematics, that usually is said to be universal, rests, like language, on human ways of experiencing the world as consisting of distinct discrete objects in a Euclidean three-dimensional space, and is a function of a mental adaptation of the organism to its environment. More advanced mathematics was developed very late in the human history, and can be said to be a cultural product to a much greater extent than language. Language and symbolic reasoning could be found in all cultures, but only a few have independently developed more complex and advanced mathematics (Tomasello 2005). Not everyone within a culture has knowledge about complex mathematics, and this knowledge has to be transferred through conscious instruction to new generations.

There are reasons to believe that an extraterrestrial intelligence would have some understanding of something that we call mathematics. I do not mean just in order to be able to develop advanced technology, but in a deeper cognitive sense. As organisms they adapt to and have to orient themselves in their specific spatial environment. Seeing the environment as discrete instances for detection, and being able to recognize spatial relations, have certainly had survival benefits. Mathematics has no different status than other skills of the human mind. It is also based on cognitive abilities evolved through the history of our species (Lakoff and Núñez 2000). Carl DeVito has recently proposed natural numbers (1, 2, 3, 4…) to be something that can be understood by an extraterrestrial intelligence. The rest of mathematics can be said to be a human creation (DeVito in press). This can be workable if we assume that we share the same

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cognitive categorization of reality in similar cluster-statistics. Humans categorize things in discrete instances, doing some sort of cluster-statistics of continuity (Rosch 1975; Rosch 1978; Taylor 2003). For example, adult listeners of a particular language classify sounds as one phoneme or another, and show no sensitivity to intermediate sounds (Kuhl 2004). In a similar way we categorize the continuum in natural numbers. For an alien real numbers might be more "natural", or mathematics based on true continua.

A convergent psychic uniformity of all intelligent species is often taken for granted. Some commentators have challenged this (McNeill 1973; Baird 1987; Westin 1987; Finney and Bentley 1998). In addition to this critique, we cannot from a cognitive standpoint assume that the extraterrestrials will have the same ability to reason as humans. Cognition is not universal; neither is it transcendental, belonging to a Platonic world of ideas, independent of the thinking subject: cognition is embodied in an subject, and is situated in a particular environment.


## 5. Cognitive foundations of communication

In order to discuss interstellar communication in a more fundamental sense we have to ask ourselves: why do we have communication in the first place? What is it and how has it evolved? From the research within the fields mentioned above, we can find some fundamental characteristics that seem to underlie all communication as we know it. I do not aim to list all sufficient or necessary qualities that characterize communication, just some that I think are particularly relevant in the quest for a possible interstellar communication, and which will force us to reconsider the universal-transcendental message objective. These are the cognitive foundations of interstellar communication: evolution, embodiment, situatedness, and

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symbolization.

**5.1. Evolution: Communication has an evolutionary history**

Communication has an evolutionary origin (Christiansen and Kirby 1997; Deacon 1997; Tomasello 2008). Human communication, whether it is of lingual, symbolic or bodily expressions, depends of how our brains work and are constructed, and how humans interact with their physical, biological and cultural environment. The human mind has to a large extent evolved as an adaptation to certain problems that our ancestors have faced during the evolutionary development of our species (Gärdenfors 2006). That is, the human brain is adapted to, firstly, the physical and biological environment of the Earth—to understand and interpret, interact and deal with, and orient itself in the Earth's physical and biological environment, in relation to its specific conditions, such as planetary orbit, gravitation, light conditions, atmosphere, radiation, temperature, chemistry, geology, ecology, fauna and flora. Secondly, the human brain is also adapted to the mind and culture of of the tellurian species *Homo sapiens*, to understand and interact with other beings of our species, to understand human feelings, thoughts, motives, etc., in a psychological and social interplay that forms our human culture. Culture can here be defined as the existence of intra-species group differences in behavioral patterns and repertoires, which are not directly determined by ecological circumstances, and which are learned and transmitted across generations (Sinha 2009; Tomasello 1999).

Tens of millions of years of social evolution have adapted our species to be highly sensitive to human social signals. Language has been around for almost two million years. Our language, with its phonemes and symbolization, has evolved due to its enhancement of communication

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between humans. Yes, it is true, our language can be used for describing the world around us, and transfer information between ourselves. But perhaps more important for its appearance is its use for social interplay: to express feelings, to gossip, for socializing and creating bonds, etc. As Robin Dunbar and others have suggested, language has interpersonal functions, and emerged for the improvement of social bonding, to hold together and sustain large groups, and to incite desired behavior in other members of the group (Dunbar 1996). It evolved because of social reasons, for social grooming, making social contracts, to coordinate action, and pass on knowledge. Alison Wray has discussed protolanguage as a holistic system for social interaction, and proposed that we started with holistic utterances that later were segmented (Wray 1998). Like primates' use of vocal and gestural signals, human language has also specific interactional goals. The signals are intended to have an effect upon the world of the sound maker (and hearer), by inciting a reaction in the hearer. In Wray's understanding, signals are holistic; they have no component parts that could be recombined in order to create new messages. The early hominids might have communicated in a similar way, but perhaps using a larger set of utterances that later on gave rise to a segmented and combinatoric language.

So language is a social device for expressing feelings, but also to disguise them. As Terry Deacon clarifies, a species' communication has evolved not just to solicit another to assume the same state, but to a large extent for manipulative purposes (Deacon 1997). Language is not just for communicating honest statements, and due to this deceitful use of the communicating practices, the communication must, then, be seen in the specific social and evolutionary context in which it is produced. Communication should in that sense be seen in a social context, rather than as an objective, de-contextualized information transfer. Communicating with the aliens will

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actually be a socializing practice.

Language had evolutionary benefits that extended the range of our capabilities, and had also an impact on the evolution of the brain itself. The gradual increase in communication led to new possibilities for the mind (Workman and Reader 2004). The symbolic artifacts that are grounded in particular structures of human cognition and communication, have been invented and modified over historical time by members of a particular group of intelligent organisms. All the symbols and constructions of a given language are not invented at one and the same time. They evolve and change over historical time as they are used and adapted to changing circumstances. Accordingly, communication is a bio-cultural hybrid, a changing product of the genetic-cultural co-evolution. There is, consequently, a very distinct possibility that the respective evolutions of the cognitive and communicational skills of terrestrials and extraterrestrials have taken very different and separate paths. If their civilization is much older than ours, which is very likely, not just their technical skills, as many have assumed, might be at a more advanced stage; even their evolutionary process will have been working during a longer period of time, and so also, because of bio-cultural changes, their way of communication. It might have evolved into something far beyond the capacity and efficiency of our present earthly way of communication.

## 5.2. Embodiment: Communication is embodied

We think with the body. The mind is not detached from the body. A key concept in contemporary cognitive science is "embodiment" (Varela, Thompson, and Rosch 1991; Lakoff and Johnson 1999; Krois et al. 2007). According to the theory of embodied cognition, intelligence, both natural and artificial, depends upon interaction with the environment.

Computation alone is not sufficient for explaining intelligence. It is also necessary to take into account sensorimotor interaction with the world. Our cognition is embodied and dependent on our bodily activity. We do not think with our brains alone, but to be able to think we need also the rest of our bodies. This embodiment gives rise to species-unique forms of cognitive representation. For example, our human body schema—the bodily organization of space, the orientation of front–back, in–out, up–down, etc.—is dependent on how our bodies are and function in the environment. Different sensory equipments would change the perceptions, but also the cognition, and in the end culture and social structure. Thus bodies of other kinds and evolutionary backgrounds would have other minds and ways of thinking.

Obviously, in regard to interstellar communication the bodily constructions of the aliens and ourselves would probably be very different due to our isolated evolutions. Our different brains and bodies, and because of that different cognition and body schemas, will decrease the possibility of finding a common ground for mutual understanding and communication. The sender and receiver are embodied, and their mental understanding cannot be separated from their bodies. We cannot assume that the extraterrestrials would have senses like ours—that would be anthropocentric. But we could assume that they are in someway or another embodied, and that they interact with their environment; that they possess some sort of spatial awareness and feeling for directionality, up and down, in and out, etc., according to the physical structure of their celestial body. Pictorial representations are difficult to use due to the cognitive differences we will have in interpreting visual sensations. A picture is nothing objective; it is changed by the perceiver's sensory apparatus, but also not least by her understanding and former experiences. John Michael Krois suggests, however, that chiral organization of the physical world is

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universal, and that this would make it possible to communicate with extraterrestrials by pictures (Krois 2010). Recognizing an image is a kind of sensorimotor activity, not just a purely mental process, according to Krois. Pictures can in that case be easier to understand than symbolic messages, because they are more basic, and are based on sensorimotoric activities.


## 5.3. Situatedness: Communication is situated

The theory of "situated cognition" claims that our cognitive processes are not just inside our brains; we also use our environment for thinking (Clark 1997; Brinck 2007). The environment has an active role in driving cognitive processes, or, as Andy Clark and David Chalmers called it, the "extended mind" (Clark and Chalmers 1998). The brain does not only need the body but also the surrounding world in order to function efficiently. Thus, cognition emerges in the interaction between the brain, the body and the world. There exists no sharp line between the brain and the world. We cannot be isolated observers. In other words, cognitive activity cannot be separated from the situations in which it occurs. To this we can add what is called "distributed cognition": that we are using our environment and objects for enhancing thinking; that we place our ideas and memories outside us, in things—in books, computers, and other external objects (Giere and Moffatt 2003). Interstellar messages are in fact distributed thoughts outside our brains.

It is thus necessary to take into account the intelligent organisms' sensorimotor interaction with the world. Cognition emerges from a history of actions in the world that are performed by an organism. Communication is therefore a situated practice. It is constrained by its surroundings, and is adapted to specific circumstances. This means that we cannot exclude the situation where the message is performed, and the physical, biological, and socio-cultural context

of the communicators. We are planet-bound creatures. We have to bear in mind that our spatial understanding is a result of our evolution and is adapted to our needs in this particular terrestrial environment, and is very well adapted to our needs for activities in the local environment. Our innate spatial understanding is of a Euclidean space, which is something different from an Einsteinean universe or the ten dimensions of string theory. So, in conclusion, where we are in time and space is totally fundamental for cognition.

## 5.4. Symbolization: Communication as a symbolization of thought

Intelligence could be seen as an evolved mental gymnastics required to survive and reproduce within its specific environment. This includes the capability of representing activities and being able to make inner models of reality. 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. A very effective tool for symbolizing thought is our communicational devices. According to John Taylor, language can be understood as a set of resources that are available to the language user for the symbolization of thought, and for the communication of these symbolizations (Taylor 2002). Language frees us from the here and now, that is true, but anyhow it rests on cognitive abilites that are a result of bio-cultural evolution here on Earth.

   Cognitive linguistics aims to situate language within more general cognitive capacities. Contrary to Arbib, I believe that linguistic theory can help us in constructing and decoding interstellar messages—in fact, I would say, it is very much needed. A lot has happened in this

field since Arbib wrote his article 30 years ago. Current cognitive linguistics can show how language is a result of an evolutionary cognitive process. If we believe that cognition and communication are not something pregiven, these perspectives can situate interstellar communication in an evolutionary context. Communication is actually an extension of pre-linguistic cognitive capacities.

Spatial experience is fundamental for cognition, as mentioned above, which also leads to the fact that many abstract concepts relate to bodily experiences. Our cognitive capacities, especially concerning concept formation, can be explained as a kind of metaphorical extension of spatial reasoning (Lakoff and Johnson 1980; Gärdenfors 2008). Abstract concepts relate to concrete, basic human experiences. Light–darkness, up–down, and other physical experiences give rise to metaphors like "knowledge is light", "ignorance is darkness", "good is up", and "bad is down", etc. Based on observations of the extraterrestrials' astrophysical environment, we might be able to make qualified guesses about their metaphors.

According to a recent article by the linguists Nicholas Evans and Stephen C. Levinson, humans have a communication system that varies at all levels: phonetic, phonological, morphological, syntactic, and semantic (Evans and Levinson 2009). They put forward strong arguments from a cognitive perspective against a Chomskean universal grammar. Languages on Earth are much more diverse in structure than we expect. It is certainly even less likely to assume an universal uniformity of communication that would be valid for all communicating creatures out there in space. We are misled by anthropocentrism, and start with our preconceived understanding of human communication that we superimpose on presumed intelligent beings that we have no knowledge of whatsoever. There are reasons to expect diversity and plasticity of

cognition and communication in the universe. The limits of what is possible in the universe are wider than what our earthbound minds can imagine.

Many of our present-day attempts at interstellar message construction have much in common with the search for a universal language in the seventeenth century, performed by among others George Dalgarno and John Wilkins, who had a rather simplistic conception of language as a mirror of reality and thought, believing that it was possible to find a structural connection between symbol, concept and things (Eco 1997). The interstellar communication problem is very much a semiotic problem: how meaning can be transferred and interpreted. An exosemiotic analysis is needed. The problem with symbols is that they are conventional, or arbitrary, as Ferdinand de Saussure called them. They are detached representations and, as such, dependent on culture and human interaction. The sign (the expression) and the signified (the content) have no intrinsic connection. The symbol refers to the inner world, not to something in the outer environment, in contrast to the signal that refers to something in the latter. We may figure out the reference of the signal, but will probably have severe problems understanding extraterrestrial symbols. It is not impossible to imagine that the aliens would have certain knowledge about their environment that in its content is similar to our own knowledge of mathematics, physics and chemistry. But their expression of it, as Göran Sonesson has clearly pointed out, would most likely be very different from ours (Sonesson 2007). In fact, most attempts at interstellar message constructions violate this basic semiotic understanding of signs that distinguishes between expression and content. In a very convincing way Sonesson shows the inevitable role semiotics must play in message constructions. If we have different ways of expressing mathematics, and then send human mathematical messages, how could the aliens—who might have exactly the

same mathematical understanding—know what we are referring to? How we, and the aliens, transfer meaning in different ways, I would say, is the result of dissimilar evolution, bodily and cognitive construction, and socio-cultural history. The symbols in use depend on how our brains work, what our bodies are like and interact in their environment, how our sensations are processed, and not least the history of our culture.

The first problem that arises in a situation of interstellar communication is realizing that it really is a message at all, as Sonesson has pointed out (Sonesson 2007). Some regularity and order, finding a repetition in the pattern, is not enough. We have to understand that someone has an intention with it that we should understand as a message. Next comes the problem of deciphering what the message means. Cultural semiotics, developed by among others Yuri Lotman, studies sign systems and the correlations between different systems (Lotman 1990). In order to understand a message the receiver must be able to fill in the gaps between the receiver's perception of the message and the sender's intention with it. The problem is that the creator of the message and the receiver of it are situated in different and specific cultural and social contexts. Relating to interstellar communication, this gap will be huge, with totally different ecological and cultural contexts. As Vakoch clearly states: "In the absence of knowledge of physical and cultural clues, communication between two species can be almost impossible" (Vakoch 1999, 26). Designing a language for cosmic intercourse, like Hans Freudenthal's *lingua cosmica*, will probably be in vain (Freudenthal 1960). The famous Pioneer plaque now traversing deep space is also too firmly restricted by human culture and cognition, and will most likely be incomprehensible for an extraterrestrial (Crane 1995). The aliens and ourselves live in different cognitive or, if you wish, semiotic worlds with ways of thinking and signification that are not in

agreement with each other. This is another way of expressing the "incommensurability problem" (Vakoch 1999). Nicholas Rescher's legitimate critique of an assumed universality of science can, I would say, be based on cognitive and semiotic foundations (Rescher 1985).

### 5.5. Conclusion

So we can conclude that: *Communication is based on cognitive abilities embodied in the organism that has developed through an evolutionary and socio-cultural process in interaction with its specific environment.* This is the case for human cognition and communication according to recent research in cognitive science and cognitive linguistics.

   Our communication is adapted to an earthly environment and for communication with our co-species. Our communication and symbolization have evolved through an evolutionary and cultural-historical process here on Earth, and are thereby constrained by our human bodies, terrestrial environment, and the socio-cultural characteristics of our species. So our human communication is in fact maladapted to interstellar communication. This understanding of human cognition might be crucial for future interstellar communication and should be taken into account in order to be able to transfer messages to other minds in the universe.

### 6. Research initiatives and solutions

How can we go from this conclusion to more plausible ways than the universal-transcendental objective of interstellar communication? To begin with, we need as much observational data as possible about the life world of the extraterrestrials. To enhance our chances of establishing communication with an extraterrestrial intelligence, we should look for exoplanets with very

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similar physical characteristics as ours, but even if we find such a planet, this will not prevent the intelligent life forms on that planet from having taken a very different evolutionary path. We know that evolution to a great extent is not only an adaptation to specific environments, but also a result of mutations and accidental occurrences. But if the aliens have adapted to similar physical forces and conditions such as gravition, light, planetary dynamics, chemistry, etc., this will enhance the possibility of having a mutual understanding of the physical environment. We also have to, of course, focus on what we at this moment can study: our own understanding of our communicational abilities and constraints. We need more knowledge about how our human cognitive and communicational abilities emerged phylogenetically and ontogenetically.

## 6.1. Phylogenesis and ontogenesis of interstellar communication

We have earlier concluded that communication is an evolving phenomenon. It might be the case that the phylogenesis and ontogenesis of communication and symbolization can guide us. I propose that, based on the knowledge of how complex communication skills have evolved since the early hominoids, but also how present-day humans in their early ontogenesis acquire a language and first learn symbols, we might have clues to interstellar communication. In the phylogenesis of communication we see the transition from animal communication to human language, from an interpersonal function to an ideational function, from signals to symbols. In the ontogenesis of communication we find how infants acquire a complex language with culture-specific symbols. Infants use computational strategies in order to detect statistical and prosodic patterns in language input, which leads to their discovery of phonemes and words of a specific language (Kuhl 2004). With a set of initial perceptual abilities that are necessary for language

acquisition, they approach language and rapidly learn from exposure to language combining pattern detection and computational abilities with social skills.

In other words, we must find methods and strategies of learning how to communicate with the extraterrestrials. We must find a way to learn their symbols. In one way or another we must try to tune into their accumulated communicational tools and symbols of their culture. This would probably demand a continuing flow of social interaction. If we receive something that must be interpreted as an artificial message, terrestrial scientists will be occupied for centuries in deciphering its meaning. But, of course, the immense distances in space will perhaps forever restrict us from more lively conversations. However, we can still listen to their transmissions.

Instead of directly trying to accomplish an information transfer by means of a symbolic abstract language with a content that we think consists of universal scientific facts, we could initiate interaction on the lower cognitive levels, and from there go on to more complex communication systems, starting with concrete messages in signals, indexical and iconic signs in interstellar cognitive semiotics. So rather than focus on shared knowledge, we could focus on shared experiences that are fundamental for a successful mutual understanding. We should search for the basic cognitive processes underlying communication that we have in common.

I suggest that we skip the search for a vehicle for information transfer and symbols, and in fact an abstract message construction altogether. In order to increase our chances of being understood, we should not send an abstract symbolic message based on presupposed universal scientific or mathematical facts. Instead, we should be very concrete and interact with them. The message must force the receiver to interpret it in just one way—it must be direct, immediately understandable, non-ambiguous, and tied to the situation and locality.

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## 6.2. Interstellar intersubjectivity

What we eagerly strive to attain in our efforts toward interstellar communication is ideally to establish a way of transferring information, to get knowledge about their world, nature, and culture, and say something to them about us in return. Before we can reach so far in communicational interaction we first have to determine if they are intelligent at all, that they are intentional, self-conscious beings that show attention to us. And we have to show that we are something alive, something intelligent and self-conscious. What is needed is intersubjectivity.

Intersubjectivity, the sharing and representing of others' mentality, is an important part of our inner worlds (Thompson 2001; Zlatev et al. 2008). 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. Cooperation about detached goals requires advanced coordination of the inner worlds of the individuals. Future encounters with aliens will face severe problems concerning intersubjectivity, in coordinating our inner worlds, feeling empathy, etc., due to our totally different biological and cultural attributes. A human and an extraterrestrial will probably even have trouble perceiving the same target, in 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 is in fact needed for all successful communication is intersubjectivity: that is, shared devices for sharing and manipulating attention. In human conversation, for example, we constantly monitor each other's attentional status. There are strong arguments, according to the

psychologist Michael Tomasello, that an infant can only understand a symbolic convention 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. The linguistic symbol is also perspectival in the sense that it embodies one way of many other available ways a situation may be construed (Tomasello 2005). Symbols do not represent the world directly, but are rather used to induce the receiver to construe certain perceptual and conceptual situations. To reach 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.

In order to reach an interstellar intersubjectivity I suggest, then, that we try to establish joint attention; that we develop a mutual referential behavior, directed gaze or mutual gaze. One option is to try to tune in our spatial organizations, and together observe things observable to both terrestrials and extraterrestrials. We can use certain astronomical landmarks in their very neighborhood, to which we can direct our joint attention—for example with reference to known pulsars in the neighborhood, as the Pioneer plaque represented the sun's relationship to 14 known pulsars. Or the Andromeda Galaxy, our nearest galaxy, that, as Carl Sagan said, would be the only object that both we and the recipients could see first-hand. The best way to find out if they understand natural numbers would be to count concrete objects in our shared physical reality, together with them. Hafner proposed transmissions simulating astronomical objects, for example the fluctuation of the sun's cycle back and forth between the stars (Hafner 1969;

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Vakoch 1998). The sounds of geological activity, such as volcanoes, earthquakes, thunder, and ocean waves, included in the Voyager recording (Vakoch 2009b), are something we both might experience if we both hear in the same frequency range. 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 the physical reality. If we succeed in this, we will have taken a first step toward an interstellar intersubjectivity.

From joint attention, or perception, we might go on to indexical reference. This can be explained as an outgrowth of the repeated experience of pairing stimuli or events. And then to imitation—to mimic their actions, and attempt to reproduce the other agents' intended actions in the world; and then further to iconic signs. The icon is a sign that has some non-arbitrary similarity to the signified, in contrast to the symbol's arbitrary relation. Vakoch has observed that icons, such as transmissions simulating natural phenomena, will be superior to symbols of our models of the phenomena (Vakoch 1998).

Research in the phylogenesis and ontogenesis of language is rapidly making progress and expanding. Here, I do not intend to postulate a particular notion of a fixed track toward higher order communication. What I want to put on the agenda are the pre-linguistic cognitive capacities that we use for communication. Merlin Donald has proposed an evolutionary scale from perception, signs, sign systems to embodied signs (Donald 1991; Donald 2001; Sonesson 2009). The first stage in his system is a transition from episodic to mimetic culture, from the culture of apes and australopithecines to *Homo erectus*. The second transition goes further on to *Homo sapiens*, from mimetic to mythical culture. The recent and largely nonbiological transition

led to a third stage of cognitive evolution, including external symbolic storage and theoretic culture.

In the second stage, mentioned above, we use iconic signs, including mime, imitation and gestures. In a similiar way we can engage in interstellar mimetics, long before we have any clue of what the message means; that is, to mimic their actions and attempt to reproduce the other agents' intended actions in the world. Imitations and modeling actions is a way of doing something together, including action, object, and result. If we get a message we could send it back. If we start to try to communicate we could send an iconic message, preferably representing something well-known in their neighborhood, maybe the emission spectrum of their sun. If they answer with the spectrum of our sun, then we have begun aligning our thoughts. With icons to mimes we achieve something together. Doing something like this, we are going through an imitative learning process—not unlike the infant's strategy to learn symbols—to comprehend the symbolic conventions of their species and culture that finally can result in a mutual understanding. Thus, we go from bodily acts to imitative acts, and then further to representative imitation, and symbolic representation.

To conclude, instead of constructing a universal and abstract message, we should be local and concrete. Instead of using arbitrary symbols and trying to transfer information, we should try to interact and establish joint attention. Instead of leaving out the context, space and time, we should tie the message firmly to the situation and the environment. So what I am proposing is a shift from the message itself to what precedes it, logically as well as temporally, phylogenetically as well as ontogentically: the mental activities, the interaction, the embodied and situated cognitive processes of the minds of the universe. That is the message.

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