STI INNSBRUCK

EXCURSE: HOW AND WHY PEOPLE SHARE MEANING

Dieter Fensel

STI Innsbruck, University of Innsbruck,
Technikerstraße 21a, 6020 Innsbruck, Austria
firstname.lastname@sti2.at

SEMANTIC TECHNOLOGY INSTITUTE INNSBRUCK

STI INNSBRUCK
Technikerstraße 21a
A - 6020 Innsbruck
Austria
http://www.sti-innsbruck.at

Excurse: How and why people share meaning

Dieter Fensel, STI Innsbruck, University of Innsbruck, dieter.fensel@sti2.at

"Semantics is the process of communicating enough meaning to result in an action."
[Segaran et al., 2009]

Language is a means to exchange meaning, however, how is this possible? In order to interpret a language element of a sender the receiver must already know what this could mean in order to understand it. That is, language is exchanging meaning but does not establish meaning and the alignment process of meaning between two subjects. It is a bit like the situation were two people speak completely different languages and try to communicate. Either they bootstrap their conversation from a common ground of basic communication means (making the noise of a pig to order pork in a restaurant) or they find the "Pierre de Rosette" which provides a translation between their two languages. However, how was the joined meaning of basic communication means established or who should have provided the translation of the two languages? The nature of this problem is obviously recursive.

One solution is **instinct**. Animals know instinctively how to interpret signals from other members of their species. An external process of evolution (suppressing the ones that did not get the meaning of the signal) and internal information processing and inheritance at a genetic level established this joined understanding of meaning. In the end, the information processing at the level of the species is explained through the information processing at the level of genetic inheritance. A very successful species in this respects are ants (cf. [Hölldobler & Wilson, 2009]). During the last 40 million years they established themselves as dominating species in their ecological niche amounting in more biomass than the human race. Their success is based on establishing joined child care, cooperation and division of labor, agriculture based on planting fungus and animal husbandry. This complex social structure and cooperation styles require complex communication patterns that are rooted in joined understanding based on mostly chemical signals. Evolution has established a tight coupling of the external chemical processes with the ones that are internal to a single ant. Based on this, the ant knows instinctively its place in society. However, this hard wired system of meaning exchange is rigid, inflexible, and evolves slowly. No surprise the Ants could not make it in 40 millions years to the Moon (cf. [Fensel & Cerri, 2010]).

Humans passed through such a development of cooperation and social structures with much faster speed. This did not leave enough time for evolution to hard wire the interpretation of communication through inborn instincts. That is we can no longer refer directly to an information process based on genes to explain the information processing between different individuals (glued together through evolution).[1] "Humans can live in

1. Chomskys' assumption of an *universal grammar* that is build in the human brain is in the same way not a solution but a neglection of the problem to be explained (cf. [Chomsky, 1965]).

a wieder range of environments than other primates because culture allows the relatively rapid accumulation of better strategies for exploiting local environments compared with genetic ineritance.“ [Richerson & Boyd, 2006] Actually genes had to be replaced by **memes** (cf. [Blackmore, 1999]) a process of cultural inheritance of information processing and exchange of meaning based on *gene-culture coevolution* (cf.[Tomasello, 1999], [Richerson & Boyd, 2006]).[2] In the following we will quickly pass through the four essential elements of this process: Analyzing why and how humans developed a culture of cooperation, how this is translated in the necessity for communication of meaning, how meaning is extracted and processed, and sum this up in a general pattern for understanding information.

1 Cooperation

“Two hunder can take down a stag, while a lone hunder can only catch a single hare.”
[Tomasello et al., 2009]

“To sum up, the species-unique structure of human collaborative activities is that of a joint goal with individuals roles, coordinated by joint attention and individual perspectives. ... Skills and motivations for cooperative communication coevolved with these collaborative activities because such communication both depended on these activities and contributed to them by facilitating the coordination needed to co-construct a joint gal and differentiated roles.**“** [Tomasello et al., 2009] His central thesis is therefore that the fast and unique way cooperation arose as a necessary means in human development is what can explain his communication skills that are a prerequisite for these cooperations. Therefore, we want take a quick bird eye view on it identifying five distinct phases.

Living in the rain forest. Around 50 million years ago, *primates*[3] and their subbranch *anthropoidea or siminas*[4] (*e.g.*, *monkeys* and also later *apes*) populated the rain forest and similar ecological terrains (cf. [Lewin 2005], [Schrenk, 2008], [Boyd & Silk, 2009], [Klein, 2009]).[5] For successfully surviving in their three dimensional habitat based on fragile branches, they had developed social behavior and communication, stereoscopic vision[6], reliable hands and feet motion to walk, moving hand over hand, and to jump, and a brain that provides enough cognitive power to achieve this complex coordination of perception and action. Like their predecessors they had developed small groups as social form of living. Around 25 million years ago,

2. http://en.wikipedia.org/wiki/Meme.
3. http://en.wikipedia.org/wiki/Primate
4. http://en.wikipedia.org/wiki/Anthropoidea#Classification_and_evolution
5. Life on our planet started around 3.5 billion years ago and evolved from organic molecules, over prokaryotes, eukarotes, multi cellular organisms in the sea to plants and animals conquering the continents, cf. http://en.wikipedia.org/wiki/Life. Only for completing the picture: the Universe is assumed to stay around for around 14 billion years; Sun and Earth for around 4,5 billion years.
6. http://en.wikipedia.org/wiki/Stereoscopy

apes started to separate from monkeys (cf. [Zimmer, 2005]).

Living on the edge. Between 5 and 8 million years ago (cf. [Tomasello, 1999], [Lewnin & Foley, 2004], [Lewin 2005], [Schrenk, 2008], [Boyd & Silk, 2009], [Klein, 2009]) sub branches of these apes started life on the boundaries of their habitat entering grass and tree savanna.[7] At that time our predecessor called **Australopithecus**[8] started to branch away from the joined predecessor of it, Chimpanzees, and Bonobos[9]. For several million years, not much of a difference was arising between these ape branches. However, the new habitat requested alteration of behavior. Upright carriage become significant more important to master the new two dimensional living area were enemies were threatening. Seeing them earlier and carrying food away in saver forest areas was a clear advantage. The hand over hand moving of apes in trees slowly become complemented by walking on feet on the ground. Actually [Richerson & Boyd, 2006] call them *bipedal apes*. This slowly freed the hand for other purposes and step by step allowed the usage and development of tools as we can also see it in rudimentary forms by Chimpanzees. "Aus der Tatsache, daß weder anatomische noch kulturelle Verteidigungs-, geschweige denn Angriffsmerkmale bei *Australophithecus anamensis* vorhanden sind, läßt sich schließen, daß ein ausgeprägtes Sozialverhalten die entscheidende Schutzfunktion gegenüber der Umwelt übernahm. In dieser frühen Phase der Hominidenentwicklung, in der eine Verteidigung mit Hilfe der Zähne nicht mehr un mit Hilfe von Werkzeugen noch nicht möglich war, lag ein weiteres Selektionsvorteil in der starken Verfeinerung und Weiterentwicklung des primatentypischen Sozialverhaltens. ... In einer solchen Umgebung war die Lebensweise von *Australopithecus africanus* einerseits darauf ausgerichtet, durch geschicktes Verhalten alle Nahrungsmöglichkeiten auszuschöpfen, andererseits war diese Ernährungsstrategie immer damit gekoppelt, für ausreichenden Schutz des Individuums zu sorgen: Kinder wurden von den Eltern getragen, die Zusammengehörigkeit ind er Gruppe wurde gefördert, **Informationen wurden ausgestauscht**, Rückzugsgebiete, zum Beispiel Bäume, wurden definiert und genutzt. ... wir wissen heute: *Australopithecus africanus* war nicht der Jäger, ..., in Wirklichkeit war er der Gejagte."[10]

Living beyond. A first and very important shift happened around 2 million years ago with the appearance of a new *genus*.[11] The **Homo habilis** and **homo erectus**[12] (cf. [Leakey, 1994], [Tomasello, 1999], [Anton, 2003], [Lewin 2005], [Zimmer, 2005], [Junker, 2008], [Schrenk, 2008], [Boyd & Silk, 2009], [Klein, 2009]) significantly altered his physical appearance, his cooperation, and his approach towards life in general. His locomotor system adopted to the erected movement, his arms and hands transformed finally from a means of transportation into a means of manipulating the

---

7. We drop the question about who was approaching whom, i.e., the apes the new habitat or vice versa.
8. http://en.wikipedia.org/wiki/Australopithecus
9. http://en.wikipedia.org/wiki/Bonobo. See also [de Waal, 2005].
10. Translated into English from [Schrenk, 2008].
11. This brake through is comparable to the moment in Nature when animals that had slowly become familiar with the border region of sea and land started to penetrate the land.
12. http://en.wikipedia.org/wiki/Homo_erectus. Earliest homa variants date up to 2.5 Million years back (cf. [Lewin 2005]).

environment, and his *brain size doubled*, and he started to sweat and lost his fur being able to run over long distances. From staying at the edge of the old habitat he started to penetrate the new one. He lost his ability to climb and living on trees but in return he became an excellent persistent walker and hunter in the Savanna. The increase of the brain size is remarkable as a brain consumes up to 20% of the energy of an adult and up to 60% of an infant (cf. [Lewin 2005]). Obviously there was strong evolutionary pressure necessary for this growth. Also new sources of food such as meat and the use of fire[13] to prepare food were necessary for this. It is also the time of steady and increasing use and construction of tools based on a social inheritance process of experience necessary for this. The overall social structure modified and became more complex reflecting the more complex cooperation forms of the new species in their new habitat. For the first time, humans started to explore the entire planet as a potential living area. A creature raised in the forest had successfully accepted the challenge to survive in the savanna and turning from a hunted creature (that uses trees and forest as a refugee in case of danger) into a hunter (cf. [Leakey, 1994], [Lewnin & Foley, 2004], [Lewin 2005]). Still, they were rather a minor species in all these habituates they were entered.

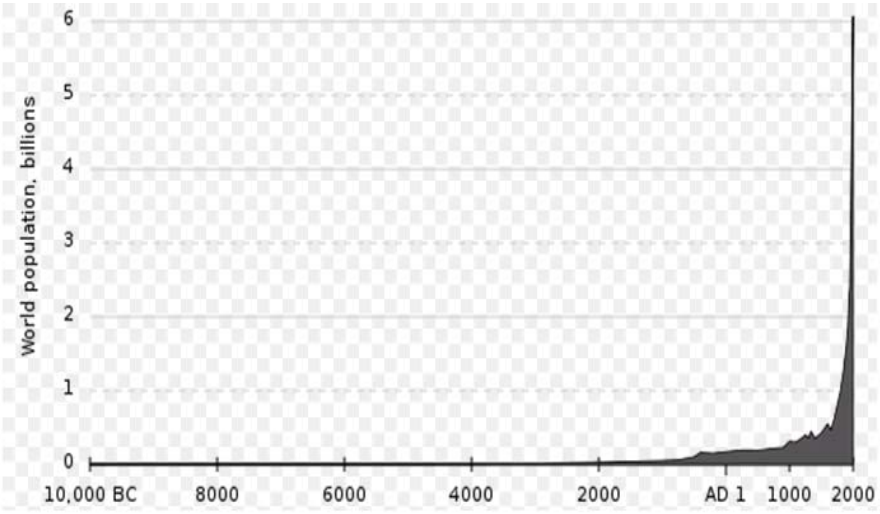
Dominate the habitat as it is. This started to change around 200,000 years ago with the appearance of a new *species*, the **homo sapiens** (cf. [Tomasello, 1999], [Lewin 2005], [Zimmer, 2005], [Junker, 2008], [Boyd & Silk, 2009]).[14] Having our body the most significant alteration in his physical appearance was that his brain size significantly increased again. The new species quickly spread all over the world and wherever it appeared the population of large animals immediately start collapsing (cf. [Junker, 2008]).[15] He has not only lived in the new habitat, he started to dominate and alter it. For this species, the wide-spread *use of symbolic communication* and *use of complex tools* and *weapons* is proven. Obviously, they also explored and invented *new cooperation styles* that allowed them to dominate any other species they found in their range. Altering instead of adapting to a habitat has become the essence of their interaction style with their environment.

Alter the habitat as a place to stay. What was first a reduction of potential enemies and meat resources turned into a process of producing the conditions his existence is depending on. During the *neolithic revolution*[16], homo sapiens not only started to dominate the new habitat. They started to reshape this new habitat. With agriculture and domestication of animals hunter-gatherers[17] turned into settled farmers. Food was no longer collected provided by external processes but rather produced by a self-run process. Again this required completely new forms of cooperation. Through its self-

13. *Fire* was not only a means to prepare food and to provide heat. It also was a powerful means to protect and to be used for hunting. Its use required a complex social cooperation mechanism to maintain its permanency (cf. [Schrenk, 2008]) and introduced a very significant selection mechanism for it. See http://en.wikipedia.org/wiki/Control_of_fire_by_early_humans. See also the excellent film "*Quest for Fire*".
14. http://en.wikipedia.org/wiki/Homo_sapiens
15. Finally, ocean fishing by homo sapiens achieved the same 200,000 years later for the last not yet conquered ecosystem, the open and deep sea (see [Crist et al., 2009]).
16. http://en.wikipedia.org/wiki/Neolithic_Revolution
17. http://en.wikipedia.org/wiki/Hunter-gatherer

referential character (producing the conditions of its own existence) the ground for exponential growth had been laid. According to Fig. 1 around five millions individuals grow up to 200 million in around 8,000 years and up to one billion during the following 1,800 years.[18] Finally, the development of efficient local and global production, transport, and communication means during the last 200 years accompanied a grow to up to seven billion humans now.

True cooperation necessary to survive as a species in scenarios that were not covered by instinctive understanding was what was needed in this transformation process. It generated a cultural process of inheritance encoding and understanding of meaning. And each new media to carry and support this process made a major change in human development. Genetically Chimpanzees, Bonobos, and Homo sapiens are 99% identically, i.e., they would normally form only three different species of the same genus and would not justify the separation of humans as a separate genus. The difference of apes on the one hand and humans on the other hand can therefore *not* explained by genetic inheritance (cf. [Tomasello, 1999], [Junker, 2008]). "This means that just as individual humans biologically inherit genes that have been adaptive in the past, they also culturally inherit artifacts and behavioral practices that represent something like the collective wisdom of their forebears."[19] [Tomasello et al., 2009].



Population_curve.svg (SVG file, nominally 550 × 275 pixels, file size: 4 KB)

This image rendered as PNG in other sizes: 200px, 500px, 1000px, 2000px.

This is a file from the Wikimedia Commons.

Fig. 1 Exponential grow in number of humans.

18. http://en.wikipedia.org/wiki/File:Population_curve.svg

2 Communication

A interesting difference between humans and animals is the ability of understanding the indented meaning of a **gesture** (cf. [Tomasello, 2008]). Humans can easily transfer meaning by pointing to something. No animal, that is not raised up and trained by humans share this ability. Even our closed relatives such as Chimpanzees fail completely on sharing meaning through gestures. This corresponds to their lack of cooperation. They nearly do not have processes were a number of their individuals cooperate in jointly achieving a goal. An exception seem to be that occasionally a group of male Chimpanzees jointly hunts smaller apes from other species. However, it does not really seem to be a truly cooperative effort. Each Chimpanzee tries to optimize his individual chance to catch the smaller monkey first and eat as much of it as he can until other Chimpanzees request violately their share (cf. [Tomasello, 2008], [Tomasello et al., 2009]). Similar mechanisms seem to be in place when a horde of scarps start to hunt a swarm of sardines. It looks like cooperation but is actually a process were individuals try to optimize their share on the overall gain. True cooperation has a higher potential. Here the individuals try to achieve the maximal gain for the group trusting that they will receive a fair share of the overall success. Such a team can achieve results that are beyond a simple process of aligning individuals gain maximization. However, it requires coordination and adoption of the individual behaviors, i.e., communication to achieve such an alignment. Indicating were the target is to the other members of the team and aliening the group to maximize the potential success become essential means for the success of the process. Soon, humans did no longer hunt smaller animals. Instead their size did no longer matter to them. “Cooperate communication then arose as a way of coordinating these collaborative activities more efficiently, first inheriting and then helping to build further a common phycological infrastructure of shared intentionality.” [Tomasello, 2008], p. 19.

A simple process of aligning individual gain maximization does not provide such a need nor does it has a similar potential for the evolutionary success of such a group. As individual player I will not try to provide hints to my competitors and if I would just try to minimize their chances to increase mine, i.e., even if I would communicate meaning it would be wise for the others not to listen to me.[20] This lack of cooperation skills has also been proven in experiments were one player can allow a second player to access food (cf. [Tomasello, 2008]). Already young children play this game in a way that the second player shares some of the gain with the first player that enables him to pick up the food. Chimpanzees completely fail on this game. The second player will not share and the first player will no longer allow the second one to get food. Both would rather die hungry than establishing a joint win-win situation. Being able to cooperate for achieving the advantage of win-win situation is what made *human communication*

19. Actually, oppositely, the cultural evolution starts to select genes such as the adult lactose digestion as a reaction towards keeping of cattle ten thousand years ago (cf. [Richerson & Boyd, 2006]).

20. “That is, they themselves communicate intentionally only to request things imperatively, and so they only understand others’ gesture when they are imperative request as well--otherwise they are simply mystified as to that the gesticulating as all about.“ [Tomasello, 2008]. p. 41.

necessary and rewarded and which explains the unique role humans play on our planet.[21]

This lack of social cooperation goes hand in hand with the little virtuosity in using **vocal calls** as means to exchange meaning (cf. [Tomasello, 2008]) Apes can learn to interpret vocal signals of member of the same species or even from other species. Therefore, apes are able to extract information form signals. However, they are not capable to send such signals consciously:

- "within any monkey or ape species all individuals have the same basic vocal repertoire, with essentially no individual differences in repertoire;
- monkeys raised in social isolation and monkeys cross-fostered by another monkey species (with very different vocal calls) still produce their same basic species-typical vocalizations (and not those of the other species);
- the connection between a vocal call and its eliciting emotion or situation is mostly very tightly fixed; non-human primates do not vocalize flexible by adjusting to the communicative situation; and
- human attempts to reach new vocalizations to monkeys and apes always fail and attempts to teach them to produce their own vocalizations on command either fail or take many thousands of trials to work only a little." [Tomasello, 2008], p. 16f

Spoken in a nutshell, listeners may be able to pick up meaning from signalers, however, signalers do neither intend to provide them nor being able to influence this provisioning. In conclusion, monkeys and apes may produce sounds that other monkeys and apes are able to interpret as a signal, however, the sender has no intention to do so. "All of this suggests that in human evolution greater tolerance among conspecifics would have been enough to begin moving in the direction of true collaboration as well as imperative pointing--with no further cognitive skills necessary beyond those of modern-day great apes." [Tomasello, 2008], p194. The vocal call is interesting because the sender and the receiver perceive the gesture in roughly the same fashion (cf. [Mead, 1934]). Therefore, there is a union of the perception of the signal, the internal reaction of the sender on it, and the way the receiver reacts on it. In consequence, there is immediate awareness of how the gesture alter the internal cognitive state and the way the receiver react on it. "In so far as one calls out the attitute in himself that one calls out in others, the response is picked out and strengthened" [Mead, 1934], p. 66.

The vocal call already could transport beyond the eyesight of a receiver. A small step towards the extension brought by written communication. Suddenly, meaning

21. The work of Marc Hauser seem to contradict some of these statements. However, it seems to lack proper scientific evidence and in the end, this is not really important for our point. Our book is not about the information processing capabilities of Chimpanzees. We only use them as an illustration for the fact that communication of meaning is *needed and rewarded* by a process of true cooperation, were different players adopt their behavior towards a cooperative process were the optimal result for the group is achieved due to sharing the results. It is the joined definition of a win-win situation in difference to simply trying to optimize the individual gain and accidently acting as a group in this process. A strong evidence for this is the fact that the humans is the only primat that has a sclera, the "white of the eye" that allows other humans to easily catch were we are looking, i.e., cooperation is based on sharing information rather then on hidding information (cf. [Tomasello, 2008], [Tomasello et al., 2009]).

could be transported and stored far the beyond a given context. Not surprisingly it development is evolving with the establishment of significant larger groups of humans that start to cooperate. Modern civilization in its early form was born. Another revolution started just 200 years ago with electronic communication. telegraphy, radio technology, telephone, television, internet, mail, and web significantly our communication. For the first time instant communication at a global scale as a mass phenomena is possible. Information measures in bytes roughly doubles every 18 months which results in *exponential* growth of this information amount.[22] We currently just see the very early begin of this process.

3 Interpretation[23]

"The brain is a very expensive organ to maintain" [Lewin 2005]

The brain size trippled during the evolution from apes to home sapiens and this on the basis that mamals in general have approximate 10 times the brainsize of repitles and amphibians (cf. [Lewin 2005]). Let's look for a moment at the organ that does information processing at the level of an individual, the human brain (see [Singer, 2002], [Singer, 2009]). There was a very critical phase in the evolution of our species where erected walk and its requirement for small pelvis aperture conflicted with the parallel request on increasing brain size. Therefore, all human babies are early birds (cf. [Leakey, 1994], [Zimmer, 2005])[24]. This disadvantage could also be an advantage. Evolution preferred the survival of babies with a high development potential less pre-shaped by genetic development. More space for shaping these organs through social processes has been generated. Also stronger requirements on the social organization of the process that is raising up these babies. An example for how environment determines the brain is three dimensional visualization. People who were blind during their first years of life are not able to see during the rest of their life even if their eyes are repaired. The precise definition of proper three dimensional visualization depends heavily on the actual shape of the face which cannot be precisely determined by the genes. Therefore, the definition of the visual processing capability of the brain is not pre-defined by genes but results from an interactive process with the environment during the first years of life. The inheritance of properties by genes already anticipates the inclusion of external stimuli to define the actual shape of the brain.

"The program for all functions of the brain is determined by the architecture of the connections through which neurons communicate with each other. Since this functional architecture is modifiable by experience throughout the postnatal phase of brain development, the specific way in which we perceive and act can be *passed by imprinting and education from one generation* to the next." [Singer, 2002] That is, there

22. http://www.guardian.co.uk/business/2009/may/18/digital-content-expansion
23. See [Fensel & Wolf, 2006] from were we take most of the argument.
24. [Leakey, 1994], [Lewnin & Foley, 2004], and [Lewin 2005] estimate that a pregnancy period of 21 months would be normal for us.

is a cultural inheritance process not present in the genes that materializes in the physical/biological structure of the brain. This is a *necessity* since the rapid evolution of our species has required an inheritance process much faster than what is implementable by genetic inheritance. Such a process is *possible* through the fact that genes include stimuli from the environment as integral part of shaping the phenotype. Information *must* and *can* be inherit via cultural processes that generation by generation reflect in the brain structures of the individuals beyond that which is determined and inherited by genes. Specific aspects of the spirit are not attached to single neurons but to their interaction patterns. Neurons can be active in various interaction patterns in which they play different roles at the same time. Such interaction patterns are composed of three elements: Neurons, connections (electrical and chemical), and a certain frequency of oscillations between the neurons established via their connections. Metaphorically speaking, a thought is a specific self-oscillation of a network of neurons. On the one hand, it is the topology of the network that determines its resonance. On the other hand, it is the resonance in the brain's interaction with the environment and with itself that creates, reinforces or decouples interaction patterns. Again, the brain is not a static device, but a device that is created through usage, or in the words of Singer „program and architecture are the same and it makes no sense to ask which side determines the other“. It is again an interaction process where both sides concretize the other. Spoken in a nutshell it is the process of thinking that generates the physical structure of the brain, i.e., it is the memes that materialize in biological hardware and not the other way around.

Around 80 to 90% of the reasoning of the brain is concerned with itself defining it as a self-referential system with partial self-consciousness. The numerical complexity of our brain is frightening. 100 billions of neurons can have hundred trillions of connections and hyper trillions of resonance patterns. Neurons can interact locally with surrounding neurons through the exchange of chemical neurotransmitters. A second kind of interaction is implemented through a network of dendrites connecting the neurons and enabling global interaction. Neurons can interact over great distances with other neurons via instant exchange of electrical signals along these dendrites. Furthermore a given neuron can participate in a number of distinct exchange processes via differences in the frequencies of the exchanged electrical signals. Metaphorically, a thought can be described as a pattern of self-oscillation and resonance among connected neurons. The numerical complexity involved in describing the potential states of a system, based on billions of nodes where every node can in principle interact with every other node in a nearly infinite spectrum of frequencies, is beyond the (current) state of Science. Finally, the ultimate, hidden material existence of reasoning is not the substantial, biological existence of the brain: but it exists as patterns of self-oscillation and resonance of the connected neurons. It is those oscillation patterns which, in the process of development of the individual brain, that create their own underlying network of links and connections.

Coming back to Ants (cf. [Fensel & Cerri, 2010]). Ants have essentially the same brain structure in principle, however possess only 0.0000001% of the number of neurons. This is clearly a significant difference in complexity. However, a colony can have more than one million individuals which brings the number back to 10-20% of a

human brain. There is, however, still a marked difference between the instant and potentially global interaction of neurons within one brain and neurons distributed over two ants' brains. Communication between ants is based on exchanging chemical pheromones and therefore local. As a result, the freedom of interaction in these networks of neurons is severely restricted and notably slow. Small chunks of 10 000 neurons interwoven with high speed interactions networks are hidden behind "Chinese walls" only allowing very slow and locally scattered interaction with other neuronal network chunks. In a human brain billions of neurons are connected globally in instant communication networks.[25]

4 Information

Information or meaning seem do have three intristic desires: Spreading as far, as massively, and as quickly as possible. Just like any other virus[26]. Up to know we have discussed information exchange and processing as a means for life. Complementary one could view life as yet another means to build up more complex generation and processing of information. Life and its permanent renewal generate steadily more complex and faster information representation and processing mechanisms, moving for example from genetic to memetic processes. In general, information representation and processing seem to be a basic category for many areas of science (cf. [Fensel & Wolf, 2006]).[27]

5 Referencees

[Anton, 2003]
S. C: Anton: Natural History of Homo erectus, *Yearbook of Physical Anthropology*, 46:126-170, 2003.

[Blackmore, 1999]
S. J. Blackmore: *The Meme Machine*, Oxford University Press, 1999.

[Boyd & Silk, 2009]
R. Boyd and J. B. Silk: *How Humans Evolved (5th ed.)*, W. W. Norton & Company, Inc., 2009.

[Chomsky, 1965]
N. Chomsky: *Aspects of the Theory of Syntax*, MIT Press, 1965.

[Crist et al., 2009]
D. T. Crist, G. Scowcroft, J. M. Harding jr.: *World Ocean Census - A Global Survey of Marine Life*, Firefly Books, 2009.

[Fensel & Cerri, 2010]
D. Fensel and D. Cerri: Why Weren't Ants the First Astronauts? In *Proceedings of the 14th World-Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2010*, Orlando,

25. In a sense the difference is similar to pre and post-internet society were instant and global interaction becomes a mass phenomena.
26. One of the most primitive self-replicating genetic information chunks.
27. In general, we believe in the third interpretation of the Universe as analyzed in [Lloyd, 2002].

Florida, USA, June 29 - July 2, 2010.

[Fensel & Wolf, 2006]
D. Fensel and D. Wolf: The Scientific Role of Computer Science in the 21st Century. In *Proceedings of the third International Workshop on Philosophy and Informatics (WSPI 2006)*, Saarbruecken, Germany, May 3-4, 2006.

[Hölldobler & Wilson, 2009]
B. Hölldobler and E. O. Wilson: *The Superorganisms*, W.W. Norten & Company, New York, 2009.

[Junker, 2008]
T. Junker: *Die Evolution des Menschen (2nd ed.)*, C.H.Beck Verlag, 2008.

[Klein, 2009]
R. G: Klein: *The Human Career (3rd ed.)*, The University of Chigago Press, 2009.

[Leakey, 1994]
R. Leakey: *The Origin of Humankind*, BasicBooks, 1994.

[Lewin 2005]
R. Lewin: *Human Evolution: An Illustrated Introduction (5th ed.)*, Blackwell Publishing, 2005.

[Lewnin & Foley, 2004]
R. Lewnin and R. A. Foley: Principles of Human Evolutoin (2nd ed.), Blackwell Publishing, 2004.

[Lloyd, 2002]
S. Lloyd: Computation Complexity of the Universe, *Physical Review Letters*, 88(23), 2002.

[Mead, 1934]
G. H. Mead: *Mind, Self, and Society*, The University of Chicago Press, 1934.

[Richerson & Boyd, 2006]
P. J. Richerson and R. Boyd: *Not by Genes Alone*, The University of Chigago Press, 2006.

[Schrenk, 2008]
F. Schrenk: *Die Frühzeit des Menschen (5]th ed.)*, C. H. Beck Verlag, 2008.

[Segaran et al., 2009]
T. Segaran, C- Evans, and J. Tayler. *Programming the Semantic Web*, O'Reilly, 2009.

[Singer, 2002]
W. Singer: *Der Beobachter im Gehirn*, Suhrkamp, 2002.

[Singer, 2009]
W. Singer: The brain, a complex self-organizing system, *European Review*, 17(2): 321-329, 2009.

[Tomasello, 1999]
M. Tomasello: *The Cultural Origions of Human Cognition*, Harvard University Press, 1999.

[Tomasello, 2008]
M. Tomasello: *Origins of Human Communication*, MIT Press, 2008.

[Tomasello et al., 2009]
M. Tomasello, J. Silk, C. Dweck, Brian Skyrms, and E. S. Spelke: *Why we cooperate*, MIT Press, 2009.

[Zimmer, 2005]
C. Zimmer: *Smithsonian Intimate Guide to Human Origins*, The Madison Press Limited, 2005.