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Natural propositions – The evolution of semiotic self-control

> *Given the oxygen, hydrogen, carbon, nitrogen, sulphur, phosphorus, etc., in sufficient quantities and under proper radiations, and living protoplasm will be produced, will develop, will gain power of self-control, and the scientific passion is sure to be generated. Such is my guess.*
> ("L", after 1902, Ms. 601, 7.50)

Many spontaneous ideas in biosemiotics and evolutionary epistemology presume that the earliest signs appearing in evolution must be simple in the sense that later, more complicated signs arise from the combinations of simpler signs. If biological cognition has evolved to fit parts of logical structure, however, the perspective should be turned 180 degrees. The "highest" Peircean sign types: propositions and their linking into arguments, are what represents aspects of reality (propositions) and give rise to inference to action (arguments) – they must present from the very beginning of biosemiotics, albeit in a rudimentary indistinct proto-form, corresponding to Peirce's idea that propositions are genuine signs, and the whole periodic table of simpler signs are but degenerate signs which naturally occur *within* propositions. Selection forces the survival of truth-bearing signs – Dicisigns. Evolution then subdivides, sophisticates and articulates proto-propositions, gradually achieving growing autonomy of its parts. So, instead of an ongoing construction from building-blocks, semiotic evolution is rather the ongoing subdivision, articulation and autonomization of a reasoning process having its very first proto-form in primitive metabolism.

Spontaneously, it might seem like a sound idea to presume primitive biological signs are simple signals, only later to combine into more complex signs. Such seems to be Terrence Deacon's idea that icons, indices, and symbols characterize large phases of biological evolution so that early biology was iconic, later to become indexical while only human beings process symbols. Hence, he reconstructs in his otherwise inspiring (1997) Peirce's notions compositionally, so that an index is taken to be a specific combination of icons while a symbol, in turn, is a specific combination of indices. I have discussed the problems in Deacon's reinterpretation of Peirce's icon-index-symbol triad elsewhere (Stjernfelt 2007, ch. 11) so I shall restrict myself to briefly summing up that discussion. Peircean symbols are not restricted to human sign use. Symbols are signs which are general as to their object; they possess an *esse in futuro*, referring to a potential continuity of future objects; they refer to their object by means of a habit, natural or cultural; they comprise icons for their understanding and indices for their object reference; and they have full propositions as an important subset. Thus, simple Pavlovian conditioning – dogs acquiring the habit of displaying eating behaviour by the ringing of a bell – will constitute a full-fledged Peircean symbol, not merely an indexical sign as Deacon would have it. It is not, like pure indices, a sign restricted to the here-and-now of actual connectedness between sign and object. The bell sound is a general type, referring, in turn, to another type, that of eating, a potential multitude of future eating situations. The here-and-now of the particular bell sound token in a particular instant functions as a Dicisign incarnating that general meaning in the actual moment of the ringing. Even a case as simple as coli bacteria (*Escherichia coli; E. coli*) swimming upstream in a sugar gradient as the result of its registration of molecules displaying a specific active site (cf. Berg 1988; Stjernfelt 2007) must be described as symbolic in Peirce's sense of the term: it is a habit (acquired phylogenetically, to be sure, in contrast to Pavlovian conditioning acquired ontogenetically), the habit connects a specific, typical aspect of molecular shape with a specific, typical action, that of oriented swimming and consumption. We shall argue this perception-action link is even the proto-form of an argument. The fact that the molecular configuration of the "active site" on the perimeter of the molecule is general may be seen from the fact that it is not unique to a specific carbohydrate but covers a wide range of different carbohydrates (cf. Adler et al. 1973). This generality is facilitated by the chemoreceptors of the cell being geared to detect sugars by means of weak interaction with the active site on the surface of the molecule. And this generality, in turn, is what makes E. coli susceptible to being fooled by the same artificial sweeteners as may human beings. The ability to commit errors is, of course, what basically characterize Dicisigns. So, Peircean symbols are not a human prerequisite only, nor are Dicisigns.

Another related problem is that even if the icon-index-symbol triad is oriented from the simple towards the complex, it is not compositional. Deacon's reconstruction makes indices consist of a specific configuration of icons, and the symbol consist of a specific configuration of indices. But pure icons form a limit concept in Peirce - they will vaguely signify any possible object resembling them, because they are not connected to any actual object (that is the function of an index) – so an index could never result from any combination of such vague, dream-like signs only. The pure index is also a limit category – like a push in the back or a pointing gesture directing attention to an object. Such signs are indeed possible, but they remain limit cases, because neither the pure icon nor the pure index is able to communicate anything. In typical usage, as we have seen, indices are connected with icons in propositions, bearing information about the object which the index merely indicates without itself giving any information at all. Finally, a pure symbol bereft of any iconical or indexical qualities is equally marginal – something like the isolated *x* of algebra – in order to be understood, a symbol must bear information in the shape of an icon and relate that information to an object by means of an index.

Thus, the collaboration of icons and indices within symbols is a way of describing the triad much closer to the actual functioning of signs than the focusing upon rare, detached specimens of the three aspects of sign use. This forms the basic reason why the tempting idea of mapping the icon-index-symbol triad onto the process of evolution is doomed to fail: pure icons, indices, symbols are marginal phenomena. So, there could never have been an evolutionary period where purely iconic signs prevailed – they are much too vague to communicate any information of value for biological processes, because their content is merely possible and does not relate to the actual world. And there could never have been a purely indexical period – indices being attention-directing and based on the here-and-now, they are unable to perform the central task of orienting and guiding biological activity into the future which requires the generality of the symbol. Rather, biological processes are characterized, from the very beginning, by the argumentative arc leading from one Dicisign to the next, typically, from primitive perception to primitive action – and the decisive criterion is that of being susceptible to deception.

Dicisigns in biology

We have already seen how the deflated and naturalized notion of propositions in the Dicisign doctrine dispenses with any necessary connection between propositions on the one hand and human language as well as explicit, conscious intention on the other. The merely functional definition of the Dicisign as that sign which is able to convey truth by means of the double grasp of Subject indices and Predicate icons, makes it clear Dicisigns are indispensable for biological sign use. A very basic evolutionary argument may be invoked here: Signs which may not convey truth are hardly efficient in biology: isolated icons only indicating vague possibilities have little if any pragmatic efficiency in cognition and communication, just like isolated indices only able to indicate that something is happening at a location but not what it is, may be of restricted, local use but not much more than that. This is why Dicisigns are ubiquitous in biology.[i] This may seem hard for both biologists and biosemioticians to appreciate, probably because of the widespread idea that propositions require the judgment of a conscious "propositional stance" found only in human beings as well as the whole of the machinery of human language to express those propositions. Here, Peirce's purely semiotic definition of the proposition as a Dicisign combining two signs into one irreducible whole gives us a formal notion of Dicisign – neither presupposing consciousness nor explicit acts of judging.[ii] We already saw in Hurford the argument for the existence of proto-proposition in the cognition of higher animals. Given the functional definition of proto-propositions, however, there is no need to restrict ourselves to higher animals. Pragmatically, the existence of Dicisigns will be displayed by specific perception-action connections – in an organism's behavioral possibility of acting in a typical, categorized way prompted by the categorical perception of some biologically important, stable feature of its environment.

Dicisigns in Perception-Action cycles

In the following, we shall run through a series of well-worn, classic examples of biosemiotics, establishing the role of proto-propositions in each of them. Thus, when the *E. coli* reads the perimeter of the carbohydrate molecule, its subsequent oriented swimming counts as the behavioral proof that a Dicisign combining the abstract shape of the active site with a here-and-now presence of such a site has been processed by the bacterium. Of course, the molecular surface configuration of this "active site" exists in undetected sugar or other inert macromolecules without any Dicisign being realized – its "activity" is only granted by the bacterium's detecting activity. The decisive precondition is that the receptors of the *E.coli* make it possible for such detection to effect a change of behaviour in a characteristic and typical way, oriented towards the continuation of its metabolism (and hence its survival). This simple biological example gives us the important clue to what is semiotically basic in biology: the stable metabolism of an organism. The ingestion of basic nutrients enters the complicated structure of coupled cycles of the metabolism, one of the functions of which is the detection by the organism of further nutrient sources.The single phases of metabolism, may, of course, be described by purely biochemical means, but it is the fact that these phases form a circular, self-sustaining structure which provides the basic biological argument structure leading from perception to action. Metabolism is not only an internal process in the organism, it needs completion by the addition of external nourishment which evolution has taught the organism to detect and consume, completing the cyclical structure.[iii] At the same time, this structure forms the prerequisite for adaptations towards sustaining this process better. This formed the basic insight in von Uexküll's early biosemiotic notion of the functional circle of animals, binding together perception signs with action signs to form the basic cyclic interweaving of perceptions with guided action. Thus, the perceptual Dicisign of reading the active site on a carbohydrate molecule – a proto-version of the proposition "This is sugar" – is followed by the action Dicisign of swimming in that direction – to form an argument: "If sugar, swim in its direction. This is sugar. So, swim in its direction". That this forms a very primitive argument[iv] – and not merely a cause-effect chain – can be induced from the fact that the E. coli may be fooled by artificial sweetener whose molecules possess the same molecular surface configuration as the active site in carbohydrates – but otherwise have a rather different chemistry without the easily releasable covalent binding energy of carbohydrates.

This is not to say, of course, that this process is not underpinned by causal relations. The semiotic aspect of the process lies in the fact that the weak, local interaction makes a whole class of surface stimuli from different sources give rise to the same, typical behaviour. Thus, it is the fact that the bacterium does *not* interact causally with the whole of the molecule (before consuming it, that is) but merely weakly interacts with a spot on its perimeter which is a precondition for its turning a semiotic and not merely causal process.[v] This argument structure binding together perception and action, of course, is close to being as simple as it may get – and the explicit analysis of it into two distinct Dicisign phases is possible for the observer equipped with the functional Dicisign definition, but surely not for the bacterium itself. It has no possibility to make any single aspect of the argument explicit nor autonomous – there are few chemical agents (besides carbohydrates, certain toxins) which the bacterium is able to categorize and react to. The automat-like character of the perception-action link testifies to its holist, not-yet-differentiated character. So the organism is not able to address the logical structure of its own perception-action chain as such nor to substitute other perceptions or conclusions for those of sugar and toxin, or eating and fleeing, respectively. Still this basic argument structure is what makes it possible, during evolution, for higher animals to refine and spread perception-action cycles to much larger parts of their surroundings, thereby enlarging their *Umwelt*, and, what is more, to isolate parts of the Argument as Dicisigns, and, in turn, parts of those Dicisigns as Subject Indices and Predicate Icons. It is the fact that metabolism has an active perception-action phase – marginal in plants and fungi, central in animals – that introduces semiotics in the simple reasoning inherent in searching the environment for nutrients (and, in the E. coli case, escaping certain toxins). The "reading" of carbohydrate and toxin gradients before a substantial concentration of either is present is what allows the animal the conclusion of going into the right direction for finding (or escaping) such concentrations.

That specific part of the object is Peirce's "Immediate Object" which stands in direct contact with the organism. Thus, the split between Immediate and Dynamic Object is the prerequisite for categorization by means of a predicate. In human translation the E. coli predicate for carbohydrates would thus be *SUGAR(x).* Peirce's functional definition of the Dicisign here allows us to acknowledge the proto-proposition processed by the bacterium when it senses the presense of carbohydrates due to its receptors weakly interacting with a carbohydrate molecule. Temporal comparisons in the course of its movement are what allows for the bacterium to compute the direction of the carbohydrate gradient and subsequently orient its swimming in that direction: *SUGAR DIRECTION(y)*. Like most if not all primitive Dicisigns, this example thus forms part of an argument from perception to action – from *Merkzeichen* to *Wirkzeichen*, as von Uexküll would have it, from perception sign to action sign. This allows us to grasp the role played by proto-propositions in von Uexküll's basic "functional circle", exactly taking the animal from a perception Dicisign, involving the functional establishment that something is the case, and to an imperative action Dicisign: swim in the sugar direction. Such simple arguments seem to involve imperative conclusions in the shape of action which are, indeed, for a pragmatist viewpoint, the basic type of proposition. Perception signs prompting action signs – belief as that which prepares for action. Simple animals do not, of course, have access to a range of different propositional attitudes to the same propositional content; that is a privilege for higher animals.

It is a very remarkable property in such primitive Dicisigns that they are extremely general - they measure one property only. The semiotic interface between the organism and its Umwelt is very restricted and covers only a few predicates like *SUGAR DIRECTION(y)* and *TOXIC DIRECTION(y)*. This is why the perception part of such primitive *Umwelten* is aptly described in sign terminology, rather than in full perception terminology. Unlike the case in higher animals with high-resolution perceptual organs, fine-grained perceptual worlds, integration of sensory modalities, attention direction, etc., here is no detailed, phenomenal world at all. Rather, the *Umwelt* of the bacterium is confined to what can be caught in very few, general predicates. So the idea that biosemiotic signs in general are the result of abstraction processes and inductions from sets of individual, egocentric experiences is simply incorrect – it only holds for certain, ontogenetically acquired signs, possible for organisms with much more elaborated sense organs and corresponding *Umwelten*. The perceptions and predicates of *E. coli* are phylogenetically evolved and not subject to any modification or learning in the lifetime of a single organism (a concept, of course, which is relative due to reproduction by cell division). Only when ontogenetic learning becomes possible can the particular individual experiences of the organism play any role. Such primitive signs are extremely stable and not subject to individual learning. The ability of higher animals, highly developed in humans, to make new signs by inductive learning from perception within individual lifetime should not, as it sometimes happens, be taken to characterize signs as such.

Firefly signaling

Everything points to the fact that cognition – as in the *E.coli* example – is a much more simple process than communication, the former requiring only an organism and an environment, the latter requiring at least two organisms between which information is passed. Just like the true recognition of sugar in *E. coli* allows for the false recognition of sugar in artificial sweeteners, the communication of true proto-propositions immediately allow for deception, the communication of false such Dicisigns with specific purposes. Firefly signaling, studied by James Lloyd and collaborators, gives an example of this much more complicated use of proto-propositions.[vi] Fireflies of the genus *Photinus* have species-specific signaling codes for mating. Typically, males fly in the evening, flashing the species-specific code in the dark, while females sit perched in the grass, to some extent responding to the male signaling. Given such responses, the males approach the females and mating may take place. Here, the proto-proposition emitted by the courting male displays the two functional features of the Dicisign. The subject part of the Dicisign is played by the foreground-background structure of the flash itself, immediately drawing attention from the females (and from other observers, including other firefly species, human beings, etc.). The predicate function of the Dicisign is given by the species-specific flashing pattern allowing for the recognition of the flying flasher as a male of, e.g., the species *Photinus pyralis*. Translated into human language, then, the Dicisign in question will be equivalent to "Here is a male *Photinus* looking for girls". The female perched in the grass – if she answers – will, say, correspondingly "Here is a female *Photinus*, please come closer". Mating and ensuing reproduction and survival of the species, of course, function as the guarantee that these Dicisigns are, in fact, true in the functional sense of truth here discussed.

Not always, however, are such signs true. Another firefly genus, *Photuris*, has specialized in mimicking the love calls of other species. So if the female in the grass is not a *Photinus*, but a *Photuris*, the response signal claiming she is a female *Photinus*, will be false. This may be fatal for the male *Photinus* who reacts to the signal, approaches the female – and is immediately eaten by her. The development of the deception strategy of the species *Photuris* obviously presupposes the already established mating code of – among others – the species *Photinus*. When we speak of "false proto-proposition", "deception" etc., of course, we are using these notions functionally, without any assumption of consciousness or explicit individual intention whatsoever. Our argument, however, is that such functional versions of true and false communication, deception etc. form the prerequisite for later evolution of consciousness in order to make more plastic and complex the processing and recognition of such proto-propositions. Just like the cognitive case of the *E. coli*, the codes in use here are phylogenetically established and not subject to change by the individuals – but just as in their case, the actual use of the code in actual sign tokens takes place in the brief lives of individuals. Many scholars may hesitate to admit that cases such as those discussed here are examples of signs – because they prefer to reserve that notion to signals depending upon codes established by the individual in ontogenetic timescale. Such an argument, however, rests on a much too drastic distinction between phylogenesis and ontogenesis, also in the light of the emerging evo-devo synthesis with insights in the connections between the two in so-called Baldwinian evolution where already established behaviours in social species function as selection pressure on individuals. Thus, "teaching", "tradition", and "culture" are increasingly found in many species, not only in higher animals – provided, again that such notions are taken in a functional use rather than in a use presupposing explicit conscious intentions – cf. the classic paper by Caro and Hauser (1992) on the functional definition of biological teaching and the elaboration of that argument to biological tradition and culture in Whiten (2011). There is no reason not to see habits established over the long run of phylogenetic evolution as semiotic codes, when the actual sign exchange takes place in ontogenetic time. Moreover, already in the firefly case, that exchange requires a certain degree of interpetation in the situation requiring some degree of individual intelligence. The spatial negotiation making the two sexes meet, of course, requires the ability of navigating in the actual surroundings whose structure cannot be coded beforehand. And the possibility that the signaling female *Photinus* might, in reality, be a hungry *Photuris*, has given rise to a specific behaviour in the *Photinus* male. He does not land directly besides the female, but a certain distance away, and then slowly approaches the female, ready to break off his courtship if he senses anything is wrong. This behaviour, of course, is also inherited, but the very decision whether to break off his approach must involve a certain degree of acute perception and cognition of the female's properties on the part of the male.

Dicisigns in Aposematism

Already in the firefly case, Dicisign use is not restricted to intraspecies communication but spread in competitive use by other species. Such use of Dicisigns is widespread in aposematism – the use of conspicuous colors and patterns to warn predators. Darwin famously analyzed animal appearance under the headline of sexual selection but already Wallace pointed to the fact that this could not account for certain phenomena, such as coloring in larvae which are not sexually active. For such phenomena, he proposed the explanation that combined with bitter taste, noxious odour or poisonous chemicals, such appearances function as a warning signal, scaring away predators – what later, in 1890, was called *aposematism* by E. Poulton (from Greek *apo*, "away" and *sema*, "sign"). Such signaling is now known in a broad variety of invertebrate species, most conspicuously in insects. It is less widespread in vertebrates, but is found in certain fish, amphibia, reptiles, even a few mammals. The "scared" predator reaction, of course, may be an inherited code determining predator behaviour, in some cases; in other cases with predators capable of ontogenetic learning, especially among omnivorous predators, such coding may be due to individual experience in an organism. Preferred aposematic colors are black, yellow, and red, providing contrast vis-a-vis green foliage. Conspicuous color combinations and patterns have been proved to enhance the learning of avoidance behaviors in predators. A famous case communicating across many species and genera is the black-and-yellow striping known, for instance, in many wasps, *Vespidae,* e.g. *Vespula Vulgaris*. By so-called Müllerian mimicry (after Fritz Müller, 1878), such sign use may spread among many species, such as honeybees – the common usage of the same sign enhancing the protection of both species. It is an interesting fact that not only immediate predators like birds may take notice of such sign use – also remote species such as human beings, never or rarely feeding upon wasps, know about the dangers from yellow-and-black striped insects. As in the firefly case, once a code is established, it may also be parasitically used, in this case by species which are not at all stinging, poisonous or ill-tasting, such as, e.g., many clearwing moths (*Sesiidae*). By using a similar sign, they enjoy some degree of protection from predators knowing the black-and-yellow stripe code – so-called Batesian mimicry (after Henry Walter Bates, 1861). Also in this case, then, the basic Dicisign character of the possibility of deception is apparent. Unlike species-specific firefly signaling, indicating the gender and species of the organism flashing, this predicate communicates a general, non-species-bound meaning approximating "Danger". The Dicisign, then is constituted by the localization and actualization of this general predicate on individual animal body appearances. Of course, standard biological description does not use anything resembling Dicisign terminology; here "warning signals", their degree of "conspicuousness", "distinctiveness" and "efficacy" form central parts of the standard terminology (Stevens and Ruxton 2012). Here the Dicisign speech act is referred to by the ordinary language notion of "warning" while the attention-drawing quality of the Dicisign subject is addressed as its "conspicuousness". Its Predicative ability to give rise to typical behaviour in the receiver, of course, is addressed by "efficacy". More generally, "signals" are taken to be distinct from "cues" so that the former are evolved for their functional purpose, the latter not so, while "signals" comprise both constant appearances (like the wasp pattern) and on-and-off communicated signals (like the firefly signal) (Scott-Philips 2007). Some argue for a purely adaptational-behavioral definition of "signal", others invoke "information transfer" as alternative or supplementary definition (ibid.). This need not occupy us here, exactly because the Dicisign definition is indeed functional. The double character of the signal in attention-direction (Subject) and behaviour-influence (Predicate), the typicality of its predicate aspect, the behavioral reaction in terms of typical behaviour, suffice to establish it as a Dicisign in the Peircean sense. The fact that the signal satisfies these functional criteria for a Dicisign differentiates it from the mere physical-cause-like interpretation of signals. Communication as the co-evolved emitter-receiver connection between two adaptive systems, providing selective advantages for both of them (in some cases involving reciprocity, in other cases not so) is sufficient for Dicisign communicative structure, because primitive truth is at stake. Aposematism evolves only if the warning signals actually truthfully warn the receiver about some property worth avoiding in the emitter which is what, derivatively, permits the evolution of deceptive use of the same signal. This important distinction, crucial to the characterization of aposematisms as Dicisigns, is given in the biological literature with the distinction between Müllerian and Batesian mimicry.

Frischian Bee signaling

A groundbreaking study in the sign use of invertebrates and an absolute classic in biosemiotics, of course, is the charting of the honeybee signaling system undertaken already in the 1920s by Karl von Frisch. Famously, von Frisch discovered that the European Honey Bee (*Apis mellifera carnica*) has an inherited code for communicating, in the hive, the location of nectar-rich flowers in the surroundings (1965, 1967). von Frisch found that, in the so-called "waggle dance" the direction and distance are communicated separately. The specific movement type of waggling shows that the bee in question is no longer moving around for transport, but for communication purposes. Now, the length of the dance sequence indicates the distance from the cube, and the direction of the dance as related to vertical gives the angle of the direction as related to the sun's actual place in the sky. This is obviously a communicative proto-proposition, expressing the bee equivalent to "there's nectar 200 meter from here, 13 degrees westerly to the direction towards the sun". The structure of this small semiotic system obviously is inherited, not ontogenetically acquired, but even more than in the firefly example, the actual use of it is dependent upon ontogenetically acquired and memorized information. The bee communicating inside the hive remembers the information it has computed during foraging, and translates relative distances in the environment to much smaller, relative distances in the map indicated by the waggle dance. There even seems to be "dialect" variations in the code between different subspecies. The use of these proto-propositions is subject to surprising plasticity and variation. A location communicated may be used only later in the day, and in that case, the receiver is able to gauge her directions according to where the sun sat in the sky in the moment of communication, even if the sun has now moved considerably in its arc across the sky. If large obstructions are placed in the surrounding Umwelt, the bee searching the communicated flower location is able to negotiate its way around very large obstacles to find the right location. A communicating bee having found nectar behind such an obstacle gives information, when back in the hive, which is only partially correct. The direction is truthfully represented despite the obstacle, but the distance is given "too long" because of the prolonged route taken – but corresponds, of course, to the actual distance, which the next bee will have to travel around the obstacle. This implies that the two aspects of the waggle dance Dicisign are computed independently by the bee. As always, the use of proto-propositions gives the possibility of false 'belief'. If the nectar-holding flowers are removed, the bees will still go to the location they have learnt about and search there. An impressive experiment shows that the von Frisch direction communication depends on a whole mental map of the surroundings in which the bees navigate by landmarks like trees, bushes, buildings etc. (Gould 2002). In a flat area without conspicuous landmarks, a beehive was placed with four large alphabet letters indicating the general directions of the corners of the world. On an overcast day, the letters were turned ninety degrees around the compass – and subsequently, the flying pattern of the bees also turned ninety degrees. This showed, of course, that they were able to recognize the shapes of the four large, different letters, and use them as landmarks in their mental map of the surrounding; the same mental map to which the waggle dance implicitly refer. The recognition of those landmarks seems to have overruled the bees' normal estimation of the sun's position in cloudy weather. A cognitive map of the surroundings based on large landmarks constitutes, in itself, a complex Dicisign with a vast, topographical predicate showing the interrelation of those landmarks.

The honeybee example thus shows how both cognitive and communicated proto-propositions may contain information gathered, kept and to some degree memorized by individual organisms in ontogenetic lifetime.

Vervet monkey alarm calls

Much effort has been spent interpreting the findings of Seyfarth, Cheney et al. pertaining to the system of alarm calls in vervet monkeys (*Chlorocebus pygerythrus*) – a system variants of which have since then been found in many other primate species. Vervet monkeys typically face three natural predators: vultures; leopards and other large cats; python snakes and poisonous snakes. They have developed specific alarm calls referring to each of the three situations, and conspecifics nearby respond by different, specific flight behaviours. In addition to that, they have a fourth alarm call relating to what the first vervet call researcher Struhsaker called "minor mammalian predators", lions, hyenas, cheetahs and other mammals – minor in the sense that they only rarely hunt for vervets. Correspondingly, this call does not elicit flight, but merely vigilant behaviour (Seyfarth, Cheney, and Marler, 1980; Cheney and Seyfarth 1990, 102-103). These signals thus are proto-propositition saying "There's an eagle/leopard/snake. Beware!" – or, to be more precise: "There's one of those chasing from the sky/from the bushes/from the earth." As Cheney and Seyfarth add (1990, 170), such a characterization must be amended in the case of mammals where there is a further subdistinction among predators with the same strategy, depending upon whether the danger is major (leopards et al.) or minor (lions et al.). In this case, some degree of ontogenetic learning seems to take place, as pups do not master completely which calls to give on which occasions and only gradually acquire mastery of the code by imitating the adults (Seyfarth and Cheney 1986). The system of alarm calls seems to presuppose the ability to correctly categorize the three predator types, and to conclude the presence of predator individuals from perceptual cues involving sight, hearing, and smell. The wide variety of visual appearances of these species from different points of view, in different lightings and settings, seems to preclude any simple stimulus-response rote learning. Again, we do not need to assume the existence of individual, conscious, communicative intention, in order to recognize a case of functional proto-propositions communicated.[vii] Maybe, however, there is some reason to suspect a degree of metacognition at stake here. Cheney and Seyfarth report cases of "tactical deception"; at one occasion, when a vervet group was lunching in a fruit tree, one monkey gave an alarm call, causing the others to flee, after which the caller himself took over the fruit tree. Such cases, of course, depend on anecdotal evidence, because such behavior cannot easily be elicited, but it seems to rely on reports from experienced primate researchers. The degree of conscious intentionality in such behavior is contested and difficult to decide. Important, however, is that such deception is not a phylogenetically evolved habit as in the *Photuris*, but rather, to some degree, an individually learned strategy in ontogenetic lifetime. Whether it is learned by coincidence and just repeated because of earlier reinforcement or it is connected to some degree of intention, planning or even metacognition and a "theory of mind" of the mental state and ensuing reaction of conspecifics has not yet been settled. Given the functional definition of Dicisigns, however, this does not matter for the characterization of alarm calls, truthful or not, as Dicisigns.

Corvidae – 'feathered apes'

The family of *Corvidae* has been the subject of much ethological and cognitive interest in recent decades. Corvids, involving ravens, crows, magpies, jackdaws, jays, etc. appear as the genera of birds which, along with *Psittaciformes* (e.g., parrots), has evolved the highest degree of intelligence. The brain/body weight ratio in ravens approach that of chimpanzees, and some are now comparing corvids to primates, referring to corvids as "feathered apes" as to intelligent behaviours. Already Aesop has, in one of his fables, a crow filling a pitcher of water with small stones in order to make the water level rise so he could drink it – a fable which now seems to have been experimentally confirmed (Bird and Emery 2009). In corvids, deception and counter-deception seems to have reached new heights. During food-saving in fall, some corvids cache thousands of kernels in individual hideouts, a large percentage of which they are able to retrieve from memory during winter due to landmark recognition. Some individuals are reliably reported to be aware whether conspecifics are watching them when they make their food storages, in which case they will later remove the food and find alternative storage for it when not observed. This seems to imply some version of functional proto-propositional knowledge of the intentions of other minds. Individuals which are, themselves, experienced thieves foraging form the caches of other birds, are reported to be the most suspicoius and most careful food cachers themselves – realizing *in actu* the old proverb "A thief believes everybody steals". Here, several proto-propositions are at stake. The very memorizing of storage caches, often close to small landmarks, constitute so many Dicisigns: "This place contains food". The deception strategy must involve proto-propositional knowledge that the observing conspecific is able to remember the cache location. Corvids are not able to communicate by means of voice, flashes or any specific sign-producing channel of communication, but the fake caching in the presence of peeping conspecifics is, in itself, a communicative act, a small piece of theatre play, falsely expressing, as it were, the proto-proposition "I hide some food here" – knowing it will be hidden better elsewere when the observer leaves. Some ethologists are careful with ascribing any mental states on the basis of behavioral observation and stick to descriptions in terms of adaptation: the corvids quickly adapt to the pressure of losing food by reshaping their behaviour. It is cautious thus to rephrase findings in the wording which presupposes the least degree of intelligence, but behavorist description is agnostic as to which processes lie behind a given behavioural adaptation so such cautiousness does not, itself, solve the issue of what takes place. At this level it is tempting to assume the contribution of some degree of conscious reasoning, but it is important that the Dicisign doctrine, again, does not require such a thing to be applicable.[viii] The recognition of the potential thief in the peeping conspecific may, again, be a purely functional Dicisign of the structure: "This conspecific may steal my cache."

Convergent evolution

It is an important finding that the animals with highest intelligence have evolved in rather distant branches of the phylogenetic tree, not only in mammal genera like primates and cetaceans, but also different branches of avians like parrots and corvids. This phenomenon is investigated under the headline of "convergent evolution": it seems as if intelligence is not an ability closely connected to particular, species-specific brain structures as has sometimes been assumed; rather, different neural structures seem able to support behaviours requiring comparable intelligence. In all cases, however, such intelligence seems to go along with a comparative growth in brain/body weight proportions. The relative independence of intelligence as to specific neural structures effectively seems to rule out, of course, that the evolution of such intelligence goes back to any common ancestor of the species involved. Rather, certain ethological similarities seem connected to high intelligence: all the species mentioned are social animals involved in power struggles and reciprocal manipulation games with conspecifics, many of them are omnivorous, requiring the ability of ontogenetical learning to distinguish a large array of edible and non-edible foods and deal with the different strategies for finding or catching it. Convergent evolution excludes assumptions that reasoning abilities should be specifically connected to very particular brain architectures and rather points to the fact that intelligence as such possesses structures which may be described, to some degree, independently of their neural instantiation. For us, of course, the Dicisign structure forms an obvious candidate to a basic structuring principle of intelligence, both in cognition and communication, and a central ingredient in reasoning, shaping one Dicisign out of another. The double function of Dicisigns seems to be what makes possible the articulation of truth, even in very simple organisms; the evolution of intelligence seems to be connected to an increase in the plasticity of proto-propositions in ontogenetic learning. The growth of predicates more remote from immediate survival activity ("food", "sex", "predator" etc.) to more descriptive predicates only mediately connected to such activity is one dimension of growing intelligence, facilitating the construction of an

Umwelt consisting of more neutral objects – worlds apart from simple *Umwelten* like that of *E.coli*, consisting of little more than nutrients and toxins. The ability to learn new predicates and associate them into kind universals during ontogenetic lifetime forms another dimension of intelligence growth. Probably deception may act as an important motor in such evolutions: the existence of the threat of deception from an ambiguous environment, from other species, or from conspecifics in social animals, acts as a strong selection pressure to evolve and develop abilities to see through the presentation of false Dicisigns. Conversely, collaboration as in honeybees, corvids, human beings, is a strong incentive to become able to communicate socially important knowledge reliably among conspecifics. Most animal Dicisigns seem to be simple, consisting of predicates taking rarely more than two variables and thus devoid of further syntactical variation. Dicisigns addressing episodic memory probably form a strong learning tool; rudimentary syntax seems to appear in some monkeys, even if not necessarily along with semantic relations governing syntactical combinations. Drawing inferences from Dicisigns is probably, in simple organisms, restricted to innate perception-action links; in animals with several different sensory modalities, this information must be synthesized as potentially adding predicates to one and the same object, and in animals with moveable sensory organs, quick perception-action cycles permit the swift zooming in of attention to Dicisign objects.

Sign action – a process differentiated through evolution

This discussion of Dicisigns in selected examples of very different biological complexity, then, serves to state the basic argument that biologically simple signs could not be isolated icons or indices, only later to be composed into more complex signs – nor simple unstructured "signals", associations or stimulus-response mechanic reactions. Biologically simple signs, rather, are full-fledged perception-action arguments – only lacking explicit internal articulation – but bearing with them, due to their double function, the possibility of later segmentation, articulation, autonomization, adaptation to further purposes, making them flexible, potentially giving semiotic structure still more plasticity and eventually making the compositional combination of different Dicisigns, of predicates and subjects, possible. Parts of the metabolism may become relatively autonomous, forming organs – and parts of the perception part of metabolism may acquire their own parts, giving rise to cognitive plasticity, association learning, memory, recursivity and much more, just like the action part of metabolism may differentiate into motor limbs and tools able to support complicated action sequences, co-shaping the environment, depending in turn on this transformation. The basic argument for this ubiquity of simple propositions stretching into arguments in biology is thus based on the observation that phylogenetically acquired habits – like bacteria swimming in the direction of sugar – must be both simple, stable, and (most of the time) true in order to support survival. If not simple, it would be beyond simple organisms to process them. If not stable, they would not be able to address stable features of the environment (such as carbohydrate's combination of easily digestible binding energy and characteristic active sites). And if not more often true than false, they would lead to the perishing of the lineage rather than its survival. Dicisigns are signs able to express truths.

This points to a biosemiotic fact of potentially vast implication: that semiotic evolution should not be seen as going from the simple to the complex in terms of beginning with atomic signs which later serve as building blocks for more complex signs. The process from simple to complex should not be conceived of as a process of composition: the overall arc of the semiotic argument process structure is there from the metabolic beginning, only in a undifferentiated, general shape – and semiotic evolution rather takes the shape of the ongoing subdivision, articulation, and sophistication of primitive signs, an ongoing refinement of parts and aspects acquiring still more autonomy. Please permit an analogy here. To trace the origin of human architecture, you will have to turn to huts, to simple shelters and bivouacs and, before them, the nests of our biological cousins the great apes, and earlier, various biological hideouts and cavities, skins and shells as protection devices, phylogenetically and ontogenetically constructed, maybe all the way down to the cell membrane. Thus, you begin with phenomena which perform the basic sheltering function of the whole edifice in a germlike form, rather than beginning with the development of bricks, planks and mortar which only much later would assemble into full buildings. The full building structure was there from the beginning, even if in a very primitive, unarticulated shape. Just like bricks, icons and indices primarily function within the wholes of Dicisigns linked up into action arguments – and they only acquire semi-autonomous status much later, during the ongoing sophistication of argument structure through evolution.

In biology, we would find a similar descent from simple, undifferentiated generality to articulated, explicit specificity in embroynic development. This was one of René Thom's core ideas, giving rise to Catastrophe Theory, and it originally formed the basis of Karl Ernst von Baer's revolutionary approach to epigenesis. The reason why early embryos are structurally much alike is not, as Haeckel later believed, that ontogenesis recapitulates phylogenesis, but rather that fertilized eggs are very simple and in a certain sense general while the ongoing development during embryogenesis forms the functional, specializing subdivision of an already functioning, metabolic whole into different cell-types and organs.[ix] Hence, on this view, semiotic compositionality, as it appears in its highest degree of articulation in human language, forms an important *achievement* rather than a possible starting principle: the ongoing relative autonomization of parts and aspects of Dicisigns and their combinations may make them more and more compositional – resulting in a growth of combination possibilities, recursivity and hence increasing cognitive plasticity. Such segmentation of the argument process thus constitutes the overall shape of the increase in "semiotic freedom" during evolution, highlighted by Hoffmeyer (2010). The reason for taking, once again, the textbook example of *E. coli* to illustrate basic sign use, is thus to insist on the fact that the kernel of semiotic cognition is the extremely simple piece of reasoning which connects typefied perception and typified action. The fundamental fact that this process may err is what displays its character of (simple) reasoning – and this formed the guideline for our quick reinterpretation of selected biosemiotic cases above. It also indicates that cognition begins long before organisms with central nervous systems evolve, and even longer before the appearance of organisms with attention-directing movable perception organs, binding of different sensory inputs into cross-modal perceptions and the construction of stable environment mappings apart from here-and-now perception. This should make us cautious with more or less automatic assumptions that nervous tissue such as found in the central nervous systems of higher animals should be the privileged or even only locus of cognitive processes. Such an idea is but a sort of magic, ascribing wonderfully special abilities to a specific type of cell tissue – overlooking the basic fact that cognition is a not merely a function of neural tissue but a process connecting the whole of an organism to aspects of its surroundings. Such an idea is what Clark (2008), pointing instead to external elements of cognitive processes, calls "neurocentrism". Not only may "anthropocentrism" make us erroneously think that all accidental properties of human cognition are properties of cognition as such – but "neurocentrism" may repeat the error on a larger scale presuming that only properties found in nervous tissues are properties of cognition as such. Rather, cognition and inference are found in the shape of perception-action argument cycles long before the evolution of multicellular organisms and the ensuing evolution of central nervous systems. Such evolution processes should rather be conceived of as adaptations to make the interface between perception and action more plastic, more versatile by adding to the range and structure of Dicisigns which the organism is able to process before turning to action. So, the specialization of certain cells to become neurons, interlinked in the CNS in multicellular organisms, forms a way of both adapting the organism to its specific surroundings and keeping the surroundings temporarily at bay by achieving still more complicated logical structures and reasoning capabilities intervening between perception and action. Neurons and central nervous systems should thus be seen as special adaptations to the requirement of complicated cognitive and logic processes – which is why they have to adapt to necessary structures of such processes. As Peirce says – bearing in mind his objective notion of "mind":

”For we must remember that the organism has not made the mind, but is only adapted to it. It has become adapted to it by an evolutionary process so that it is not far from correct to say that it is the mind that has made the organism.” (”Abstract of 8 lectures”, undated, NEM IV, 141)

The more varied the problems posed by the surroundings, including the social labyrinths of fellow conspecifics, become, the more complicated the intervening structure between perception and action must develop in order to adapt plastically – and the more that structure must conform to basic regularities of semiotics and logic: "Logic, for me, is the study of the essential conditions to which signs must conform in order to function as such" (Peirce, "Kaina Stoicheia", 1904). And, what is more, the more variation the environment presents within the small ontogenetic time-scale window of single organism life, the more of reasoning must be transported from the slow process of phylogenetic Darwinian adaption (teaching, e.g., bacteria, over millions of generations, the Argument habit of following sugar and avoiding certain toxins) to the comparatively extremely quick process of ontogenetic adaptive learning (teaching, e.g., apes, over a period of days, to acquire the habit of associating a specific location in the jungle with the presence of specific fruits). Here, biosemioticians must learn not to commit the time-scale error of automatically taking long-term habits for being non-semiotic while short-term habits are seen as having a semiotic nature.[x] The actual sign-exchange, both in the bacterium and the ape example, always takes place in the vanishing moments of individual ontogenetic lifetime - whether the underlying code habit is constituted in the vast timescale of phylogenetic adaptation or in the speedy timescale of ontogenetic learning or somewhere in between does not make any difference in principle (although it does make an enormous difference in behavioural plasticity).

Let us sum up then, the character of primitive, metabolic inference. It connects a perception Dicisign with an action Dicisign to an Argument which, agains, form a section of the the overall metabolism of the cell. The reason for calling it an Argument is its ability to attain truth – and to err, respectively.[xi] As an Argument, of course, it lacks a series of important aspects characterizing explicit arguments made by human beings. The connection between its part has been established over the phylogentic timescale of evolution and could only be changed in the same way. There is no ontogenetic freedom to exchange the parts of it for other parts in an online trial-and-error process. No matter which consciousness definition you adhere to, there is no reason to assume any conscious access to the conclusion or to other parts or aspects of the argument structure. The argument appears as a behavioral gestalt, whose parts are only accessible as such to the external observer and analyst, not to the bacterium.

Finally, this overall argument implies that the the distinction between man and animal must be sought elsewhere than in a distinction between icons/indices on the one hand and symbols on the other – namely in the growing degree of explicit control and metasemiotics, the ability for an organism to make explicit and control its own use of signs.

Hypostatic Abstraction

With the intensified research into human prehistory occupying many different disciplines, a Pandora's box of old questions has been reopened: the origin of language, the emergence of culture, the physical anthropology and evolution of human beings – and, conversely, the issue of communicative and cognitive abilities of other higher animals as compared to those of human beings. What is specific to human semiotic and cognitive abilities as compared to those of higher animals? A series of different answers to this issue of the semiotic or cognitive ”missing link” between higher animals and human beings are already on the market: symbol use (Terrence Deacon), shared attention (Jerome Bruner, Michael Tomasello), language syntax (Chomsky), specific types of ”blending” (Fauconnier and Turner), etc. The discussion is both electrified and muddled by the fact that these hypotheses range over different fields such as psychology, linguistics, semiotics, cognitive science, anthropology, etc. This implies that the proposals mentioned are not even directly comparable – in order to be compared, they should so to speak be translated into each others' terminology. What would, e.g., the psychological notion of ”joint attention” amount to if translated into the terminology of linguistics, semiotics, or neuroscience? The possibility exists that it might turn out to mean approximately or even exactly the same as one or several of the other proposals – this could only be decided after such a reconstruction process which is, by no means, a simple translation issue but a reconstruction which will only be possible after a process of conceptual and empirical development and which will, in itself, constitute a main part of a solution. I have aired the idea that a good candidate for this semiotic-cognitive ”missing link” might be Peirce's notion of ”hypostatic abstraction” (Stjernfelt 2007, ch. 11). Probably, no single semiotic feature may presumably be held responsible for all semiotic and cognitive differences between human beings and higher animals – still I find hypostatic abstraction to be one of the central candidate devices because it permits the making explicit and controling of various prehuman semiotic capacities and hence indispensable for the construction of human thought and language. Let us revisit Peirce's discussions of the term.[xii] Peirce never wrote a comprehensive treatise on the issue but returns to it over and over again in his mature work around the turn of the century.

Here, it refers a process as well as a product, to be found in a bundle of related semio-cognitive events: *Linguistically*: the construction of an (abstract) noun from more concrete expressions, such as adjectives ("hard" -> "hardness"), a verb ("give" -> "giver", "gift", "given"), or a (more concrete) noun ("object" -> "objecthood"), etc. From the sentence "The sky is blue", the sentence "The sky possesses blueness" is constructed. *Logically*: the corresponding construction of a subject on the basis of a predicate, thus adding a new 2nd-order individual ("blueness") to the domain represented. *Mathematically*: the application of a meta-level operation or object regulating other, more basic operations or objects (e.g., passing from the existence of different types of connections between entities to forming the concept of "relation" as a new abstract object. The properties of this object now become open to investigation in higher-level hypostatic abstractions (the "symmetry", "transitivity", etc. of relations may now be investigated).[xiii] *Cognitively*: the process of taking a thought for a thing, so that a new cognitive object is constructed on the basis of a thought – alternatively described as the "stiffening" of transient, fleeting cognitive content into a stable shape facilitating further reasoning pertaining to this new, abstract object. *Perceptually*: the spatialization of a temporal perception process, such as forming the trajectory as an abstraction from the array of locations covered by the perceived movement of an object: going from "a point moves" to "the line traced by the moving point".[xiv]

Peirce's ambitious idea is that these rather different examples constitute different occurrences of the same basic cognitive-logical structure and process characterized by their result: the emergence of a new, higher-level cognitive object. Most often, these aspects of hypostatic abstraction are merely mentioned as examples; they are not explicitly distinguished and interrelated as subtypes of the concept. The basic cognitive purposivity of hypostatic abstraction is this: it facilitates the explicit reasoning and investigation pertaining to general issues which would otherwise remain implicit, transient or lost in concrete particulars (of course, once the forming of hypostatic abstractions is possible it need not build on existing particulars and thus may refer to non-existing or fictive universals). The many different linguistic devices for hypostatic abstraction are tools which further develop, detail, and make explicit aspects of the ongoing cognitive process of reasoning. Thus, the adjective ”red” basically refers to particular, concrete, here-and-now occurrences of that color and allows for their comparison, while the noun ”redness” (or ”the color red”, ”the red”, etc.) constructs a new, stable, abstract object interconnecting these different occurrences and makes possible the further reasoning on this color as such, abstracted from its concrete occurrences, and on its relation to other colors, other properties etc.

Hypostatic abstraction may be described as a simple deduction from a premise ”This object is red” to a conclusion ”Redness exists (in this object)”, so that it makes sense to say that the hypostatic abstraction is an entity whose being consists in the (purported) truth of a predicate expression:

”For by means of abstraction the transitory elements of thought, the {epea pteroenta},[xv] are made substantive elements, as James terms them, {epea apteroenta}. It thus becomes possible to study their relations and to apply to these relations discoveries already made respecting analogous relations. In this way, for example, operations become themselves the subjects of operations.

To take a most elementary example -- from the idea of a particle moving, we pass to the idea of a particle describing a line. This line is then thought as moving, and so as generating a surface; and so the relations of surfaces become the subject of thought. An abstraction is an ens rationis whose being consists in the truth of an ordinary predication.” (”Relatives” in Baldwin’s Dictionary, 1901, 3.642)

This should not be taken to imply that hypostatic abstraction expressions referring to non-existing objects may not exist. ”Unicornicity” is a hypostatic abstraction from "unicorn" even if no unicorns exist – the implication of Peirce's definition is that, in this case, the hypostatic abstraction does not have any ”being”, that is, it does not refer to any real possibility like in the cases of ”redness” or ”hardness” or "trajectory". The deductive character of hypostatic abstraction is not changed by this observation – like any deduction, its validity dependes on the soundness of the premise invoked: ”If and only if cases involving *x* exists, then *x*-ness has being”.

Thus, if no *x* exists, *x*-ness has no being, – but in many cases the validity of this claim may be investigated both by investigating *x*’s and investigating *x*-ness. Thus, the hypostatic abstractive deduction forms no guarantee that the resulting abstraction has a *fundamentum in re* and refers to really existing kinds – the well-known examples of fallacious hypostatic abstractions in the history of science such as "phlogiston" or "caloric" testify to that. The fact that hypostatic abstraction is a deduction has often been confused with the possibly abductive character of the reasoning process in which a hypostatic abstraction may take part. Making a hypostatic abstraction may, in many cases, be part of a trial-and-error reasoning process where the abstraction made is subject to further investigation so as to determine its degree of reality. Thus, the deductive step of hypostatic abstraction forms, in this broader perspecive, part of an abduction whose valitidy must be investigated by further de- or induction on the basis of the abstraction made. This is why hypostatic abstraction has sometimes been characterized as deduction, sometimes as abduction (cf. the papers of Pape and Short in Houser et al. 1997; cf. Stjernfelt 2007, 458). It should immediately be added that Peirce takes great care to distinguish this process from what he calls ”distinction”, the attention ability which permits focusing on a particular part or aspect of an object at the expense of other parts or aspects of that object – and which is often confused with hypostatic abstraction. These focusing abilities come in three variants, nicknamed ”dissociation”, ”prescission”, and ”discrimination”, respectively. Dissociation is what permits the distinction between different independent qualities, such as ”red” from ”blue”: prescission is what permits the distinction of a part which may be supposed to exist independently of another part, such as ”space” from ”color”, while discrimination is what permits the distinction of a part which may be only imagined separately, such as ”color” from ”space”. These two latter distinction types are important to the investigation of objects involving features dependent on each other in different patternings. The kind of attention they pertain to, however, involves imagining the object endowed with indeterminate parts:

”In general, prescission is always accomplished by imagining ourselves in situations in which certain elements of fact cannot be ascertained. This is a different and more complicated operation than merely attending to one element and neglecting the rest.” ("Terminology", 1893, 2.428)

According to Peirce, it is of paramount importance to keep the distinctions apart from hypostatic abstraction – while the former pertain to the degree of particularity and generality and thus permit chains of increasing generality like ”red” – ”color” – ”hue”, the latter does not lead to higher generality but to the creation of new, abstract or ideal objects of thought or discourse.[xvi] The distinction between the two may be expressed as follows:

"But even in the very first passage in which abstraction occurs as a term of logic, two distinct meanings of it are given, the one the contemplation of a form apart from matter, as when we think of whiteness, and the other the thinking of a nature indifferenter, or without regard to the differences of its individuals, as when we think of a white thing, generally. The latter process is called, also, precision (or better, prescission): and it would greatly contribute to perspicuity of thought and expression if we were to return to the usage of the best scholastic doctors and designate it by that name exclusively, restricting abstraction to the former process by which we obtain notions corresponding to the "abstract nouns." (”Terminology” 1893, 2.428n)

In most concrete cases, of course, the two procedures work closely in tandem: before the hypostatic abstraction of ”redness”, a distinction is required to isolate the property of ”red” in the object (more generally, hypostatic abstraction is impossible without a preceding distinction) – but still, the working of the two must be kept analytically distinct. In contrast to many empiricist theories of abstraction, moreover, it should be added that Peirce does not identify any of the two with induction as the statistical investigation of properties in a sample of objects. Abstraction does not presuppose induction and it is perfectly possible to perform a hypostatic abstraction on the basis of one observed object only (even if it may be wiser to perform it after an induction summing up knowledge of a wider sample of objects). An important aspect of hypostatic abstraction is that, in making a second-order object out of a thought, it gives it concrete form and thus facilitates cognitive and logic manipulation and investigation of it – as if it were a particular individual object:

"Intuition is the regarding of the abstract in a concrete form, by the realistic hypostatization of relations; that is the one sole method of valuable thought. Very shallow is the prevalent notion that this is something to be avoided. You might as well say at once that reasoning is to be avoided because it has led to so much error; quite in the same philistine line of thought would that be; and so well in accord with the spirit of nominalism that I wonder some one does not put it forward. The true precept is not to abstain from hypostatization, but to do it intelligently. . . "
(”A Guess at the Riddle”, c. 1890, 1.383)

This implies that the hypostatically abstract object may be seen as if it shared some of the characteristics of particular individuals: it has properties, it stands in various relations to other such objects, it may be subsumed by still higher genera – in that sense hypostatic abstraction is a simplifying device involving cognitive economy because it permits to use some of the same means for their investigation which we use interacting with particulars. Peirce also ascribes abstractions a seminal role in his famous distinction between corollarial and theorematic deductions (see ch. 9) the former only relying upon definition of concepts appearing in the premises, the latter requiring the introduction of additional elements in the shape of postulates to conduct the proof. Theorematic reasoning, of course, requires creativity and guessing, even if being deductive – and the most challenging theorematic deductions are taken to involve the introduction of abstractions:

”Deductions are of two kinds, which I call corollarial and theorematic. The corollarial are those reasonings by which all corollaries and the majority of what are called theorems are deduced; the theorematic are those by which the major theorems are deduced. If you take the thesis of a corollary, -- i.e. the proposition to be proved, and carefully analyze its meaning, by substituting for each term its definition, you will find that its truth follows, in a straightforward manner, from previous propositions similarly analyzed. But when it comes to proving a major theorem, you will very often find you have need of a lemma, which is a demonstrable proposition about something outside the subject of inquiry; and even if a lemma does not have to be demonstrated, it is necessary to introduce the definition of something which the thesis of the theorem does not contemplate. In the most remarkable cases, this is some abstraction; that is to say, a subject whose existence consists in some fact about other things. Such, for example, are operations considered as in themselves subject to operation; lines, which are nothing but descriptions of the motion of a particle, considered as being themselves movable; collections; numbers; and the like. When the reform of mathematical reasoning now going on is complete, it will be seen that every such supposition ought to be supported by a proper postulate. At any rate Kant himself ought to admit, and would admit if he were alive today, that the conclusion of reasoning of this kind, although it is strictly deductive, does not flow from definitions alone, but that postulates are requisite for it." ("On the Logic of drawing History from Ancient Documents especially from Testimonies", 1901, 7.204)

As to the discussion of the semiotic "missing link" it should be mentioned that many higher animals are able to make prescissions – the ability to isolate features in an object is the precondition for associative learning, linking up co-occurrent such features – just as they are able to make deductions on the basis of phylogenetically inherited or ontogenetically acquired habits. Theorematic reasoning and Hypostatic abstractions, on the other hand, seem to be missing among animal proto-concepts.

Self-control by abstraction in human semiotics

In a central argument, Peirce links the special semiotic and cognitive abilities in human beings to a higher degree of self-control which is, in turn, connected to the ability to make hypostatic abstractions. Let us first scrutinize this notion of "self-control". An important idea here is that self-control is crucial for inferences to count as real reasonings, as he epigrammatically may say: "... reasoning is thought subjected to self-control ..." ("Pragmaticism, Prag. [4]" c. 1905, 5.533). This is why computers ("logical machines") are not taken to be able to reason – even if their actions may formally realize inference structures and they are able to produce outputs which are interpretable as truths – they do not possess any self-control. The potentiality of performing a specific action is sufficient to count as a habit – but belief requires the self-control of habit: "[Readiness] to act in a certain way under given circumstances and when actuated by a given motive is a habit; and a deliberate, or self-controlled, habit is precisely a belief" ("A Survey of Pragmatism", 1907, 5.480). Fully realized self-control, on the other hand, may have as its result the formation of mechanical-like thought habits:

"The power of self-control is certainly not a power over what one is doing at the very instant the operation of self-control is commenced. It consists (to mention only the leading constituents) first, in comparing one's past deeds with standards, second, in rational deliberation concerning how one will act in the future, in itself a highly complicated operation, third, in the formation of a resolve, fourth, in the creation, on the basis of the resolve, of a strong determination, or modification of habit. This operation of self-control is a process in which logical sequence is converted into mechanical sequence or something of the sort. How this happens, we are in my opinion as yet entirely ignorant. There is a class of signs in which the logical sequence is at the same time a mechanical sequence and very likely this fact enters into the explanation." (Letter to F.C.S.Schiller, undated, 8.320)

This, however, is only possible as the result of a complex process involving standards, future acts, and a decision to modify thought habits. Such self-control is required for full mastering of reasoning – but is, at the same time, the result of a long process with simpler biological antecedents. Thus, when speaking about simple perception-action loops as "inferences" with the structure of "arguments", we should not take this in the full value of self-controlled thought, the degree of control at stake primarily being performed by selection pressure. Importantly, Peirce sees a decisive aspect of self-control in the psychological ability to isolate a thought from other intrusions – a psychological equivalent to the logical notion of "distinction" discussed above:

"Contemplation consists in using our self-control to remove us from the forcible intrusion of other thoughts, and in considering the interesting bearings of what may lie hidden in the icon, so as to cause the subjective intensity of it to increase." ("Short Logic", 1893, 7.555)

The isolation of the iconic sign – the predicate – may count as a first step in human self-control – to be followed by the hypostatic taking of that sign to be a thing in itself. Hypostatization, now, is crucially connected to the particularity of human reasoning. Peirce himself only rarely discusses hypostatic abstraction in connection to the man-animal issue. The most important locus is the following quote:

”To return to self-control, which I can but slightly sketch, at this time, of course there are inhibitions and coördinations that entirely escape consciousness. There are, in the next place, modes of self-control which seem quite instinctive. Next, there is a kind of self-control which results from training. Next, a man can be his own training-master and thus control his self-control. When this point is reached much or all the training may be conducted in imagination. When a man trains himself, thus controlling control, he must have some moral rule in view, however special and irrational it may be. But next he may undertake to improve this rule; that is, to exercise a control over his control of control. To do this he must have in view something higher than an irrational rule. He must have some sort of moral principle. This, in turn, may be controlled by reference to an esthetic ideal of what is fine. There are certainly more grades than I have enumerated. Perhaps their number is indefinite. The brutes are certainly capable of more than one grade of control; but it seems to me that our superiority to them is more due to our greater number of grades of self-control than it is to our versatility.
Doctor Y. Is it not due to our faculty of language?
Pragmaticist. To my thinking that faculty is itself a phenomenon of self-control. For thinking is a kind of conduct, and is itself controllable, as everybody knows. Now the intellectual control of thinking takes place by

thinking about thought. All thinking is by signs; and the brutes use signs. But they perhaps rarely think of them as signs. To do so is manifestly a second step in the use of language. Brutes use language, and seem to exercise some little control over it. But they certainly do not carry this control to anything like the same grade that we do. They do not criticize their thought logically. One extremely important grade of thinking about thought, which my logical analyses have shown to be one of chief, if not the chief, explanation of the power of mathematical reasoning, is a stock topic of ridicule among the wits. This operation is performed when something, that one has thought about any subject, is itself made a subject of thought (...)"[xvii]
("Pragmaticism, Prag. [4]" c. 1905, 5.533)

This long quote gives two important arguments. The first is that self-control comes in many grades which increase during evolution. Our hypothesis here will be that this increase corresponds to the increase of articulation and segmentation of the perception-action chain into detailed argument structures. Any relative autonomization of a part of that chain corresponds to an increase in self-control. On top of such grades of self-control which is already present in higher animals, Peirce presents an architecture of additional human self-control grades: 1) training; 2) self-training, controlling one's own self-control, involving imagination; 3) adoption of a rule guiding this meta-control; 4) improvement of that rule after some higher ethical standard, thus controlling the control over one's control; 5) controlling, in turn, that rule after some aesthetic standard (Peirce's notion of aesthetics pertaining to all goals which are worth pursuing).[xviii] Every such step, of course, takes the former step as its object, thus creating a new hypostatic abstraction subject to variation and evaluation. Many higher animals, it is well-known, may be subject to training, but the next, decisive step of self-training seems only rudimentarily accessible to higher animals. The other crucial argument here is that such self-control is seminal to human thought and language – and that this self-control is facilitated by thinking of our signs as signs, by thinking about thought and thereby becoming able to criticize and control our own thought logically. Self-control involves taking one's own thought as the object of a meta-level thought.[xix] But this is only possible by making the first thought an object – stiffening in the shape of a hypostatic abstraction. Such self-control even makes possible language. How should this be interpreted? – it is well known that natural language learning does not take place by the explicit memorizing of linguistic rules and that practicing knowledge of grammar does not entail any explicit insight in grammatical principles (much like Peirce's logical distinction between implicit *logica utens* and explicit *logica docens* which differ in that the former is interested in the results of reasoning, not the process, the latter vice versa). The work performed by self-control here is more basic – it is the ability to wonder and check whether a particular sign is suitably used, focusing upon the relations between sign, object, and interpretant, upon its relation to other signs and their objects and interpretants. Such ability is taken to be the prerequisite to the establishment of grammar, fine-grained taxonomies, tuning of schematic content, expression-content couplings, etc. in the development of languages.[xx]

It is important to Peirce's notion of self-control, now, that such self-control is a merely *restrictive* measure, selecting valuable inferences among less valuable inferences – thus, it presupposes the existence of inferences which it then, subsequently, turns into reasoning by controlling them:

"But self-control is the character which distinguishes reasonings from the processes by which perceptual judgments are formed, and self-control of any kind is purely inhibitory. It originates nothing. Therefore it cannot be in the act of adoption of an inference, in the pronouncing of it to be reasonable, that the formal conceptions in question can first emerge. It must be in the first perceiving that so one might conceivably reason. And what is the nature of that? I see that I have instinctively described the phenomenon as a "perceiving." I do not wish to argue from words; but a word may furnish a valuable suggestion. What can our first acquaintance with an inference, when it is not yet adopted, be but a perception of the world of ideas?" ("Lectures on Pragmatism" 1903, 5.194)

The question of the roots of inference is here answered phenomenologically – investigating the origin of inference structures as seen from the perspective of the human mind. Before subjecting an inference to control and evaluating it, we must first be able to perceive it in "the world of ideas". This idealist wording of course leaves out the fact that we access that world not by any direct, mystic, purely intuitive route, but only by the intermediary of diagrams, facilitated by imagination and experiment. The inhibitory work performed by the different levels of self-control, then, presupposes a wealth of possible inferences and abstract objects to chose between. The imaginative creation, variation and combination of such inferences and objects – at each of the control levels – is thus the prerequisite for inhibitory self-control to perform its function – Peirce's cognitive version of the Darwinian combination of variation with selection. And posed as an evolutionary question, the basic pool of such inference structure is found in the perception-action habits refined through the evolution of animals – habits which have been subjected to increasing degrees of control already over the course of evolution, before they are made, in turn, the object of the vastly increasing human processes of self-control by means of hypostatic abstraction and diagram experimentation.[xxi] Thus, it is an important corollary of self-control, as described here, that it always involves (at least) two levels, that of imaginary creation, and that of inhibitory controlling. This implies that the focus of control must alternate between the levels, evolving inferences on the lower level and pruning them on the higher level. This makes self-control a special case of Peirce's important idea of the dialogicity of logic. This, I think, makes it possible to compare the Peircean notion of self-control by hypostatic abstraction with Tomasello's central ideas of joint attention.

Hypostatic Abstraction and Joint Attention

How does Peirce’s idea of hypostatic abstraction fit the Tomasellian idea of joint attention? For a first glance, the two ideas may seem wide apart, but for a closer glance important connections appear. Shared attention can not, of course, be reduced to two parties both of them intending the same object. It also involves the knowledge in each part of the other part’s attention. But even that is not sufficient. As Frédéric Kaplan and Verena Hafner insist from the point of view of implementing joint attention in robot research, joint attention is not achieved even by robots tracking other robots’ attention and coordinating that with their own attention (which is robotologically possible but does not entail shared attention):

”To reach joint attention an agent must understand, monitor and direct the intentions underlying the attentional behaviour of the other agent. Attention can only be reached if both agents are aware of this coordination of “perspectives” towards the world.“ (Kaplan and Hafner 2004, 68)

Joint attention thus requires for each agent to assume the famous “intentional stance” towards the other: the attention direction detected in the other agent is interpreted as a sign that an intention is directing that attention to some goal. But even that is not sufficient: each agent must be able to influence the other’s attention, for instance by directing it by means of gesture, eye movements, linguistic cues, etc. And such influence is only possible based on a skill of social interaction: the agents must be able to master turn-taking, role-switching and ritualized games, as Kaplan underlines. If no turn-taking schema is active, the agents will not know who is directing whose attention at any given moment. Thus, the apparently simple phenomenon of “joint attention” entails a whole series of interrelated concepts – a molecule of social interaction. But something similar is the case with Peircean hypostatic abstraction. It forms, of course, one of the major techniques of letting “symbols grow”, Peirce’s brief version of the Enlightenment ideal of common, increasing knowledge construction, cf. ch. 11. It does so by means of its ability to take other signs as its object, thereby making their content and role explicit, and hence the possible object of scrutinizing, comparing and controlling them. And this whole process of thought, according to Peirce, has an irreducible dialogic structure: "Accordingly, it is not merely a fact of human Psychology, but a necessity of Logic, that every logical evolution of thought should be dialogic." ("Prolegomena", 1906, 4.551)

This necessity lies in the articulation of logic in signs fit to communicating them from a person in one moment to the same person (or other) in the next moment: "All thinking is dialogic in form. Your self of one instant appeals to your deeper self for his assent. Consequently, all thinking is conducted in signs ..." ("Amazing Mazes" 4, 1909, 6.338). This gives rise to the possibility of performing logical arguments describable by a temporal sequence of propositions, the same person occupying alternately pro- and con-positions in an ongoing dialogic process. These important ideas have often been overlooked because Peirce's ideas on this are only scarcely represented in his published work and have not been much discussed in the Peirce literature, but it has been highlighted in the wake of the tradition of Hintikkan game-theoretical semantics (Hintikka, Hilpinen; most recently, Pietarinen 2006 has furthered the investigation of this issue). This idea occurs in the context of Peirce's logic representation systems known as Existential Graphs whose Alpha and Beta parts are isomorphic to propositional logic and first order predicate logic with identity, respectively. Peirce's idea is that these representations reveal a dialogic structure inherent in logical arguments. One agent, the so-called Grapheus, is responsible for the construction of the discursive world, while the other, the so-called Graphist, is responsible for counter-arguing the single steps of its construction. The two agents thus collaborate in critically investigating a logical issue and take it to conclusion, and they may, of course, often be instantiated in one and the same mind during soliloquious thought processes. In Pietarinen's Hintikkan interpretation, they may be seen as playing a semantic game against each other, and the existence of a winning strategy on the part of one of them is the game-theoretical equivalent to the truth of that part's argument. We shall not here go deeply into the specific means the two agents use when interacting in Peirce's elaboration of the existential graphs, but in our context, Peirce has some important general developments of what is involved:

"Now nothing can be controlled that cannot be observed while it is in action. It is therefore requisite that both minds but especially the Graphist-mind should have a power of self-observation. Moreover, control supposes a capacity in that which is to be controlled of acting in accordance with definite general tendencies of a tolerable stable nature, which implies a reality in this governing principle. But these habits, so to call them, must be capable of being modified according to some ideal in the mind of the controlling agent; and this controlling agent is to be the very same as the agent controlled; the control extending even to the modes of control themselves, since we suppose that the interpreter-mind under the guidance of the Graphist-mind discusses the rationale of logic itself." (MS 280: 30–32, quoted from Pietarinen 2006)

The dialogic structure facilitates control of the thought process, because one part's utterance in the game takes the other part's utterance as its object in a hypostatic abstraction. What is visible, of course, is only the part's manifest utterance, but that utterance is the response to the whole preceding game and, in that respect, indirectly refers to it – much like a move in a chess game implicitly refers to the whole preceding game and one player's interpretation of the other's intention as perceived from his move sequence. Of course, hypostatic abstractions are not possible within the representation systems offered in the Alpha and Beta parts of the Existential Graphs (hypostatic abstractions quantify over other signs such as predicates and thus belong to second-order logic). Peirce envisaged this second order part in his Gamma graphs which were to comprise a part aimed at the explicit representation of hypostatic abstractions. But naturally, this representation of them takes place in a hypostatic abstraction of second order. If logical thinking necessarily possesses a dialogic structure, it forces the individual engaging in such thinking to divide so as to accomodate to it:

"There is no reason why "thought," in what has just been said, should be taken in that narrow sense in which silence and darkness are favorable to thought. It should rather be understood as covering all rational life, so that an experiment shall be an operation of thought. Of course, that ultimate state of habit to which the action of self-control ultimately tends, where no room is left for further self-control, is, in the case of thought, the state of fixed belief, or perfect knowledge. Two things here are all-important to assure oneself of and to remember. The first is that a person is not absolutely an individual. His thoughts are what he is "saying to himself," that is, is saying to that other self that is just coming into life in the flow of time.

When one reasons, it is that critical self that one is trying to persuade; and all thought whatsoever is a sign, and is mostly of the nature of language. The second thing to remember is that the man's circle of society (however widely or narrowly this phrase may be understood), is a sort of loosely compacted person, in some respects of higher rank than the person of an individual organism. It is these two things alone that render it possible for you -- but only in the abstract, and in a Pickwickian sense -- to distinguish between absolute truth and what you do not doubt." ("What Pragmatism Is”, 1905, 5.420-421)

This being the case, there seems to be a deep connection between the dialogic structure of reasoning and self-control on the level of semiotics and logic – and the central place enjoyed by shared attention on the level of human psychology according to Tomasello's hypothesis. The parent-child dyad interaction trains the child in the first human level of self-control with the parent as the teacher, of course, but with the continuous exchange of positions making it possible for the child to experience the dialogue structure and internalize it for the benefit of its critical self-control abilities (and for later social interactions as well, of course). Thus, a hypothesis can be stated that there is a connection between the human ability to use signs about signs and thereby exercise semiotic self-control, on the one hand, and the ability of human beings to engage in joint attentions with other subjects shaping a shared world informed by shared thoughts in the shape of shared diagram experiments. The overall argument of this chapter, then, is that the gradual appearance of logic and semiotic capabilities during evolution forms the backbone of the increase of cognitive competences from simple biology to higher animals and human beings. This appearance takes the shape of the ongoing articulation, subdivision and making explicit of a basic argument structure inherent in perception-action loops. The basic reason is that biological semiosis must be oriented toward adequacy truths for survival reasons, making biological cognition acutely dependent upon the ability to perceive and act in a way which is adequate to the environment, thus expressing the linking of proto-propositions. This is not to say that issues like the emergence of communication, awareness, consciousness, emotions, episodic memory, human language and much else are not important. Quite on the contrary, in this framework, such capabilities arise during evolution in order to enhance, speed up, widen, and control the basic, biological process of argumentative cognition.

[i] Against this idea of truth in biology an argument may be made marshaling a deflated truth notion to be relevant for biology only. Thus, Cussins (1990), based on the investigation of categorization in connectionist networks, proposed that in biological organisms the notion of *success* may be substituted for that of truth. Such a conception gives a distinction between a success-governed level pertaining to proto-thoughts and the narrower, truth-governed level relevant only for full-fledged thoughts. The pragmatist conception of Dicisigns, however, already has deflated the notion of propositions so as to include proto-propositions with action conclusions, just like pragmatism, in general, makes no sharp delimitation of truth from success. A problem in the distinction proposed would also be that many human phenomena would be difficult to categorize as there is no reason to believe that human beings do not, to a large extent, base their explicit truth claims upon proto-thoughts.

[ii] Thus, our claim for the biological relevance of Dicisigns follows the naturalization of intentionality as argued in different ways by Millikan ("Aboutness is associated with a purpose only when the purpose is *explicitly represented*. On the other hand, for there to be an explicit representation of a purpose, *there must first be a purpose* to represent" (2000) – that purpose giving rise to signs whose meaning is not explicitly represented but may be induced from their having truth conditions) or Hoffmeyer (the notions of evolutionary and individual intentionality in organisms).

[iii] Metabolism as a process is thus intrinsically in need of completion. This forms the root of predicates, in themselves signs in need of completion; cf. Deacon's notion of "incomplete" nature (2012b).

[iv] Calling it an argument is based on the fact that it displays the double structure of Dicisigns, triggering an action sign. Dealing with an idealized model in which the same active site regularly gives rise to the same action, it is a deductive argument. But it is important to add that it almost completely lacks the quality which Peirce requires for an inference structure to count as real, full-blown reasoning: namely that of self-control (see below). When I say "almost" it is because the argument may change, of course, over the long range of millions of generations due to the process of evolution. If the *Umwelt* of the bacterium were contaminated with a poisonous agent displaying the same "active site" as carbohydrates, this would be a grave challenge to *E. coli*. If a mutation occurs, however, making some bacteria able to distinguish sugar from this toxic substance by means of other active sites on the periphery of the relevant molecules, of course, a mutated group of *E. coli* might survive. Such adaptability could be interpreted as a sort of (very weak) self-control at the level of the lineage rather than on the organism level (organism and lineage levels, it could be added, are not distinct in bacteria to the same degree as in higher animals with sexual reproduction, due to bacterial genetic exchange and the absence of the condition of individual death).

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[v] Thus, the difference between the weak interaction of "reading" the active site on the one hand and the binding and breaking covalent bonds in chemical reactions is semiotically important. The former allows for identifiying the molecule without chemically interacting with it, due to the weak van der Waals bonds made possible by the variation of electric charge on the surface of the molecule.

[vi] Cf. El-Hani, Queiroz and Stjernfelt (2010).

[vii] Cf. Queiroz (2012)

[viii] In intelligent birds and apes trained by human researchers, the mastery of proto-propositions may reach impressive levels and even give rise to the explicit expression of structured propositions. Sue Savage-Rumbaugh's bonobo Kanzi and Irene Pepperberg's now deceased grey parrot Alex are famous for their semiotic capabilities, mastering sign language, and some, truncated version of human language, respectively. Both of these individuals are able to express a long and seemingly indefinite amount of compositional proto-propositions, not only in the imperative but also declarative (prompted, of course, by small snack rewards). Alex had a vocabulary of more than 100 words, and his ability to recognize properties in previously unseen objects was impressive. Shown such an object and asked, e.g. "What colour is it?", he would answer, truthfully: "It is blue", the same going for question about other properties such as shape, size or number, with an 80% correctness rate of the answers. These results are contested, but it seems as if a simple interpretation in terms of stimulus-response is precluded, as the stimulus correctly categorized has not been encountered before and the answers would also be given in the absence of Pepperberg. Both Kanzi and Alex display considerable ability to express completely new proto-propositions by composition from an acquired lexicon of proper names, common nouns and adjectives. Their communication results, of course, are possible only within the special symbioses they have developed as trainees of human scientists. Such communication capabilities, however, presuppose cognitive abilities to discern, structure, and recognize the proto-propositional content communicated and so reveal a cognitive mastery of proto-propositional perception and memory which may be more widespread in the species to which they belong.

[ix] Thom (1928, 1988). In the tradition of semiotics, the linguist Viggo Brøndal had a similar intuition when he structurally composed all word classes from four basics (r,d,R,D), but maintaining that in the evolution of language, the four of them would have to have appeared together, entangled, yet undifferentiated, in the primitive word class of interjections which in some sense performs all of the functions of the specialized word classes at once, albeit indistinctively. Only the evolution of languages allowed, in his view, the emergence of the clear, discinct types of r,d,R,D and their ensuing compositional combination into specific word classes performing specialized functions. (Brøndal 1948)

[x] Hoffmeyer (1996) makes a similar argument.

[xi] The notion of truth implied here, of course, is weaker than your average truth definition in terms of correspondence between an explicit proposition and an aspect of reality. Primitive biological truth might be described as adequacy of perception and correlated action – measured on the perception-action link's support of metabolism. If that link does not support metabolism, of course, it will be weeded out in the long run of natural selection. The overall argument here claims that such primitive adequacy truth forms the root of more developed truth types in higher animals and human beings.

[xii] As with many of his interesting proposals, the discussions of "hypostatic abstraction" (or "hypostatis", "subjective abstraction", etc.) are scattered over his work, so a bit of reconstruction work is necessary.

[xiii] One of Peirce's own examples of hypostatic abstraction in mathematics concerns the successive abstractions of sets from elements, powers from sets, cardinal numbers from powers: "In order to get an inkling -- though a very slight one -- of the importance of this operation in mathematics, it will suffice to remember that a collection is an hypostatic abstraction, or ens rationis, that multitude is the hypostatic abstraction derived from a predicate of a collection, and that a cardinal number is an abstraction attached to a multitude. So an ordinal number is an abstraction attached to a place, which in its turn is a hypostatic abstraction from a relative character of a unit of a series, itself an abstraction again" ("Consequences of Critical Common-Sensism", 1905, 5.534; Peirce writes "collections" and "multitudes" for sets and powers).

[xiv] A Peirce quote giving many different examples of Hypostatic Abstraction is the following: ”But hypostatic abstraction, the abstraction which transforms "it is light" into "there is light here," which is the sense which I shall commonly attach to the word abstraction (since prescission will do for precisive abstraction) is a very special mode of thought. It consists in taking a feature of a percept or percepts (after it has already been prescinded from the other elements of the percept), so as to take propositional form in a judgment (indeed, it may operate upon any judgment whatsoever), and in conceiving this fact to consist in the relation between the subject of that judgment and another subject, which has a mode of being that merely consists in the truth of propositions of which the corresponding concrete term is the predicate. Thus, we transform the proposition, "honey is sweet," into "honey possesses sweetness." "Sweetness" might be called a fictitious thing, in one sense. But since the mode of being attributed to it consists in no more than the fact that some things are sweet, and it is not pretended, or imagined, that it has any other mode of being, there is, after all, no fiction. The only profession made is that we consider the fact of honey being sweet under the form of a relation; and so we really can. I have selected sweetness as an instance of one of the least useful of abstractions. Yet even this is convenient. It facilitates such thoughts as that the sweetness of honey is particularly cloying; that the sweetness of honey is something like the sweetness of a honeymoon;

etc. Abstractions are particularly congenial to mathematics. Everyday life first, for example, found the need of that class of abstractions which we call collections. Instead of saying that some human beings are males and all the rest females, it was found convenient to say that mankind consists of the male part and the female part. The same thought makes classes of collections, such as pairs, leashes, quatrains, hands, weeks, dozens, baker's dozens, sonnets, scores, quires, hundreds, long hundreds, gross, reams, thousands, myriads, lacs, millions, milliards, milliasses, etc. These have suggested a great branch of mathematics. Again, a point moves: it is by abstraction that the geometer says that it "describes a line." This line, though an abstraction, itself moves; and this is regarded as generating a surface; and so on. So likewise, when the analyst treats operations as themselves subjects of operations, a method whose utility will not be denied, this is another instance of abstraction. Maxwell's notion of a tension exercised upon lines of electrical force, transverse to them, is somewhat similar. These examples exhibit the great rolling billows of abstraction in the ocean of mathematical thought; but when we come to a minute examination of it, we shall find, in every department, incessant ripples of the same form of thought, of which the examples I have mentioned give no hint" (”Minute Logic”, 1902, 4.235).

[xv] "Epea pteroenta" is a Homeric metaphor meaning "winged words" (strong idioms) - James added the negative "Epea apteroenta", plucked words, to indicate nominalization.

[xvi] As a realist, Peirce holds that some hypostatically abstract concepts refer to aspects of reality ("gravity") while others do not ("phlogiston").

[xvii] In the left-out part of the quote given, Peirce goes into his recurring example of hypostatic abstraction, Molière’s joke from *Le malade imaginaire* about the idle inference from ”opium puts people to sleep” and to ”opium possesses a virtus dormativa” where Peirce agues that this ridiculed inference does in fact represent a step (albeit very small) forward in reasoning, because it opens the issue of what this dormitive powers more exactly consist in, how strong it is as compared to that of other substances, etc., and thus facilitates further investigations. Without such further investigations, of course, the hypostatic abstraction remains idle.

[xviii] The special concept of aesthetics referred to here is discussed later in the quote: "And you, Doctor W., will see that since pragmaticism makes the purport to consist in a conditional proposition concerning conduct, a sufficiently deliberate consideration of that purport will reflect that the conditional conduct ought to be regulated by an ethical principle, which by further selfcriticism may be made to accord with an esthetical ideal. For I cannot admit that any ideal can be too high for a duly transfigured esthetics. So, although I do not think that an esthetic valuation is essentially involved, actualiter (so to speak) in every intellectual purport, I do think that it is a virtual factor of a duly rationalized purport. That is to say, it really does

belong to the purport, since conduct may depend upon its being appealed to. Yet in ordinary cases, it will not be needful that this should be done." ("Consequences of Critical Common-Sensism", 1905, 5.535) That "duly transfigured" aesthetics is the generalized doctrine of all ideals possible to pursue; the idea is that such ideals may play a role in thought even if not explicitly addressed at all.

[xix] We remark in the passing that Peirce, in this nesting of control acts into higher-level control acts, seems to subscribe to an Enlightenment ideal of the moral autonomy of human reasoning, cf. ch. 10.

[xx] Reasoning as opposed to mechanical compuation is characterized by self-control. Given the tower of control of control discussed here, however, self-control seems to appear as a matter of degree. Even if perfect self-control may be achievable on one level, this hardly involves all levels at the same time. Conversely, cases of intermediary control are possible, Peirce muses in a psychological argument: "If, however, as the English suppose, the feeling of rationality is the product of a sort of subconscious reasoning--by which I mean an operation which would be a reasoning if it were fully conscious and deliberate--the accompanying feeling of evidence may well be due to a dim recollection of the experimentation with diagrams." ("Minute Logic", 1902, 2.172) Subconscious diagram experiment – controlled only to some degree – could lie behind non-substantiated evidence-feelings.

[xxi] It goes without saying that this overall evolutionary increase in self-control recruits further capabilities to create higher level, more efficient cognition and action – such as consciousness, emotions, episodic memory, human language etc.