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Conceptor: a Model of selected Consciousness Features including Emergence of Basic Speech Structures in Early Childhood

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We have proposed that an information-processing machine called conceptor can model some aspects of consciousness. Conceptor was designed as a technical device for information processing (Fialkowski, 1995) that utilizes neither numerical representation (numbers) nor numerical operations (arithmetic), as opposed to computers. It was found to posses some features that may be appropriate for modeling elements of consciousness (Fialkowski, 1999a).

Conceptor is an attribute-based machine that automatically generates concepts from descriptors of a dynamically changing environment. The conceptor is connected to its environment thorough its input that periodically produces a set of descriptors characterizing the current state of the environment. Conceptor's main task is to create, in a solely inductive manner, a coherent and condensed representation of reality (constituting its working environment) that is derived exclusively from observations of that reality. In this approach the concepts are dynamic entities, growing from concept seeds and can be created at any level of the conceptor processing. The conceptor itself establishes connections between related concepts in growth. Both the concepts and the connections are dynamically adjusted by new information from input.

The representation of the environment established in the conceptor can be probed through directives. The result is an "illumination" of all concepts transitively related to those listed in a directive. The illumination is defined by both the character and strength of the relations. The conceptor design also facilitates conditional directives. The **if**-directive is the equivalent of a *gedanken* experiment, answering, for example, a query what would the representation be, if two unrelated concepts were equivalent.
The soundness of the proposed approach can be derived inductively from the uniformity of the conceptor processing at all levels and the successful simulation of its lowest level.

An entry point for considering some properties of the conceptor for consciousness modeling was Dennett's (1992, p. 256) statement that: "…cognitive scientists (…) are right to insist that you don't really have a good model of consciousness until you solve the problem of what functions it [the brain] performs and **how it performs them - mechanically**, without benefit of Mind. As Philip Johnson-Laird puts it, "Any scientific theory of the mind has to treat it as an automaton" (Johnson-Laird, 1983, p. 477)." (emphasis added).

The conceptor has been designed as an automaton. The following conceptor's features have been stressed for consciousness modeling (Fialkowski 1999a,b) and later developed by us towards modeling of more advanced consciousness features including, as discussed later here, basic speech structures.

1. According to Dennett (p.166): "…an element of content becomes conscious (…) not by entering some functionally defined and anatomically located system, but by **changing state right where it is: by acquiring some property** (…). The idea that consciousness is a ***mode of action*** of the brain rather than a *subsystem* of the brain has much to recommend it (see e.g., Kinsbourne, 1980; Neumann, 1990; Crick and Koch, 1990)." (emphasis added). The conceptor offers, as a model, all features suggested by the researchers quoted above. In the conceptor, illumination is a "**mode of action"** and may be performed in any part of the network **"by acquiring some property right where it is".**
2. Two researchers: Marr (1982) and Jackendoff (1987) propose three levels of analysis present in the mental phenomenon. Conceptor offers three such levels.
3. If illumination can be treated in terms of "what the conceptor is conscious of", then the performance of the conceptor is in agreement with both Jackendoff's and Johnson- Lairds's claims that whatever we are conscious of is rather a result of processing than processing itself. Illumination is not processing, but a result of it. Each illumination results from the processing being performed at the lowest level and is a kind of its representation.
4. In the conceptor, initiation of an illumination is performed through activation of one or many own nests,

according to the directive executed. This activation procedure reveals some resemblance to the "searchlight" approach proposed by Crick (1984).
5. The conceptor's architecture at the lowest and the medium level may offer an answer to Dennett's (p.271) quandary:
"…the cortex must be a medium in which unstable connection patterns can rapidly alter these transient contents of the whole "space" - without, of course, erasing long-term memory in the process. How can these two very different sorts of "representation" coexist in the same medium at the same time?"
In the conceptor the long-term memory is bound to the lowest level and remains unchanged whatever reading request is directed to it. On the other hand, illumination is performed in a short-term memory that is superimposed on the long-term memory. All rapid changes resulting from reading different concepts take place in the short-term memory.
6. The conceptor fulfils Fodor's (1983) requirements for isotropy as any of the things it has learned can contribute to any of the things with which it is currently confronted.
7. The conceptor is an implementation of Treisman's (1988) claim that *seeing* should be distinguished from *identifying.* Conceptor's samples are "separate temporary episodic representations" (as Treisman put it). They are a "preamble" for identifying an object (concept).
8. In the conceptor, (as Dennett (p. 277) put it): "Simple or overlearned tasks (…) can be routinely executed without the enlistment of extra forces, and hence unconsciously,…)". Conceptor offers processing possibilities for such tasks without invoking any reference to its knowledge base.

Apart from the discussed above aspects of the conceptor's modeling potential further research indicated new possibilities yielded by a functional unit of the machine called non-numerical correlator. It was designed for identification of time correlations between different concepts. In that instance, the following procedure is applied:
For any concept A selected for the identification of a correlated time pattern, all samples preceding the concept until a certain time horizon are taken from input short-term memory and memorized in the correlator for the analysis. It is to be noted that the time factor is implicitly incorporated in the samples as they are memorized in the same sequence as their input into the conceptor. When the selected concept A appears in the conceptor for the second time, the samples preceding A in the second appearance are merged with the samples of the first appearance of concept A. Their merger, however, is specific. In the merged samples, the samples closest to each other are those that originated in similar time spans before occurrence of each A, i.e. those two that have appeared just before the first and the second occurrences of the concept A, preceded by the two samples that occurred the moment before, and so on. After at least three such mergers, an automatic search for a pattern preceding the occurrences of concept A may begin. For the three occurrences of concept A, all subsets of the descriptors from the preceding samples that occurred three times could be considered concepts and/or descriptors correlated with concept A. They are memorized together with their original time layout derived from the merged samples. The pattern so identified is verified in the same way with each new occurrence of concept A (i.e. the processing takes place for four merged samples, for five of them, and so on).
The method is a remote analog of the detection of a signal from below the noise level. With the increase in the number of merged samples, some patterns that only sometimes precede A may be also detected through a higher than average presence in the merged sample.
In the simplest case the pattern could be a concept B preceding A. Then one could adopt the hypothesis that B is a cause for A. This hypothesis could be considered valid as long as the occurrences of B are close to A.
Generally a pattern correlated with a concept is a "story" involving a time display of many concepts.

In particular, a statement of a relation between concepts B and A established by the correlator and memorized constitutes a basic element of the conceptor's representation. It may be considered as a phrase in a simple internal conceptor's language. If the conceptor were exposed to speech learning, what we would need to change in its processing?
Elements of speech come from the environment in the form of acoustic signals. Referring to the conceptor's processing modalities (Fialkowski 1995, 1999a) the appropriately coded acoustic signals are processed like other sensory information, i.e. they could establish their own nests at the sensory level after at least three repetitions. When being "thought of" (in the conceptor framework this means a generation of the identifier on request) in parallel to the sensory nests, token nests would be established for them. In the process of teaching and as a result thereof, these token concepts would be structurally connected (e.g. with "part of" relation asserted) to those concepts that were target objects in the teaching process. In this context speech is a **supplier of token concepts** that may be subsequently used as proxies for other concepts, as well as become names of concepts derived from the processing of

token concepts. We found that such concepts without any internal structures had been proposed by Fodor (1998, p.121) in his conceptual atomism approach.
Provided that sentences of spoken, natural language reflect the results of internal processing of information, the conceptor would **have an "innate" ability to produce phrases** of the following structure:

"token concept B' " – "token concept of relation R' " / "token concept of A' "

i.e., a word representing B bound (denoted by "-") to a word representing an action R; those two related (denoted by "/") to a word representing A.
The "passive form" should be emphasized by the conceptor in its language productions as the concept reflecting the result of an action is a focal point and may record many causes of this action (many token concepts of type A'). Moreover, B' and R' may (but do not have to) be represented by one token concept.
Thus, in the conceptor framework, a **basic syntactic construction is not necessarily an independent faculty of speech (or natural language) but may result from the mode of the internal information representation in the brain.**
The construction is **common** for internal records and is **context-independent**. It is a **mechanism for pre-pairing** syntactic properties with their semantic correlates discussed, for example, by Pinker (1984, p. 41). The mechanism for pre-paring, however, **is the feature of consciousness** representation and not a part of speech acquisition mechanism. Hence, speech acquisition mechanism acts on the pre-pared representation in order to establish a vocal expression for already internally existing pattern.
It implies, however, that **prior to speech** there must have been a language-oriented *modus operandi* in brain. The idea has its origins in Chomsky's view of the existence of a template for the grammar of all human languages, a view shared by other researchers including one of us (Fialkowski 1994a,b)
It also implies that during child development, acquisition of speech should follow, or at least should be concurrent with, emergence of consciousness (as presented by Macphail, 1998), because despite the common construction of the internal records of token concepts that is innate, concrete word constructions are the result of a conscious process (in the conceptor it is invoking concepts to the internal scene **on request**). Thus, according to the model provided by conceptor, speech constructions **cannot precede** emergence of consciousness during a child development.

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