Moran, J., & Desimone, R. (1985). Selective attention gates visual processing in the extrastrate cortex. *Science*, *229*(4715), 782–784. doi:10.1126/science.4023713

Weng, J. (2010). A 5-chunk developmental brain-mind network model for multiple events in complex backgrounds. In *Proceedings of the IEEE International Joint Conference on Neural Networks,* Barcelona, Spain.

Weng, J., Luwang, T., Lu, H., & Xue, X. (2008). Multilayer in-place learning networks for modeling functional layers in the laminar cortex. *Neural Networks*, *21*, 150–159. doi:10.1016/j.neunet.2007.12.048

Weng, J., Zhang, Q., Chi, M., & Xue, X. (2009). Complex text processing by the temporal context machines. In *Proceedings of the IEEE 8th International Conference on Development and Learning,* Shanghai, China (pp. 1-8).

SOME SHIFTS FOR DISCUSSING SYMBOL GROUNDING

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To answer the question whether the symbol grounding (SG) problem has been solved, the best thing to do is to revert to the latest definition that Stevan Harnad, who first pointed out this as a "problem", has given: it "is the problem of causally connecting symbols inside an autonomous system to their referents in the external world without the mediation of an external interpreter" (Harnad, 2010). I think that in discussing this topic we need to make some shifts.

(1) In the new Harnad's formulation, the problem has lost a strong bias present in the 1990 formulation, that was inclined to consider *sensorimotor* events as the prototypical grounding sources. So the first shift we need is one from a molecular perspective to a molar one (to use the old Tolman's terminology), like the one that made possible, even to behaviourists, to go from stimulus to situation and perhaps to environment, and from response to behaviour. Many of the questions asked by Cangelosi can be answered if "looking for grounding" is not considered as looking only for strict sensorimotor connections of symbols, but as abstractions at different layers of events involving the individual. Abstract words like "freedom" or "beauty" *must* be grounded if they are not pure sounds when uttered, and grounding comes from many situations, sensorimotor in origin, that become more and more abstract scripts with experience.

Sloman (2010) is right that Kant had already said everything. Kant was attracted by Hume's idea of concepts built from experience according to association laws, but he was stuck with abstract concepts (number, causality, substance, etc.); since they don't look normal abstractions from experience, so they cannot be simply learnt, his answer was that they are particular concepts called categories. Such concepts are named "a priori synthetic judgments": synthetic because they are constructed from experience but "a priori" because this construction is made by a function. (Kant named it consciousness, we could name it central processor.) that works according to general principles. Such principles go beyond (transcend) experience: so they are built "genetically", they are what cognitivist named "functional architecture" and in a robot are part of firmware. Stimuli reflect the environmental structure, but our knowledge is built according to constraints determined by our cognitive system functioning and resources (so Kant was right that we never know "things in themselves").

(2) A second change of perspective is rethinking what *symbols* are. I think that looking for grounding components for syntactic labels or function words is misleading, simply because such words are *not* symbols.

Let me elaborate more on this point. The question to ask after the latest Harnad's formulation of the SG problem is: are there systems that are able to manipulate symbols in a non-formal

way, without having to rely on the builder/user interpretation? the answer seems yes, but now Harnad clarifies that the question was originally intended in terms of full human-scale systems, and we have to admit that at such level the problem is far to be solved. So the answer to the first subproblem posed by Cangelosi is both yes (at a simple scale) and no (at the full Turing scale).

But if the symbol grounding problem can be considered solved only at a full scale, then the second subproblem posed by Cangelosi is not a separate problem but is very connected with the first and may become the main problem. This is because, as Harnad (1990) himself had pointed out, labels (words) assume the function of symbols only when they take place in propositions, otherwise they are "inert taxonomies". Now, a proposition can only be built when there are at least two words and at least one predicate is present or implied. The need for a syntax comes already with only two words. The simplest and more natural syntactic "rule" would be simple juxtaposition, but toddlers learn very early to use more sophisticated ways of connecting different symbols. As we know, after having uttered their first word expressing a whole sentence, toddlers combine two words using a peculiar syntax (Braine, 1976), where one word assumes the role of "pivot" and the other changes (as in "mama comes", "mama good" etc.). From the very start, word ordering tends to be determined by the intended focus (the concept that has focus comes first) (Halliday, 1967). More complex relationships can only be expressed by using special "non-content" words like articles, prepositions, etc., even if at the beginning they are perceived and used as holistic forms (e.g. expressions like "the ball" or "in other words" may be intended as "theball" or "inotherwords" by toddlers) (Rapaport, 2007).

So the problem that Cangelosi describes as one of symbol-symbol relations can mean two different things: how *relationships* are grounded or how *words for relationships* are. One can ask whether words like "with" or "how" are symbols themselves or they just work as a "gluing" material for symbols properly considered. I think that syntactic elements are procedural patterns, acquired via social interaction, about how to glue together properly considered symbols. Relationships, however, are abstracted and grounded from sensorimotor (and beyond) events.

(3) Harnad (2010) seems to consider meaning a broader concept than grounding. But is it possible a non-grounded meaning? what has to be added to grounding for obtaining meaning? In Harnad's view, it seems that this "plus" is something like "feeling". But I think that the third bias that must be overcome is considering grounding sources only as external, i.e. strictly originated by the canonical five senses. Proprioception is often forgotten, although many concepts stem from our bodily states (e.g. happiness from well-being) and are grounded just like visual perceptions.

The SG problem, from the very start, originated in a context (the Chinese Room, the Merry-Go-Round situation, etc.) where the focus was on *understanding*. I think that the only empirical way for testing grounding is just understanding. Meaning and grounding, then, are double-linked. Grounding can be tested as invariant meaning across changes, be they syntactic or pragmatic (context, expectations, etc.) changes. When interpretation changes, grounding is different. Changes that do not affect understanding need not grounding: changing word ordering, making syntax errors like toddlers or people beginning to learn a foreign language, are factors that often do not affect understanding. In these cases looking for grounding of single words is worthless.

REFERENCES

Braine, M. D. S. (1976). Children's First word combinations. *Monographs of the Society for Research in Child Development*, 41.

Halliday, M. (1967). Notes on Transitivity and Theme in English (Part 2). *Journal of Linguistics*, *3*, 206.

Harnad, S. (1990). The Symbol Grounding Problem. *Physica D. Nonlinear Phenomena*, *42*, 335–346. doi:10.1016/0167-2789(90)90087-6

Harnad, S. (2010). Symbol Grounding Problem: Turing-Scale Solution Needed. *AMD Newsletter, 7*, 1, 4.

Sloman, A. (2010). Symbol Grounding is Not a Serious Problem. Theory Tethering Is. *AMD Newsletter*, *7*(1), 7–8.

THE POSSIBLE ROLE OF INTRINSIC PROPERTIES OF THE LANGUAGE COGNITIVE SYSTEM IN EXPLAINING OUR LANGUAGE CAPACITIES

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One of the most interesting questions in the study of language concerns the symbol grounding problem, in particular the relationship between indices and symbols. The capability of using indices seems to be explainable, from an evolutionary point of view, in terms of the relations between the agents and their environment. The capability to refer to external objects by means of indexical labels is useful: agents start to produce sounds in the presence of some relevant objects or events and the evolutionary process selects such ability because of its usefulness. Some kinds of animal posses such a capability, and also human being can use labels. But human being are also able to use symbols, that is, they can create symbol-symbol relationships. The attempt to explicate the transition from an indexical system to a symbol system by means of cognitive and Artificial Intelligence models is still not fully satisfying: for instance, robots have not been able to develop a language really comparable to human language. But robots don't have a control system as much complex as the human brain is: as Chomsky pointed out, the possibility to develop the human language could depend on the presence of predetermined structures in our minds/brains. Such structures have been in all probability naturally developed, because of their utility, by evolutionary processes: Artificial Life models can be useful in showing such aspects of the language development, in particular about its possible bases. Nevertheless, the actual complexity of language could exceed the possibilities of a fully evolutionary explanation in terms of relationships between words and objects/events: at least for the most complex aspects of language, such as its symbolic level, the mere relationships between words and objects/events could not represent a completely satisfying source of explanation. To explain the more complex aspects of language it could be necessary to analyse internal - mind/brain - structures. Language could be interpreted as an artefact created by the relationship between the human beings and their environment, but once created language - as a complex cognitive system - could exceed the properties directly deriving from such relationship.

A metaphor of such kinds of supervening structures is the development of economy: the use of money has created a system - the economic world - that is characterized by properties not immediately reducible to the properties of mere exchanges money-goods. But there is a difference between the economy system and language system: whereas the economy can be explained as a social artefact, it could be that language is an artefact naturalistically explainable. The language system could exceed the mere interactions between the human beings and their environment because of the creation of a language system much more complicated in comparison with such relations: but such a system could be explainable from a naturalistic point of view, in case we suppose it is implemented in brain structures.

In conclusion, Artificial Intelligence models - in particular, Robotics and Artificial Life - could be useful in showing the evolutionary bases of language development, but their actual incapacity in explaining some - symbolic - aspects of language could depend on the fact that, for such an explanation, we need a different point of view: a point of view concentrating on the properties of the language cognitive system. For example, properties like the rules analysed