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Wherein is Human Cognition Systematic?

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Abstract The "systematicity argument" has been used to argue for a classical cognitive architecture (Fodor in The Language of Thought. Harvester Press, London, 1975, Why there still has to be a language of thought? In Psychosemantics, appendix. MIT Press, Cambridge, pp 135–154, 1987; Fodor and Pylyshyn in Cognition 28:3–71, 1988; Aizawa in The systematicity arguments. Kluwer Academic Press, Dordrecht, 2003). From the premises that cognition is systematic and that the best/only explanation of systematicity is compositional structure, it concludes that cognition is to be explained in terms of symbols (in a language of thought) and formal rules. The debate, with connectionism, has mostly centered on the second premise-whether an explanation of systematicity requires compositional structure, which neural networks do not to exhibit (for example, Hadley and Hayward, in Minds and Machines, 7:1–37). In this paper, I will take issue with the first premise. Several arguments will be deployed that show that cognition is not systematic in general; that, in fact, systematicity seems to be related to language. I will argue that it is just verbal minds that are systematic, and they are so because of the structuring role of language in cognition. A dual-process theory of cognition will be defended as the best explanation of the facts.

Keywords Systematicity · Compositionality · Verbal minds

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Introduction

One of the strongest arguments in favour of a classical cognitive architecture-one based on language-like mental symbols and inferential processes over them-, was the systematicity argument (Fodor 1975; Fodor 1987; Fodor and Pylyshyn 1988). According to such argument, in outline, (1) cognition is systematic; (2) the only remotely plausible explanation for systematicity is a cognitivist architecture, one based on the compositionality of the vehicles of cognition. Therefore, cognitivism is "the only game in town": connectionist networks either are implementation of classical models or they fail as accounts of cognition. Classical Artificial Intelligence provided an important "existence proof" for such an approach. For many years, connectionism tried to meet this challenge by resisting (2), i.e., trying to show that connectionist architectures are also able to account for the systematicity of human cognition, even if their vehicles do not mix compositionally. The debate that ensued turned on the question of how to conceive of the constituent structure of cognition, which both sides assumed as required by the systematicity argument.

In this contribution, we want to take issue with the first premise: that cognition is systematic. We agree that human cognition is sometimes systematic; but systematicity cannot be taken as a defining feature of cognition per se. Hence, neither classical cognitivism nor connectionist cognitivism provide the right approach for a general approach to cognition, while they may account for some special features of human cognition. Embodied approaches, such as dynamical systems theory and ecological perception, have already proved more promising to understand cognition from the bottom up (Gomila and Calvo 2008; Spivey 2007), and evidence is growing of interaction-dominant cognitive processes (Kello et al. 2010, for a review). From this standpoint, the question of systematicity becomes the question of how cognition becomes systematic, when it does, out of a non-systematic, non-compositional, interactive and complex, ground level.

In order to challenge the assumption that all cognition is systematic, we will first discuss in the next section how the notion of systematicity is to be understood, and then present a battery of arguments against its being a general property of cognition. In section "Systematicity is Language-Dependent", we will show that thought systematicity is syntax-bound, which suggests that it depends upon language. In section "Non-Verbal Beings do not Exhibit Cognitive Systematicity", we will discuss evidence of cognitive abilities in non-verbal beings that indicate that they are not systematic.

On these grounds, it will be concluded that cognition is not systematic in general. However, it will be conceded that verbal minds are sometimes able of systematic processes (as in reasoning and problem solving). This raises the question of how is it possible for a non-systematic mind to exhibit systematicity; or more properly, how minds become systematic, given that the processes that exhibit cognitive systematicity develop later in infancy. The proposed answer to this question will be that verbal minds become able of systematic processes by becoming verbal. On these grounds, it will be argued that symbolist approaches in Cognitive Science invert the order of dependency between language and thought to account for the (assumed) isomorphy between them. While the classicists arguments for the systematicity of thought were modeled on the example of language, they claimed thought to be more basic, and the systematicity of language derived from the systematicity of thought, while the right relationship seems to go the other way around. Language acquisition is rather the key to cognitive systematicity.

In summary, instead of assuming an architecture of symbols and rules as the ground level of cognition, such symbolic level seems to be a higher level of organization made possible by language, whose semantics is to be grounded in a more basic level of cognitive architecture which is not systematic and compositional in the first place, but rather dynamic and interaction-dominant. This approach, suggested by Dennett (1993) some years ago, can be seen nowadays as a version of a "dual-process" theory of cognition (Spelke 2003; Carruthers 2005; Evans and Frankish 2009)-but one that views the basic cognitive level in dynamical, interactivist, sensorio-motor, terms. Such basic level of cognition is not systematic in the way specified by the challenge, and it is wrong to try to look at this basic level for precise, discrete, and stable enough, states to be called symbols—that correspond to the meanings of words. Language restructures this basic level and makes possible the appearance of a new level of cognition, which can be characterized as systematic, among other properties, and which seems distinctively human.

The Systematicity Argument for a LOT

In "The Language of Thought" (Fodor 1975), the systematicity argument played a central role in Fodor's claim for a "language of thought" (LOT), and a classical cognitive architecture, where cognitive processes were conceived as inferential transitions of symbolic structures according to formal rules. It was not the only argument put forward by Fodor, but it was clearly more palatable than the strong form of conceptual nativism that was the other main argument. In "Why there still has to be a language of thought?" (Fodor 1987), the arguments were made synthetic and focused. In Fodor and Pylyshyn (1988), the systematicity argument became the cornerstone of their challenge to the, then new, connectionist models. It triggered a lot of controversy and stimulated both the development of connectionism and of its interpretation. As other approaches, critical of the representational-computational assumptions of mainstream Cognitive Science, which can be grouped together as "embodied" or "interactive" approaches (Gomila and Calvo 2008), are getting momentum, a re-assessment of this central argument seems in order.

The basic structure of the systematicity argument can be summarized as follows:

(a) Cognition is systematic.
(b) The best (only) explanation of systematicity is compositional structure.
Therefore, (c) the best explanation of cognition requires compositional structure.

In Fodor and Pylyshyn (1988), this argument is used to challenge connectionism: either it cannot explain cognition (if disregards constituent structure), or it is just an implementation of a classical architecture (where the symbols of the LOT are given further analysis, one level down). The most common reaction to such a challenge consisted in rejecting premise b, while tacitly assuming the truth of premise a. It is not my purpose here to review the debate that followed, but rather to take issue with the validity of premise a. For that purpose, we need to go deeper in what is meant by systematicity.

The notion of systematicity at stake was cashed out not by a explicit definition, but through linguistic examples. In fact, in Fodor (1987), the notion of systematicity is introduced by appeal to linguistic examples; the strategy goes:

(a) There's a certain property that linguistic capacities have in virtue of the fact that natural languages have a combinatorial semantics.
(b) Thought has this property too.
(c) So thought too must have a combinatorial semantics (Fodor 1987, 148)

We will insist that thought does not have this property in general, but just for processes that are somehow dependent upon language. But the idea here is that the way we understand and produce sentences is systematic, which means that there is an intrinsic connection between the ability to produce or understand one sentence and many others. It is contraposed to learning a language by memorizing a phrase book: in this latter case, one can learn each phrase independently of any other, while in language learning one cannot learn how to say "*John loves Mary*" without learning at the same time to say "*Mary loves John*" (Fodor's example). Now, does thought have this property in general? Fodor thinks so because the function of language is to express thought, and rejects the possibility that thought is systematic just for creatures that speak a language.

It is important to notice that it is conceptual-inferential systematicity that matters here: the intrinsic connections between what can be thought. It is possible to formulate a different notion of systematicity that concerns design structure, for instance; to claim, for instance, that there has to be a necessary link between the different parts of a body, like if it has two lungs it's got to have two kidneys; or between sensors and actuators (like "walkers have vision", let's say). This is clearly a different notion of systematicity, but it is not the one Fodor and Pylyshyn were concerned with. In the same vein, a notion of behavioral systematicity could be put forward, to claim that there are internal links between the different behaviours of a system (let's say, between the "fly" and "fight" reflexes, so that if a system has one, then it also has the other). Similarly, a notion of skill or abilities systematicity could be articulated, to claim intrinsic connections among different skills ("if you know how to speak, then you are also able to sing", let's say, or "if you can grasp, then you can also scratch"). All these notions of systematicity are different and they can not be taken for granted a priori: it has to be ascertained whether any of them holds true for some kind of entities. But it is important to keep in mind that it is conceptual systematicity that is at stake.

In order to avoid the not uncommon reproach that Fodor's notion of systematicity was implicitly explained in terms of compositional structure, so that it could be viewed as tautological, Brian McLaughlin has tried to provide an independent characterization of systematicity (McLaughlin 2009). According to this proposal, systematicity is to be conceived in terms of lawful connections, but the critical question remains the same: whether if a thinker is able to entertain a certain thought, then it follows that she is also able to entertain many other thoughts. Again, the basic idea here is the lawful connection between thoughts, in opposition to what could be described to a list-like, bounded, thought repertoire, but in a way that avoids appealing to linguistic examples, which seem implying compositional structure. For thinking to be systematic, then, it is required that there exists a necessary connection among the different thoughts an entity can entertain.

The advantage of this formulation is that it doesn't smuggle compositional structure in the very characterization of systematicity, which is a standard objection to the argument from connectionist quarters. It also provides a clear indication of how to empirically test whether a cognitive being exhibits systematicity: given a conceptual ability, it raises the question of whether there are other conceptual abilities that come with it, that are interlinked. Of course, questions about the individuation of conceptual abilities may arise in this regard, but at least provide a clearer way to proceed, instead of taking just for granted that these dependencies hold. In the following two sections we will discuss empirical evidence that converges in a negative answer in this regard: cognition is not systematic in general. It rather seems to be a language-dependent property, one of the features of verbal minds.

Systematicity is Language-Dependent

As already mentioned, the examples through which Fodor characterizes cognitive systematiciy are all linguistic ones. A most typical example is "brown cow": to be able to think thoughts about "brown cow", a thinker has to be able to think thoughts about "brown" and about "cows". Another recurrent example, already mentioned, is "*John loves Mary*"/"*May loves John*". In this section, we will argue that he overlooks some important details concerning this kind of evidence, that point to the conclusion that cognitive systematicity is related to language.

Thus, Fodor does not seem aware that the patterns of systematicity in the examples he provides, are syntactically-bounded. Thoughts are structured in ways that are limited by the rules of syntax, rather than the other way around, as would be required if systematicity were a general property of cognition, independent of language. In other words, not all possible recombinations of the basic units make sense or happen to be interconnected, but just those that are syntactically correct: while algebraic intersection has the commutative properties, conceptual combination is restricted by syntactic rules. Thus, "cow brown" is not a possible thought content for English speakers, while the other way around holds for speakers of Spanish. "The tree is tall" expresses a possible thought, systematically dependent on its components, but these cannot be meaningfully combined this way "tall the is tree", for example. The point here is that the combinatorial restrictions to full systematicity are grounded in the language used to express the thought, which suggests that the systematic connections depend on the syntactic structure, rather than on a language-independent LOT.

A similar point can be made when it is realized that some apparent systematic connections take time to develop-related to the mastering of the corresponding linguistic structures, as I will insist in the next section. Thus, while it could be claimed, from a LOT point of view, that “John loves Mary” and “Mary is loved by John” are systematically related-so that if one can think a thought she is also able to think the other one, given that they express the same content, the same truth-conditions-, as it happens children master the first kind of structure by their third year of life, while they master the passive construction by the fifth; before that point, they understand “*Mary is loved by John*” as equivalent to “*Mary loves John*” (Karmiloff and Karmiloff-Smith 2002). Again, this suggests a) that linguistic systematicity is bounded by syntactic rules; and b) that systematic connections in the thought contents expressed by these sentences are driven that syntax; therefore they cannot be given a principled account in terms of the LOT, which suggests that thought contents are dependent on language, rather than the other way around. Ceteris paribus, a parallel argument could be made regarding opacity (that semantic property that occurs when substitution of co-referential expressions fails to be truth-preserving): to understand “John sings” and “Mary thinks” is not enough to understand “Mary thinks that John sings” when John is not singing: false belief understanding takes almost two more years than syntactically active, simple sentences. In fact, it has been forcefully argued that false belief understanding is contingent on the acquisition of the syntactical complementizer structure [de Villiers and de Villiers (2009), for a recent review of the evidence that supports such a view].

Evidence of context-sensitivity of conceptual combination also calls into question the systematicity of examples such as “brown cow”. Systematicity implies that once “brown” and “cow” concepts are available, then “brown cow” is also available. However, examples abound where the meaning of the compound cannot be derived (algebraically) from the meaning of the components. We can say the “brown cow” is Fodor’s “pet example”, but it is not enough to understand “pet” and “example” to understand the compound. Examples of failure of conceptual systematicity abound: “cupboard” does not refer to the intersection of the set of cups and the set of boards, and a “tea spoon” is not the class of teas that happen to be also spoons. And so on and so forth. In each case, the way the basic meanings compose is variable, dependent on the lexical context, the analogies chosen by the speakers, and the very component meanings involved, to the extent that it is not true that, if one understands “X” and “Y”, one will also understand the combination “XY”, as required by systematicity (a well studied phenomena, vd. Estes and Gluksberg 2000; Costello and Keane 2000). While context-sensitivity has been discussed by connectionists as a property that calls into question that systematicity is best explained by compositional structure, it can also be viewed as challenging the very plausibility of systematicity in the first place. Besides, it also points to the linguistic dependence of concepts, at least as complex ones are concerned.

Finally, the empirical evidence also strongly supports the conclusion that cognitive systematicity is strongly influenced by linguistic development, because lexical labelling changes the way concepts are grasped. Such effects have been demonstrated experimentally in a series of works by Lupyan et al. (2007, 2010), Lupyan (2008a, b). He has proven that lexical labels play a role in concept learning, making it faster; in making concepts coherent, reinforcing the correlated perceptual features that comprise them, and make them more discrete and definite, thus making less memorable their exemplars; and even in visual search, facilitating visual processing of lexically homogeneous familiar stimuli, in what he has called “the grouping effect”. This is specially so for highly variable categories, whose perceptual similarity of the member exemplars is small. But in general, a label increases the internal coherence of a category, so that their members are considered as intra-category more similar, and inter-category more different, than without the lexical label. In this way, the sharpness and accuracy of the categorization is also improved. However, it requires highlighting some properties while abstracting over others. Color may not be important for “chair”, but it may be for “tomato”. The more abstract a category, the more difficulty in recognizing particular exemplars. Hence, lexical categorization may come at a cost, of greater recognition errors of particulars. Labeling amounts to a representational shift, a different way to code the stimulus.

Syntactic development also provides the ground for cognitive systematicity: through the combinatorial integration of different concepts into predicative structures. In a recent study, based on the Childes corpus of speech production (http://childes.psy.cmu.edu/), we studied the linguistic production of three infants from 20 to 30 months of age, using a lexical networks approach (Barceló et al. 2012). We found a sharp “syntactic explosion” around 27 months of age. Before that time, words appear in pairs or tryads, with just a few words appearing in many different proferences; from that moment on, when infants appear to master the basics of syntactical rules, they begin to combine in an open-ended way the different words they already mastered. Here is where a systematic connections among the different proferences can be ascertained.

In summary, systematicity of thought seems to follow the systematicity of language because its properties mirror those of language, rather than the other way around: from a cognitive point of view, there are no principled reasons why some combinations are not available. The best explanation, then, is that systematicity is to be understood, not in terms of a combinatorial system (which would generate many more combinations than the ones that are parseable), but in terms of a recursive system of hierarchical dependencies, which we acquire with language.

Non-Verbal Beings do not Exhibit Cognitive Systematicity

Given Fodor’s tendency to rely on linguistic examples, it is not clear how to proceed in order to find out whether non-verbal creatures exhibit systematicity. McLaughlin’s way to characterize systematicity offers a more useful way to proceed, because it suggests a clearer approach to operationalizing such a notion in non-verbal tasks, which is the critical arena to find out whether all cognition is systematic. Given a conceptual ability, we have to find out whether there are other such abilities that are lawfully connected to it, such that having one involves having the other, or whether they are independent of each other. Even so, it is not perfectly clear how to proceed, or how much evidence would be required to establish whether non-verbal creatures are cognitively systematic or not: would it be enough to show that they are not for a single example? How many of them would be required if not? Conversely, it could be claimed that the burden of proof belongs to those that claim that non-verbal minds are systematic, to begin with.

Fortunately, we don't need to get entangled with these questions. We can defer to a broad empirical literature on conceptual development, and its corresponding comparative research, that takes it for a well-established fact that non-verbal creatures do not exhibit systematic cognition (to mention a well-known representative, Spelke 2003). Mostly using habituation-dishabituation paradigms with infants, it has been shown both (1) that some conceptual understanding starts much earlier than previously thought-concepts of object, agency, space, animated being, numerosity, cause,… among them-; and (2) that infants do not combine systematically these concepts in their behavioral interactions.

To illustrate, I'll focus on a particularly revelatory series of studies, on spatial coding (Hermer-Vázquez et al. 1999), which compared pre-linguistic children, human adults and rats, on a disorientation and reorientation task. This task, first used experimentally with rats (Cheng 1986), is as follows: after subjects were familiarized with a closed rectangular chamber, and were able to identify the location of a single food source at one corner, they were removed and disoriented. Later, they were returned to the chamber and allowed to search for the now-hidden food location. Where the rats first search for food indicates the memory information they use to reorient themselves. But the shape of the chamber is an ambiguous cue, because corners are diagonally identical; if rats use that cue, about 50 % of the time they will end in the opposite corner. Food source is completely specified, though, by wall variable brightness and odor. If rats reliably find the food source, then, it is because they are using these cues. Where do rats search? Rats were looking equally at the right corner and the diagonally opposite corner, despite the rich information cues that could be used, and which are used by the rats in other tasks, to resolve the ambiguity of a memory based on geometry only. This suggests that spatial conceptualization is not systematically connected to odor and brightness categorization in rats. Cheng (1986) thus concluded that spatial reorientation in rats depended on a module of geometrical knowledge.

While it is contentious whether there exists a specific module for reorientation, the relevance of geometrical cues for reorientation is out of question. The environmental set-up is enduring and rarely involves deceptive symmetries. Most other cues-plants, odours, colors, object configuration-can be transient and hence less reliable. Not surprisingly, rats are not alone in focusing on geometry to reorient themselves; many other species do the same (O'Keefe and Burgess 1996). Among the latter, human children: previous research by Spelke's group modified the reorientation task to be used with 18–24 month olds (Hermer and Spelke 1994, 1996). Instead of a food source, the target corner was a hidden toy: children witnessed how it was hidden, and after disoriented by being lifted and turned, they had to search it. In one condition, no distinctive landmark was added to a completely white chamber, so that only ambiguous geometrical information was available for the infant. In a second condition, a blue wall was added to break the chamber symmetry. As rats, infants look equally at the two geometrically identical corners, even in the second condition, where a disambiguating cue (the blue wall) was available. Other disambiguating cues were used (texture, patterning of wall surface), to no avail, despite the fact that all these other sources of information are used by infants in other tasks. On the contrary, human adults do use such disambiguating cues in the reorientation tasks if available (Hermer and Spelke 1994). In conclusion, it seems that infants rely for reorientation on a robust but geometrically-specific system, while human adults can reorient in a more flexible manner, using all kinds of disambiguating sources, combining them systematically.

Furthermore, the source of this flexibility-understood here as the possibility to systematically combine different concepts to code for a location-, has to do with development of spatial language. At about 4 years of age, object-centered spatial expressions such as "at the blue side" and "behind the wall" appear, while "left" and "right" first occured around 6 years of age. Correspondingly, success at the reorientation task where the toy is hidden to the left or the right of the wall, does not occur until age 6. The studies reported in Hermer-Vázquez et al. (1999) support the conclusion that linguistic development is the key factor in this transition. This time, a dual task method was used with adult participants, on the grounds that language processing cannot be splitted between two processes at once (Broadbent 1971). Thus, it was hypothesized that if linguistic processing was prevented to become involved in the reorientation task, by being assigned a different, concurrent, task, adult performance would rely just on geometrical information, just like prelinguistic infants.

Such a second task was a verbal shadowing one, where participants have to repeat online what they hear through earphones. In this condition, participants searched equally at both geometrically identical opposite corners, even if the color landmark was available. Thus, verbal shadowing impaired adult's ability to combine the color of the wall with the geometrical configuration, but it did not impaired the latter, suggesting its automaticity and phylogenetic robustness. Use of color and other landmarks, on the contrary, seems to rely on language, given its sensitivity to verbal interference. To make sure that this effect is due to verbal interference as such, a different interference task of similar difficulty was used, such as a nonverbal rhythm tapping. In this condition, the second task did not create an interference and subjects were able to search the hidden object at the right place. Such interference effects of verbal shadowing have been interpreted as evidence that in the non-dual setting, spatial reorientation takes advantage of a linguistic representational vehicle, which provides the means to integrate different ways to code the situation.

Similar examples can be found in animal psychology-but for the restructuring effect of language. In fact, studies of ape cognition indicate that non-human primates are good at perception, but not so good at cognitive processes, such as reasoning (Gómez 2004; Premack 2004; Penn et al. 2008). On the other hand, the best evidence of systematic understanding in these species seems to derive from symbol using. Non-verbal minds, then, seem to exhibit highly specialized and encapsulated cognitive abilities.

On the Priority of Language

I have argued that cognition is not systematic in general, but just when language is involved. This suggests the further view that verbal minds are systematic because they are verbal. Given that language is not ready for use at birth, a natural view of verbal minds suggests itself, according to which cognition becomes systematic through language acquisition. In other words, infant minds are not particularly different from other animal minds, but for their potential for development and their linguistic predisposition. Human minds become verbal in a social setting in which they develop, and in this process, they also become systematic: it is the syntactic structures acquired that provides the intrinsic connections between the different thought contents. I've argued, on the grounds of an extensive review of the exponentially-growing literature in this area, that recent research on the relationships among language and thought provide evidence for such a view (Gomila 2012). In so doing, I propose to reverse the order of dependency between language and thought: instead of taking the systematicity of language as derived from the systematicity of thought, I propose that the systematicity of thought is derived from the systematicity of language.

I have already touched upon the temporal priority of syntactic systematicity over cognitive systematicity; it makes sense that temporal priority goes with logical precedence. In this section, I will just discuss the main roadblock to such a view: the strong conceptual nativist assumption-that in order to acquire a systematic language, a previous systematic LOT needs to be available in the first place-, which constituted the other main argument for a LOT in Fodor (1975). Whether this argument to succeed, then, I'm in trouble. But I think it is clear that this is a sort of desperate and complicated move-a sort of epicycle.

This is a straightforward way to object to our proposal, but addressed against Dennett:

> But we aren't told how an initially unsystematic mind could learn a systematic language, given that the latter is ipso facto able to express propositions that the former is unable to entertain. How, for example, does a mind that can think that John loves Mary but not that Mary loves John learn a language that is able to say both? Nor is it clear what could make language itself systematic if not the systematicity of the thoughts that it is used to express; so the idea that the mind learns systematicity from language just sweeps the problem from under the hall rug to under the rug in the parlour. On balance, I think we had better take it for granted, and as part of what is not negotiable, that systematicity and productivity are grounded in the 'architecture' of mental representation and not in the vagaries of experience. (Fodor 1998, pp. 26–27)

An analogous argument was levelled in the Geology of the twenties of last century against Wegener's theory of continental drift: Wegener was accused of "solving" a problem-continental drift-by creating another one-the gigantic force needed to move the continents in the first place-. So Geology will be better off denying continental drift, and assuming that the tectonics of plates are constitutive part of the "architecture" of the terrestrial crust. In other words, Fodor's way to solve the problem of the systematicity and productivity of higher cognition is solved by making systematicity and productivity properties of all human cognition, in order to avoid the question of how higher cognition gets of the ground. The problem with this "solution" is that, as we have reviewed, it doesn't find support in the evidence; we find many developmental transitions in infancy, and language seems to be associated to such transitions; and some important cognitive differences between non-verbal and verbal minds seem inescapable (Penn et al. 2008). At a minimum, a contended solution should be able to acknowledge the facts in the first place.

A reductio of such an argument can be obtained through a comparison. If Fodor's argument were correct, I couldn't learn to cut with a scissors, because to do so I should already be able to use the scissors, and therefore, it wouldn't be really learning. The mistake here is that tools require practice, because they involve new hand movements, new ways of sensorimotor coordination. Much the same happens with linguistic and conceptual abilities: they are not suddenly acquired. Fodor's argument is driven by the intuition that the first language is acquired as a second language: by translating it into an already available language: the "original" language of thought. However, both scientific evidence and common experience show that infants learn their first language in a very different way from how adults learn second languages. Just as spiders do not come equipped with a master plan of the webs the build, but just with a basic set of operations, babies do not need the full complexity of language to begin with. Complex structures may be the outcome of interactive processes. There is no need to supposed a perfect isomorphy between mechanism and behavior.

The weakness of Fodor's circularity argument for the claim that all concepts are innate, then, lies in his assumption that the only way to explain concept learning is hypothesis formation and hypothesis testing. But, as Fodor himself recently acknowledged (Fodor 2008), what follows from this argument is that hypothesis formation and testing is a confused model of concept learning. Moreover, it is not true that this is the only model of concept acquisition (Gomila 2011). Applied to functional enrichment, Fodor's argument is even more problematic, because functionalities are not supposed to be learned by hypothesis formation and testing. Babies do not learn to walk by forming hypothesis about how to distribute body weight, for instance. It is a matter of increasing coordination through practice, which in the case of language is socially shared. Hence, philosophical arguments cannot block the real question: whether or not pre-verbal and non-verbal minds are systematic and productive, and whether they become so after learning a language. If that's the case, an account is in order of such a cognitive restructuring. Taken for granted that all cognition is systematic because linguistic adult cognition is, incurs a petitio.

The question raised by Fodor, though, is still relevant. We have to explain "how an initially unsystematic mind could learn a systematic language, given that the latter is ipso facto able to express propositions that the former is unable to entertain". We have already insisted that the latter part is just relevant if the process is conceived as hypothesis formation and testing: a way to entertain the hypothesis in the first place is required for such a model. But it is not the only model. Associative learning provides an alternative. And the distinction characteristic of dual theories between implicit and explicit representation is also clarifying in this respect: "learning words provides explicit internal labels for ideas that were previously merely implicit, and this gain in explicitness has cognitive consequences." (Gentner 2003, p. 225). Even within mainstream Cognitive Psychology it is well known the powerful effect of verbal coding (Miller 1956): "the most customary kind of recoding… is to translate into a verbal code" (p. 89), at least as regards cognitive economy and facilitation of several processes, including long-term memory or reasoning. Besides, the hierarchical structures of dependency within the sentence provides the kind of combinatorial mechanism required for cognitive systematicity.

Conclusion: A "Dual Process" View of Cognition

Several researchers working in the area of the psychology of thinking have converged on the idea that human cognition can take place in one of two main regimes: we are able of intuitive, fast, automatic, unconscious, implicit, parallel, associative processes, but we are also able of reflexive, slow, controlled, conscious, explicit, serial, rule-based processes. Thus, dual theories of cognition have been proposed, for memory (Schacter 1987), reasoning (Kahneman 2002; Evans and Over 1996; Stanovich 1999; Sloman 1996, 2002); knowledge representation (Anderson 1993; Dienes and Perner 1999); learning (Berry and Dienes 1993; Reber 1989); and theory of mind (Gomila 2001; Reddy 2008). We believe that this duality also corresponds to the divide between non-systematic and systematic processes.

The former processes are thought to be cognitively basic, evolutionary ancient, and not easily controllable (for instance, by verbal instruction). The latter require attention and effort, take more time, and require conscious control. Thus, if we take the case of skill learning, we can distinguish low level navigational abilities, such as crossing a street, and high level abilities, such a piloting a ship. The crucial question is how these two levels of cognition are related; in particular, do they exist alongside each other, competing for control? Or do they constitute separate systems within a common architecture? Even more fundamental: why is it that the higher level appears in development, if it is possible to succeed with the basic one.

At the moment, there is no consensus on how to conceive of these two different systems, and their interrelation. Thus, the basic level can be seen as a collection of different, modular, systems of "core knowledge", while the other one makes flexible control possible by "broadcasting" the outcome of each of them to the whole system, making possible a flexible, increased, control, through mental rehearsal in inner speech (Frankish 2004; Carruthers 2005; Evans and Frankish 2009). But it is also possible to conceive the basic level in interactivist, dynamic, terms. The basic cognitive architecture involves language-independent perceptual categorization (which are applied to language learning to begin with); there are reasons to doubt that such basic capacities constitute symbolic, a modal, concepts; they rather develop and differentiate as more or less stable attractors in dynamical system of continuous processing (Spivey 2007; Kello et al. 2010). From this point of view, there is no need for a language of thought to account for this basic cognitive level, which does not depend on the tokening of mental symbols, but the activation of distributed, context-relative, coupled patterns of brain networks. Lexical labels do not create concepts ex nihilo; they rather transform those basic sensorimotor contingencies into meaningful units that can be combined productively.

Human cognition, then, while it arises from sensorimotor, bodily interaction with the world, is not exhausted by it; or rather, part of this worldy experience concerns social symbols, that can be internalized and give rise to symbolic mediators of such interactions. Higher cognition-the abstract, discrete, propositional, "controlled", flexible, forms of cognition, seems to rely on such a mediation, which can be understood as a new level of cognitive organization. A cognitive function of language, then, can be to make cognition more abstract, and context-independent: more self-controlled.

The important point of consensus, then, for dual theories of cognition lies in viewing language as the critical development making possible this new level of cognitive organization. Thus, when we consider the non-verbal cognitive abilities of adult humans, we don't find much difference with the abilities of other primates. They all seem to use fast and frugal, unconscious systems (which can be called modules if such notion is weakened to the point of vacuity). Verbal minds, on the contrary, are something completely different: we are slower, effortful, conscious, inferential, flexible. It could be claimed that, through language, our minds become general-purpose, while animal minds are specialized (Premack 2004). Humans can recombine mental elements, going beyond sensorimotor experience. While non-verbal minds can represent what they perceive, humans can represent what they imagine. Another way to go is to say that language provides propositional structure to thoughts, in a systematic and productive way. This amounts to reverse the direction of dependence between language and thinking proposed by Fodor and the LOT. Thought becomes systematic through language, by making possible a combinatorial system of representation with the "concrete infinitude" of language. Language also provides the mechanism of meta-representation, which makes possible increased forms of control and flexibility.

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