Incomplete language-of-thought in infancy

Jean-Rémy Hochmann

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Comment on: Quilty-Dunn, Porot, & Mandelbaum (2023). The Best Game in Town: The Re-Emergence of the Language of Thought Hypothesis Across the Cognitive Sciences. *Behavioral and Brain Sciences*

Jean-Rémy Hochmann

CNRS UMR5229 - Institut des Sciences Cognitives Marc Jeannerod, 67 Boulevard Pinel, 69675, Bron, France.
Université Lyon 1 Claude Bernard, France
Telephone : +33 (0)4 37 91 12 70
E-mail: hochmann@isc.cnrs.fr
Homepage : https://sites.google.com/site/jrhochmann/

Abstract

The view that infants possess a full-fledged propositional Language of Thought (LoT) is appealing, providing a unifying account for infants' precocious reasoning skills in many domains. However, careful appraisal of empirical evidence suggests that there are still no convincing evidence that infants possess discrete representations of abstract relations, suggesting that infants' LoT remains incomplete. Parallel arguments hold for perception.

Main Text

The view that infants possess a propositional Language of Thought (LoT) appeals as a unifying account for precocious physical (Stahl & Feigenson, 2015), logical (Cesana-Arlotti et al., 2018), probabilistic (Téglás et al., 2007; Denison & Xu, 2010) and social reasoning (Baillargeon, Scott & He, 2010; Hamlin, Wynn & Bloom, 2007; Powell & Spelke, 2013). It suggests continuity along development in the format of human thought. But arguing for such continuity also raises questions. Most, if not all, of the cognitive skills of young infants are also documented in non-human species (Krupenye et al., 2016; Engelman et al., 2022), suggesting continuity along evolution. We should thus attribute the same type of thoughts to non-human animals and human infants, to animals and human adults. How, then, do we account for animals' failure to acquire human natural languages and develop unique human cognitive skills? Careful appraisal of the available data and careful experimental designs may instead highlight important discontinuities in the format of thought along both developmental and evolutionary scales, suggesting that a full-fledged LoT, involving all six properties identified by Quilty-Dunn, Porot & Mandelbaum (2022) is not yet available to young infants (nor to animals).

I applaud the project of Quilty-Dunn et al. to list specific properties of a propositional LoT and evaluate the presence of these properties in various subdomains of cognitive science. The strength of the evidence for each property in all domains is however inequal. In particular, before concluding that infants possess a full-fledged LoT, we need to provide evidence for each property, individually, and also investigate the limits of each property. I will focus on the first property, "discrete constituents". It is the most important, as it is presupposed by most other properties: roles are attributed to discrete constituents; predication combines discrete constituents; logical operators are conceived as discrete constituents. Contrary to Quilty-Dunn et al., I will argue that, while both perception and infant cognition certainly possess discrete representations of objects and possibly of features, there is no evidence for discrete representations of relations in perception nor in pre-lexical infants.

While experimental evidence suggests that perceptual representations of relational events and scenes are generalizable to a certain extent (e.g., Papeo, 2020; Goupil, Papeo & Hochmann, 2022; see Kominski & Scholl, 2020 for the limits of those generalizations), there is no evidence that those representations are discrete, dissociated from the object representations. Rather, relations may well be represented by perceptual schema composed of discrete *object* representations. The generalizability can be obtained through the underspecification of object representations, a process we previously called "abstraction by impoverishment" (Hochmann & Papeo, 2022). For instance, in perception, a schematic social interaction would consist in two schematic bodies facing each-other (Papeo, 2020), a schematic relation of support would consist in an empty object file on top of another empty object file, etc. Similar representations, with object files possibly enriched with thematic roles, may account for the representation of many relational events in infancy (Tatone, Geraci & Csibra, 2015; Rochat, Striano & Morgan, 2004; Leslie & Keeble, 1987).

We recently provided direct evidence supporting the proposal that pre-lexical infants lack discrete representations for abstract relations (Hochmann, 2022). We showed that infants can represent the relation same in a format that is abstract, as it can generalize to novel instances of the relation. However those representations are limited to four same individuals, suggesting that the format of infants' representations is not something like *S(A,B)*, where *A* and *B* would be object representations and *S* the representation of the relation between those objects, but rather *(X X)*, where *X* is a variable for an object (see Hochmann, 2022 for the full argumentation). The repetition of the variable carries the relational content *same*, but only symbols for objects are explicitly represented. This view is reinforced by the systematic failure of young children and other animal species in the relational match-to-sample task, where they need to match pairs of same or different images (e.g., matching square-square to circle-circle and square-star to moon-triangle). If infants and young children possessed discrete symbols *S* and *D* for the relations same and different, they should activate *S* for both square-square and circle-circle, and *D* for both square-star and moon-triangle, and easily match *S* to *S* or *D* to *D*. Instead children fail until the age of 4, and only succeed when actively using the words "same" and "different" (Hochmann, Tuerk et al., 2017). Likewise, chimpanzees (and other animal species) fail the relational match-to-sample task, unless they previously acquired external unitary symbols that refer to the relations same and different (Premack, 1983; Thompson, Oden & Boysen, 1997). These observations highlight a discontinuity along human development. They put forward the hypothesis that relations are initially represented in mental models, and that discrete representations of relations are related to the acquisition of words for those relations. The discrete symbols for abstract relations are possibly no other than the words that refer to those relations.

Finally, even granting infants the capacity to solve the disjunctive syllogism (Cesana-Arlotti et al., 2018) or to compute negation (Hochmann & Toro, 2021), more experimental work is necessary to describe the format of the representations that permit those performances. While discrete logical operators could account for these data, other hypotheses are still on the table, including among others, probabilistic representations and inhibitory mechanisms.

In conclusion, the LoT hypothesis is a hypothesis about the format of mental representations. Despite the appeal of a unifying account of cognition and perception, from infancy to adulthood, from bees to humans, discontinuities in the format of thoughts deserve to be studied and highlighted. Quilty-Dunn et al. provide a framework to think about these issues in infants – as well as in non-human animals – and develop experimental approaches to decide whether each LoT property is present or absent in infancy, whether infants indeed possess a propositional LoT, or whether they still need to acquire some of the pieces before they can fully play the game.

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