



## Language acquisition and innate cognitive abilities: An approach from the mental models theory

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**Abstract.** According to Hornstein, generative grammar needs to give an account of the fact that children can learn any language living in contexts with many limitations and shortcomings from the linguistic point of view. He thinks that inductive theories are not able to explain a learning with such limitations and shortcomings. Likewise, in his view, semantic theories do not show why semantics is necessary to account for that fact. However, this paper is intended to argue in favor of the idea that an essentially semantic cognitive theory, the mental models theory, can not only to explain the aforementioned fact, but also make it evident that semantics is essential in most human intellectual activities.

**Keywords:** Generative grammar; iconicity; language acquisition; mental models; semantics.

### [es] Adquisición del lenguaje y capacidades cognitivas innatas: Un enfoque desde la teoría de los modelos mentales

**Resumen.** Según Hornstein, la gramática generativa necesita ofrecer una explicación del hecho de que los niños pueden aprender cualquier idioma viviendo en contextos con muchas limitaciones y deficiencias desde el punto de vista lingüístico. Piensa que las teorías inductivas no son capaces de aclarar cómo acontece el aprendizaje con tales limitaciones y deficiencias. Del mismo modo, en su opinión, las teorías semánticas no muestran por qué la semántica es necesaria para explicar ese hecho. No obstante, el propósito de este trabajo es argumentar a favor de la idea de que una teoría cognitiva esencialmente semántica, la teoría de los modelos mentales, puede no solo clarificar el mencionado hecho, sino también evidenciar que la semántica es fundamental en la mayor parte de las actividades intelectuales humanas.

**Palabras clave:** Gramática generativa; iconicidad; adquisición del lenguaje; modelos mentales; semántica.

**Contents.** 1. Introduction. 2. The problem of language acquisition. 3. The mental models theory: iconicity and possibilities. 4. The difficulties in the learning process of language and the mental models theory. 5. Conclusions and general discussion. Acknowledgments. References.

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## 1. Introduction

Based on Hornstein (1987), it can be said that generative grammar has a problem that needs to solve or, at least, overcome. Children usually learn language (regardless of the particular language) in circumstances of clear linguistic limitations and deficiencies. From his point of view, it is hard to account for this fact by adopting an inductive perspective. However, from an innate approach, doubts can also raise. In this way, Hornstein (1987) thinks, for example, that, if the framework assumed is semantic, one important difficulty to deal with is precisely the demonstration that semantics is absolutely necessary to give a solution for that problem.

In this paper, nevertheless, it will be tried to show that a particular essentially semantic framework can be clearly appropriate in this regard. That framework is the one of the mental models theory (e.g., Khemlani, Byrne, & Johnson-Laird, 2018). Thus, the basis of the argumentation will be that, given the clear experimental and empirical support that the cognitive science literature offers to this theory, it seems to be necessary to take it into account in the studies about language. Furthermore, it will be explained how the mental models theory can give not only an account that is coherent from the linguistic point of view, but also that is consistent with what cognitive science appears to accept nowadays, the relevant point being, obviously, that that account can solve the aforementioned problem of language acquisition. And this is so because this theory seems to refer to innate skills or abilities that allow sorting out the difficulties related to the limitations in the process of learning of the grammatical rules of any language.

To achieve this goal, firstly, the problem of the deficiencies in the language acquisition process will be explained in more detail. Secondly, the general approach of the mental models theory will be described. Lastly, how this last theory can solve the problem indicated by Hornstein (1987) will be accounted for.

## 2. The problem of language acquisition

Indeed, Hornstein (1987) points out three limitations or deficiencies that are often present in any language acquisition process of any child. Those are the following:

[I] A child learning a language does not usually receive messages by means of absolutely correctly built sentences. What he/she generally receives are parts or pieces of information that really need more elements to adequately construct a sentence.

[II] He/she learns a number of data that is not infinite. Nonetheless, he/she is able to build, from those data, infinite sentences.

[III] With no explicit teaching, a child gets to know when a sentence does not follow the grammar of the specific language or transmits equivocal information.

According to Hornstein (1987), the third one is the most important point, since the other two points are somehow included in it. However, what appears to be most relevant here is that the three mentioned points clearly show, as claimed by Hornstein, that no inductive theory, that is, no theory rejecting innate linguistic structures in human beings, can explain the real learning process of language. The book by Hornstein (1987) gives several reasons for this. Nevertheless, the part of his arguments on which this paper will be focused is the one related to his idea that the innate proposals can also have their difficulties. In particular, as said, from his point of view, the complexity is in the semantic approaches, which are named Neo-Fregean by him. In his opinion, these last approaches are complex not because it is clear that semantics is not necessary to solve the problem, but because, as also indicated, they do not demonstrate that these issues cannot be dealt with without adopting a semantic dimension.

But beyond other proposals addressing difficulties akin to this one, such as that of the government-binding theory (see, e.g., Chomsky, 1981; Hornstein, 1987, 1995), or that of minimalism supported by Hornstein (see, e.g., Hornstein, 1995, 2001; Hornstein, Nunes, & Grohmann, 2006), as stated, this paper attempts to argue in favor of the idea that a semantic account, based upon the mental models theory, and hence very different from the ones deemed as Neo-Fregean by Hornstein (1987), can be absolutely necessary in this way if it is not wished to ignore what contemporary cognitive science reveals at present by means of experimental results. Evidently, because it is a cognitive theory, it speaks about certain abilities that can be found in the human mind, and the assumption of such abilities is precisely what, as shown below, can solve the linguistic problem described above.

### **3. The mental models theory: iconicity and possibilities**

Two important concepts in the mental models theory are that of iconicity and that of possibility (e.g., Johnson-Laird, 2012). The one of iconicity is explicitly related by its proponents to approaches such as that of Peirce (1931-1958), which is acknowledged even in relatively recent papers (e.g., Johnson-Laird, Khemlani, & Goodwin, 2015). On the other hand, the one of possibility, while its adherents do not usually accept that (e.g., Khemlani, Hinterecker, & Johnson-Laird, 2017), can remind and be linked to modal logic (see, e.g., López-Astorga, 2017). In any case, the general idea is that any expression refers to one or several possibilities that iconically describe reality or the world. And that can be clearly seen by means of an example, as it is demonstrated by the following conditional sentence:

[IV] “If Pam is not well then she has the flu” (Khemlani et al., 2018: 1890).

In principle, following basic texts presenting the theory (e.g., Oakhill & Garnham, 1996), it can be thought that a sentence such as [IV] refers to the same possibilities as those in which the conditional is true in classical logic. Thus, such possibilities could be these ones:

- [V.1] Pam is not well & Pam has the flu  
 [V.2] Pam is well & Pam has the flu  
 [V.3] Pam is well & Pam does not have the flu

However, as claimed, the possibilities are iconic, which means that [V.1], [V.2], and [V.3] should describe, in an iconic way, possible scenarios in which [IV] can be true, and this leads to a problem: [V.2] is not an actual possible scenario because the situations in which somebody is well and has the flu at the same time are very unusual. According to the mental models theory, people often note facts such this one by means of modulation processes (e.g., Quelhas & Johnson-Laird, 2017; Quelhas, Johnson-Laird, & Juhas, 2010). In those processes, semantics is essential because the meaning of the words embedded in the sentences is what enables to see that certain possibilities cannot be admitted (in this case, for example, the meaning of ‘flu’ leads to the rejection of [V.2], since, given that, if somebody has the flu, he/she is sick, if somebody has the flu, he/she cannot be well).

Of course, in modulation, pragmatics can also have an influence (e.g., Johnson-Laird & Byrne, 2002) but, although it is undoubtedly so, it can also be thought that, likewise, it is clear that the theory is basically semantic, and that semantics is the essential aspect in it. Nevertheless, beyond this point, it is obvious that, in [IV], the rejection of [V.2] is not the only result of modulation. Because the meaning of ‘flu’ is known (and, if it is wished to explicitly consider pragmatics, given that everyday experience shows so too), one more possibility can be taken into account: somebody may not have the flu and, at once, may not be well for other reason (e.g., because of other illness), which leads to this new iconic possibility:

- [V.4] Pam is not well & Pam does not have the flu

Therefore, the actual possibilities corresponding to [IV] are [V.1], [V.3], and [V.4], and, by means of mental processes such as this one, the mental models can account for and predict the results obtained by carrying out empirical experimentation and reported in the specialized literature of cognitive science. Thus, it can be said that this theory is a very good option to assume to explain reasoning and why people usually make inferences of certain kinds and do not accept inferences of other kinds. Nonetheless, what is most relevant here is that a machinery such as that described in this section can show that, really, [IV] is wrongly expressed, and that a better sentence could be, for example,

- [VI] If Pam is well, then she does not have the flu.

Certainly, possibilities [V.1], [V.3], [V.4] seems to be more suitable for a sentence such as [VI] than for a sentence such as [IV], and this, *inter alia*, because the former reflects in natural language the true combinations of possibilities that can be thought for the fact that Pam is (not) well and the fact that she has (does not have) the flu in a much better way (for the relationship between the possibilities of the mental models theory and the logical form of the conditional, see, e.g., López-Astorga, 2015).

But, in addition, a framework such as the one described above can also remove the difficulties raised by [I], [II], and [III]. This is addressed in the next section.

#### **4. The difficulties in the learning process of language and the mental models theory**

As mentioned, the first problem is given by [I]. However, the framework of the mental models theory reveals that linguistic expressions being absolutely perfect and well built are not always necessary. Beyond the fact that what has been commented on in the previous section shows that what is literally expressed is not often what is really understood when the iconic possibilities corresponding to the expressions are taken into account, there are works describing how the mental models theory can explain why separate pieces of messages can be linked by people and, by virtue of the possibilities that can be assigned to them, underlying grammatical relationships between such pieces can be recovered.

One of those works can be, for example, that of López-Astorga (2015). In it, an experiment carried out by Fiddick, Cosmides, and Tooby (2000) is analyzed. This last paper is proposed with the goal to give evidence in favor of a different theory: the social contracts theory (e.g., Cosmides, 1989). However, a detailed commentary on what this last theory claims and its main thesis is beyond the aims of this section. What is important now is the review of one of the experimental conditions in Fiddick et al. (2000) made by López-Astorga (2015). That condition is a version of Peter Wason's four cards selection task (e.g., Wason, 1966, 1968), and, in it, a story about a farmer is told. Basically, what happens is that the farmer has a lot of potatoes and wants to sell some of them. For this reason, the farmer goes to a village in which people speaks a different language. Nevertheless, he understands that one of the people in the village says:

**“I want some potatoes”** (Fiddick et al., 2000: 28, bolds in text; see also, e.g., López-Astorga, 2015: 245).

And the farmer responds:

**“I want some corn”** (Fiddick et al., 2000: 28, bolds in text; see also, e.g., López-Astorga, 2015: 245).

In this manner, four cards are presented to the participants in this experimental condition. One of the faces of those cards indicates whether or not the person in the village gives corn to the farmer, and the other one whether or not the farmer gives potatoes to the person in the village. Nonetheless, what the participants see is only one of the faces of each of those four cards. Thus, what they can really see is the following:

First card: The farmer delivers potatoes to the person in the village

Second card: The farmer delivers nothing to the person in the village

Third card: The person in the village delivers corn to the farmer

Fourth card: The person in the village delivers nothing to the farmer

And what they have to do is to point out the card or the cards that can reveal whether or not the person in the village fulfills his/her part of the agreement.

According to Fiddick et al. (2000), most of their participants preferred the first and fourth cards, which was interpreted by them as a proof in favor of their framework. However, the point here is that the analysis made by López-Astorga (2015) based upon the mental models theory seems to reveal that what the participants actually did was to link the assertions ‘I want some potatoes’ and ‘I want some corn’ by means of a conditional relationship.

Indeed, the selection of the mentioned cards makes it evident that what is being tried to check is whether or not the situation that is not wished (i.e., the situation in which the farmer delivers potatoes and the person in the village delivers nothing) happens. Clearly, the election of the first card is intended to see whether or not, when the farmer delivers potatoes, the person in the village responds delivering corn, and the choice of the fourth card is made to see whether or not, when the person in the village delivers nothing, the farmer delivers potatoes. Accordingly, what is being done is to attempt to verify that, expressed as an iconic model, this situation does not occur:

[VII] The farmer delivers potatoes & The person in the village delivers nothing

But, if this is so, it is also clear that the other three combinations of possibilities are allowed. Obviously, such combinations are these ones:

[VIII.1]The farmer delivers potatoes & The person in the village delivers corn

[VIII.2]The farmer delivers nothing & The person in the village delivers corn

[VIII.3]The farmer delivers nothing & The person in the village delivers nothing

However, following López-Astorga’s (2015) arguments, given that it is absolutely clear that [VIII.1], [VIII.2], and [VIII.3] are parallel with and correspond to models such as [V.1], [V.2], [V.3], it is totally justified to think that the participants linked what was said by the person in the village and what said by the farmer by means of a conditional relationship, and that hence they made the task considering an underlying conditional sentence akin to this one:

[IX] If the farmer delivers potatoes, then the person in the village delivers corn.

Therefore, it is obvious that the fact that children often only receive parts or pieces of information needing to be completed is not a real problem in the language acquisition process. The mental models theory can easily account for the way those parts or pieces can be bound in order that they make sense. Nevertheless, this, clearly, also solves the problem related to [II]. As shown by means of the previous experimental condition, the semantic meaning of the words suffices to begin to create possibilities. Thus, it is evident that the

number of possibilities that can be constructed can be deemed, in principle, as infinite. The data may not be infinite, but the combinations of possibilities that can be built from them can be, as it can be concluded from López-Astorga's (2015) analysis of the experimental condition in Fiddick et al. (2000) described above, even previous to and independent from grammatical rules. And this in turn reveals that [II] does not cause difficulties under the framework of the mental models theory either, since any combination of possibilities that can be imagined can be built in the human mind.

Finally, as far as [III] is concerned, it can be reminded that, according to Hornstein (1987), it is the most important one. This is so, in his view, because, if its problem is removed, the problems related to [I] and [II] are removed as well. However, whether or not this is correct, the truth is that the explanations above following the mental models theory enable to ignore [III] too. Firstly, if (as shown with the commentaries about the experiment addressed in this section) it is possible until to note the real underlying grammatical relationships that link isolated assertions, it is also possible to be aware of when an incompatibility with the grammar of a specific language exists or the data are equivocal. For instance, the example of [IV] and [VI] is very clear in this way. By the mental process reviewing combinations of possibilities and the phenomenon of modulation, it is not hard to discover that [IV] is not expressed in the best possible way, and that there is no doubt that [VI] is a better alternative. Besides, the theory is able to explain what happens in the human mind even in cases of linguistic messages with equivocal content such as this one:

[X] Peter and John began to run and he fell to the ground.

[X] has equivocal content because it is not clear in it whether 'he' refers to Peter or John. But, according to the mental models theory, any individual can note this because he/she has the cognitive ability to attribute to [X] two alternative iconic models:

[XI.1] Peter and John began to run & Peter fell to the ground

[XI.2] Peter and John began to run & John fell to the ground

So, without further information, people can think that both [XI.1] and [XI.2] are possible for [X] and that, accordingly, this last assertion is not clear.

Of course, similar analyses can be made with other connectives and other types of expressions. In fact, the literature on the mental models theory contains examples of combinations of possibilities and processes of modulation for very different kinds of sentences (see, e.g., the references indicated in this paper). Nevertheless, the point is that the explanations above appear to make it obvious that the limitations and deficiencies related to [I], [II], and [III] can be eliminated if the mental models theory is assumed.

## 5. Conclusions and general discussion

Hence it can be claimed that there is a basically semantic proposal that can solve important difficulties usually linked to the problem of language acquisition. Nevertheless, it is also clear that the mental models theory is not a semantic approach in the exact sense Hornstein (1987) uses that adjective.

As said, following him, the semantic theories are Neo-Fregean, and they differentiate three levels. They speak about a syntactic dimension that leads to semantic elements, to which rules coming from pragmatics are applied. Nonetheless, the rules coming from pragmatics do not have a direct influence on semantics, as the semantic level is independent from contextual variables and, therefore, pragmatics.

Clearly, this is not the structure of the mental models theory. As seen, the important level in this last framework is semantics. In principle, it ignores logical form (even if there are works trying to relate it to syntax; e.g., López-Astorga, 2015). Besides, as also stated, the essentially semantic activity described by the mental models theory can be qualified by pragmatics. In this way, although processes such as the one of modulation are mainly semantic in the theory, this does not mean that they are absolutely alien to pragmatics, and hence contextual variables can have an influence here. Accordingly, it cannot be stated that the mental models theory is one more Neo-Fregean proposal.

So, maybe the most relevant conclusion to draw from this paper can be that to think about a semantic approach to solve the problems dealt with above does not necessarily imply to assume a semantic theory of the kind considered by Hornstein (1987). Other alternatives are possible and what is interesting about the mental models theory is that, in addition, it seems to be consistent with the empirical data reported in most of the experimental researches carried out in cognitive science in recent times. This last point alone already makes it valuable. Nevertheless, although it was neither proposed nor thought with that goal and its interests are initially different, perhaps an unanticipated consequence of it is also, as explained here, that it has the necessary machinery to offer an account of the problem of language acquisition and the difficulties regarding the limitations and deficiencies with which that process occurs, whatever the particular language being learned.

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