1. The inferential process

The correct interpretation of what a speaker meant to communicate through the linguistic stimuli he chose to express requires an inferential ability that lies beyond the grammatical decoding process.

Relevance Theory is a framework for pragmatic-cognitive studies that counts on a careful observation of linguistic inferences. According to the Theory, interpretation of pragmatic inferences must accomplish the following sub-tasks, that develop simultaneously and not consecutively (Sperber & Wilson, 2002a, p. 261):

a. Constructing an appropriate hypothesis about explicit content (in relevance-theoretic terms, EXPLICATURES) via decoding, disambiguation, reference resolution, and other pragmatic enrichment processes.

b. Constructing an appropriate hypothesis about the intended contextual assumptions (in relevance-theoretic terms, IMPLICATED PREMISES).

c. Constructing an appropriate hypothesis about the intended contextual implications (in relevance-theoretic terms, IMPLICATED CONCLUSIONS).

By noting that item "c"'s "implicated conclusions" correspond to the conclusions extracted from the inferential process — and therefore, to a representation of speaker's communicative intention —, it can be assumed that information processed both in sub-tasks "a" and "b" correspond to premises of such inferential computation.

Being so, the explicature level (first sub-task), representing small pragmatic enrichments on sentence's linguistic coded content, enters the inferential process as a verbally explicit data premise, whereas speaker's contextual assumptions (second sub-task) enter the system as a contextual premise.

Therefore, from manipulations on the information made verbally explicit by the speaker and on contextual information (the premises), one can infer conclusions on what the speaker meant with his utterance.

By means of illustration, we might consider the following example:

(1) I finished the chair.

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Although not much of speaker's communicative intention could be extracted from 1)'s logic form, the listener might resort to the sub-tasks in comprehension process described above in order to infer what was meant with the utterance.

Supposing that 1) was uttered by the cabinetmaker in charge of repairing his client's damaged chair, the listener (the client himself) would effortlessly accomplish sub-task "a" by realizing that by "chair" the speaker intended to refer to the particular object their professional relation was motivated by, and not to an administrative position (e.g. chair of Vice-President), for example. Among other explicatures that could be listed as calculated by this listener in 1), we can cite the verb "to finish" having its meaning comprehended as a reference to the event of completing a job pre-ordered to be concluded within an expected time frame.

However, the linguistic explicit data processed in sub-task "a" are not sufficient to lead the listener to the conclusions to be obtained in sub-task "c". Supposing that 1) had been uttered by the cabinetmaker in a phone conversation, it remains required for the client to consider the contextual information that sustains the statement as relevant enough to have been pronounced. Such contextual premise (that results from sub-task "b") could be fulfilled by the understanding that the cabinetmaker was expected to call the client as soon as the chair was ready to be picked up.

Being so, following the inferential process that takes as premises both explicit linguistic content and implicit contextual information, it can be concluded that speaker's communicative intention in 1) was "hidden" in the following implicature: "come pick up your chair!".

2. Scalar implicature

Horn scales (Horn, 1972) comprise terms that share semantic affinities but are distinguishable by their semantic strength (informative degree), in such a way that necessary entailment relations are established from the strong terms (top of the scales) to the weak terms (bottom of the scales).

For example, terms like "all" and "some", respectively the strong and the weak one in a Horn scale, establish a logical relation of entailment: the truth-value of a sentence like 2a) guarantees the truth-value of a sentence like 2b).

(2) a. All the students have arrived.

b. Some of the students have arrived.

On the opposite direction, the truth-value of 2b) cannot assert about the truth or falsity of 2a), since the weak term, in its logical-semantic connotation, limits its scope of information to the pertinent quantity of "some". Tracing a lower limit of semantic strength to be interpreted and keeping the stronger terms still potentially acceptable, such logical-semantic understanding of weak terms is frequently referred as lower-bound. The lower-bound interpretation of "some" can be paraphrased as "at least some and perhaps all".
Scalar implicatures are pragmatic interventions on the logical-semantic meaning of weak scalar terms that provide these terms with upper-bound interpretations. Being so, in scalar implicature contexts, weak terms like "some" in 3) don't communicate potential compatibility with their correspondent strong terms (e.g. "...and perhaps all") but reject them through direct implicated denial.

(3) A: — Did the students arrive?
   B: — Some of them did.

Scalar implicatures scope is not restricted to canonical Horn scales. The same effect of denial of a more embracing term, gesture or event can be found in particular contexts that would relate only indirectly or metaphorically to concepts like "scalar", "strong term" and "weak term" (see Hirschberg, 1985).

(4) A: — Did you clean the house?
   B: — I cleaned the room.

(5) A: — Did you prepare dinner?
   B: — I lighted the oven.

According to Relevance Theory, the concept of scalar implicatures can be more accurately defined as describing

just cases where there is an explicit or implicit question as to whether the use of a more informative expression than the one employed by the speaker (e.g. "all" instead of "some") would have been warranted, and in such cases, a denial of a more informative claim can indeed be implicated by the use of the less informative expression. (Noveck & Sperber, 2007, p. 11)

Returning to the sub-tasks model of inferential comprehension seen in section 1, the entering of the literal/semantic content of the weak term in the inferential process can be located in sub-task "a" (the one who deals with verbally explicit content); the identification of a contextual question about the applicability of a stronger term would operate in sub-task "b"; and the inference of the speaker's communicative intention of denying the strong contextual term though the verbalization of the weak term would have place in sub-task "c".

Therefore, the interpretation of scalar implicature given to the weak terms in 3), 4) and 5) is product of the recognition of the verbal premises (the weak terms made explicit), of the contextual premises (questions implying "all the students", "the whole house" and "the whole event of preparing the dinner"), and, finally, of speakers B's intended implicatures.
3. Acquisition of scalar implicature

The direct association between the literal/semantic perspective of weak scalar terms and their lower-bound interpretation and between the pragmatic enrichment of such terms and their upper-bound interpretation made popular experiments on acquisition of scalar implicature as instruments of observation of pragmatic maturation in children.

The relevant works for the purpose of this study will be submitted to brief critical analysis before we present our own experimental contribution.

3.1. Are children more logical than adults?

Noveck's (2001) "When children are more logical than adults" is one of the most influent studies on acquisition of scalar implicature.

In one of the study's experiments, three boxes were presented to children aged between 5;1 and 9;5 acquiring English, being two of them open and one of them closed. One of the open boxes contained a parrot and a bear and, the other one, only a parrot. Based on the information that the closed box had the same content as one or another of the open boxes, participants had to judge the statement "there might be a parrot in the [closed] box" as true or false.

Considering that there were parrots in both of the open boxes and that the closed box had the same content as one of them, the presence of a parrot in the closed box was a logical necessity, and therefore the statement "there must be a parrot" and not "there might be a parrot" would be the most accurate one concerning the content of the closed box.

Being so, the acceptance of the sentence with the weak term by participants would indicate a lower-bound interpretation given by them, in which the logical-semantic meaning of "might" is not incompatible with the more informative alternative "must"; whereas the rejection of the sentence would indicate its upper-bound/scalar implicature interpretation, in which the weak term implicates the denial of its correspondent stronger term.

The results showed that the sentence was accepted by 72% of the 5-year-olds, 80% of the 7-year-olds and 69% of the 9-year-olds. Only 35% of the adults tested as control group had the same reaction.

The surprising suggestion that even 9-year-old children do not achieve adult rates of upper-bound comprehension of weak scalar terms is justified by Noveck through a hypothesis of pragmatic delay, according to which certain pragmatic milestones required for scalar implicature calculation are not yet fully developed in children.

Subjects predominantly logical-semantic (lower-bound) interpretation of weak scalar terms made the author propose that children are "more logical than adults" in this case.

Resorting to the inferential model applied to the extraction of scalar implicatures presented in section 2, the following critical observation can be elaborated concerning Noveck's three boxes experiment: the strong alternative
"there must be a parrot") was presented as the result of a logical consequence reasoning, which might have blocked children's access to the contextual premise of the inferential process, the one corresponding to the strong contextual term to be denied by the verbally expressed weak term.

By asserting that the closed box had the same content as one or another of the open boxes, the experimenter could only suppose that participants were able to successfully infer a "must" from such logical equation to be contrasted with the uttered weak term. Therefore, instead of having demonstrated inability with the inferential process that leads to scalar implicature extraction, the children tested by Noveck (2001) might not have had access to one of the premises that were supposed to feed such inferential process due to the indirect form in which it was provided.

Further evidence for our proposal will be found in the studies that follow. We end this subsection by pointing out that if our proposal is correct and children in Noveck’s study failed in scalar implicature computation because the strong relevant term was "encoded" as the result of a logical consequence reasoning, then children failed for being less logical and not more logical than adults, as suggested by the author.

3.2. The naturalistic environment for scalar implicatures

Papafragou & Tantalou (2004) tested children from 4;1 to 6;1 acquiring Greek. A set of animals that was supposed to fulfill different tasks was presented to participants. Children were asked to give each animal a prize only if they considered that the assigned tasks were successfully fulfilled.

After having performed the assigned activity out of the child's sight, the animal was asked by the experimenter if the task was accomplished — in a question that suggested but not made explicit the strong scalar term —, and the animal's answer contained the correspondent weak term. Therefore, if the tested child did not give the prize to the animal, a scalar implicature interpretation would be indicated, since the weak term uttered in animal's answer would have been comprehended as a confession of non-accomplishment of the stipulated goal (represented by the strong term denied through implicature).

The experimental material was composed by quantificational scale (<all, some>), encyclopedic scales and ad hoc scales, that was respectively included in dialogues as the following examples show:

(6) Experimenter: — Did you color the stars?
   Elephant: — I colored some.

(7) Experimenter: — Did you eat the sandwich?
   Bear: — I ate the cheese.

(8) Experimenter — Did you wrap the gifts?
   Cow: — I wrapped the parrot.
The results showed that 77.5% of the children did not give the prize to the animals when sentences with quantificational terms were uttered, 70% when sentences contained encyclopedic weak terms and 90% when the relevant scale was *ad hoc*.

Papafragou & Tantalou (2004) attributed their success in inducing scalar implicature calculation in children to the naturalistic conversational environment that the experiment was able to simulate, in which pragmatically justified dialogues resulted in denial of the strong terms clearly implicated in the questions by the weak terms in the answers. Consequentially, children's failure in scalar implicature calculation suggested by previous studies (like Noveck (2001)) would be due to pragmatic infelicities originated from methodological lapses.

Observing Papafragou & Tantalou's (2004) impressions through the perspective of the inferential model proposed in our first and second sections, more evidence can be collected in favor of the critical analysis that we did for Noveck's (2001) experiment. If it is true that children failed in interpreting scalar implicature in the three boxes experiment due to their incapacity of converting the logical contextual formula into contextual premise (the strong term) to be included in the inferential process, then it was predictable that a methodological facilitation to the access to such premise would result in higher rates of successful pragmatic operations.

Among the other occasions on which Papafragou returned to the topic of acquisition of scalar implicatures, Skordos & Papafragou (2016) is the one that deserves to be highlighted for the purposes of this work. By exploring the necessary conditions of accessibility of the strong contextual terms in order to make children give upper-bound interpretation to weak terms, the authors demonstrated that the mere presence of the strong terms in the experimental contexts was not enough, and that in order to be perceived by children as the strong scalar alternatives, they had to be presented as relevant scalar contrasts to the weak terms.

Being so, it seems that scalar implicature calculation as the conclusion of an inferential process is conditioned to a clear access to the contextual premise for children. For them, the interpretative process goes beyond the level of explicatures (in which the lower-bound literal interpretation is generated) only when the strong contextual alternative is distinctively perceived as an information worthy of consideration along with the verbal premise.

### 3.3. Scalar implicatures and logical reasoning

Our experiment was designed with the purpose of testing children's ability to infer both scalar implicatures and missing pieces of contextual information.

Matching Noveck's (2001) age selection of participants, our subjects were 5-year-olds (14), 7-year-olds (26) and 9-year-olds (26) acquiring Brazilian Portuguese as their first language. 22 adults formed the control group. This was the first experiment on acquisition of scalar implicature conducted with Brazilian Portuguese speakers.
A puppet who loved to listen to stories was presented to participants. Children was informed by the experimenter that the puppet was very forgetful, although he claimed to have an excellent memory. Therefore, participants were requested to help to verify if the puppet remembers the stories that he listens to. At the end of each story, a question concerning it was made to the puppet and it was the subject's task to judge puppet's answers correct or false.

Twenty-four stories were told to participants. In half of the stories, maximum scalar values were displayed as unreached goals, e.g. only two out of the three boys of the story had lunch (context 1). The other half of the stories focused on lower-limit scalar information, without contrasting it with maximum scalar values, e.g. Felipe did the two first exercises (without mention of the others) (context 2).

In contexts 1, puppet’s answers to experimenter's questions contained the relevant weak term (e.g. "some of the boys had lunch"), and its acceptance by children would indicate scalar implicature computation (upper-bound interpretation), since the denial of the strong term implicated by the weak one is imperative for the sentence to match with the story's sense of unreached goal.

In contexts 2, puppet's sentences contained a lower-bound statement (e.g. "Felipe did at least some of the exercises and perhaps all") that required inference of the logical consequence "...and perhaps all", omitted in the story but logically correct. Being so, whereas the "possibility of being all" must be rejected through scalar inference in order for puppet's answers to be acceptable in contexts 1, the "...and perhaps all" made explicit by the puppet in contexts 2 must be compared with an inferred informative gap of the context (story), to be accessed through logical reasoning.

The structure of experimenter's questions to the puppet in contexts 1 was inspired by Papafragou & Tantalou (2004), in such a way that the relevant strong term is suggested but not made explicit (e.g. "did the boys of the story have lunch?"), whereas the questions elaborated for contexts 2 reinforced the lower-bound contextual environment by suggesting the requirement of a lower limit of information ("e.g. were there any exercises that Felipe did?").

Distractive sequences of experimenter's question and puppet's answer were randomly distributed among the test sequences. Distractive puppet's statements concerned trivial facts narrated in the stories. In order to control for yeas bias, most of distractive puppet's answers were false.

The following examples are representative of experiment's contexts 1 (upper-bound) and contexts 2 (lower-bound), respectively:

(9) **Pedro had two brothers. He wanted to play outside but he knew his mother would only allow him and his brothers to play after he and his brothers had lunch. But Pedro wasn’t hungry and only his brothers had lunch. Thus, neither he or his brothers could play outside.**

Experimenter: — Did the boys of the story have lunch?

Puppet: — Some of the boys had lunch.
Felipe was struggling with his math homework and he asked his father for help. However, Felipe’s father was busy and couldn't spend much time teaching his son. After seeing that Felipe had gotten the two first exercises right, his father thought he could leave the boy alone with the other exercises.

Experimenter: — Were there any exercises that Felipe did?
Puppet: — Felipe did at least some of the exercises and perhaps all.

As depicted in figure 1, children showed much higher rates of acceptance of puppet's answers in contexts 1.

![Figure 1: acceptance (%) of puppet's answer.](image)

Table 1: p-value between conditions. Fisher's exact test (significance 0.05).

<table>
<thead>
<tr>
<th>Age Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-year-olds</td>
<td>0.0274</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>0.0001</td>
</tr>
<tr>
<td>9-year-olds</td>
<td>0.0459</td>
</tr>
<tr>
<td>Adults</td>
<td>0.9010</td>
</tr>
</tbody>
</table>

Children's behavior in contexts 1 indicates their ability to extract scalar implicatures when the strong alternatives to be denied by the weak terms are clearly presented as contextual premises. These are results that corroborate Papafragou & Tantalou's (2004) findings.
4. Pragmatic and contextual inferences

As explained in the previous section, stories elaborated as contexts 2 did not present upper quantificational or action/event limits, but only information representative of the bottom segment of the scales. For example, in 10), Felipe's difficulties with his homework are suggested to be solved by the intervention of his father, who helped him with the two first exercises, in such a way that a satisfactory outcome was achieved even in the absence of information about a quantificational goal having been reached or not. Therefore, the "and perhaps all" part of puppet's statement does not correspond to any explicit reference in the story, what allegedly provoked children's high rates of rejection of such statements.

Being so, the following observations on children's reactions can be made: if it is true that many of the participants showed difficulty with the "and perhaps all" segments due to the absence of direct correspondent references in the stories, then a symptom of a child inability to infer non-explicit pieces of information is suggested. On the other hand, the verified ability of the subjects to calculate scalar implicatures in contexts 1 points to the opposite conclusion, since they were able to infer non-explicit information in such experimental condition: the denial of contextual strong terms by the pronounced weak terms.

In order to propose a solution to this apparent contradiction, the conceptual distinctions between pragmatic inferences and contextual inferences must be highlighted.

As detailed in section 1, the purpose of the pragmatic inferential process is that of revealing to a listener the intention that a speaker meant to convey through his linguistic utterance. Therefore, if the intended meaning of "some" is an implicated denial, the own comprehension of the sentence depends on interpreter's pragmatic inference ability.

On its turn, in order to realize that from a story in which a boy made the two first exercises we can extract as a logical consequence the information that the other exercises might have been done as well, no intention-reading is required. The communicative interaction between the storyteller and the audience is successfully completed once the utterances are corrected comprehended, whereas contextual inferences can be characterized as logical relations that in this case operate on the retained linguistic information and, therefore, take place after the linguistic comprehension.

Being so, implicatures belong to the pragmatic inferences category, given that manipulations on the verbal and contextual premises lead to the fulfillment of the informational gap corresponding to speaker's communicative intention, whereas contextual inferences are dedicated to the fulfillment of informational gaps concerning particularities of situations referred by language, but not the linguistic interpretation itself.

It can also be assumed that the derivation of implicatures counts on destabilizations of meaning promoted by the entering in the process of the contextual premises: being framed in particular contexts, the purely logical-semantic meanings (by then enriched only by explicatures) might not present
themselves as the most relevant or adequate ones anymore. Meanwhile, no contextual premises that trigger any consistent interpretative revision of a verbally codified meaning can be found in statements like puppet's answer in contexts 2 ("Felipe did at least some of the exercises and perhaps all"). In such cases, the interpretative process is completed without the extraction of implicatures, and any search for contextual informative gaps (like the matching with the story of the "and perhaps all" segment) happens already as a contextual inference.

Returning to Noveck's (2001) experiment, we can identity in it both of the categories of inferences acting sequentially to achieve the implicature computation. As detailed in subsection 3.1, the interpretation of the sentence containing the term "might" was expected to take into consideration the informative contrast between this weak term and the strong term resulting from the logical equation concerning the content of the closed box. That is to say that in order to be activated, the pragmatic inferential process needed to be fed with a contextual premise (the strong term) that already was, in its turn, the result of another inferential process: a contextual inferential process about the experimental material (the three boxes).

Our experiment, on the other hand, provided us with the opportunity of observing participant's behavior with each type of inference separately, in such a way that the eventual failure in one of them would not compromise the performance with the other. Thus, in contexts 1, elaborated as upper-bound linguistic environments, mastering of the pragmatic inference process that leads to the extraction of scalar implicatures by children was indicated (corroborating with Papafragou & Tantalou (2004)), whereas much poorer performance was found in contexts 2.

Being so, if not even the 9-year-olds tested by Noveck (2001) demonstrated ability with the required contextual inference, it could be expected that not even the 9-year-olds tested by us would succeed in the same type of inferential processing.

It is not the proposal of this work to discuss if it is more remarkable — and therefore more worthy of future research — that 4-year-olds already master linguistic inferences (according to Papafragou & Tantalou (2004)) or that 9-year-olds are still unable to resolve certain contextual inferences. However, we believe that a fundamental and exclusive component of linguistic inferences that deserves mention is the mindreading: the overdeveloped human species' ability to recognize other people's intentions.

From any theoretical perspective, the linguistic pragmatics must always consider, to some extent, the themes of intentionality and intention-reading, already present in its seminal work: "Meaning" (Grice, 1957). In order to consider a interlocutor to be cooperative — in Griceans terms — or their utterances to be relevant — in Relevance Theory terms — the intention to communicate and to be comprehended needs to be recognized as carried by the speaker's verbal expression. Returning the focus to the present work, we can propose that the interpretative process that leads to the extraction of implicatures
would not even be activated if the existence of a communicative intention to be inferred was not assumed by the listener.

An investigation that takes this portion of human cognition into primary account might lead us to conclude that linguistic inference skills could not take long to mature in children. We know, for example, that newborns already devote a high proportion of their attention to human faces and voices (Baron-Cohen (1995)), that in the first year of life we are already able to turn our attention to pointed or stared objects (Tomasello et al. (2005)) and that, in the second year, we tend to imitate other people's intentional gestures — but not accidental ones (Carpenter, Nagel & Tomasello, (1998)).

Papafragou (2001), revolving around the close relationship between mindreading and linguistic computation, highlights the precocity of this cognitive interaction, traceable in rudimentary implicatures such as indirect requests for action, already comprehended and produced by 2-year-olds.

Approaching the theme through a different perspective, Relevance Theory addresses the extraordinary human ability to recognize communicative intentions in modular terms. Understanding by ostensive stimuli all communicative acts that the receiver perceives as carriers of intentions to be inferred (the use of languages being the most important) and that set his interpretive process in motion immediately and automatically, Sperber & Wilson (2002b, p. 28) propose:

This procedure, although simple to use, is neither trivial nor easy to discover. So how can it be that people, including young children, spontaneously use it in communication and comprehension, and expect their audience to use it as a matter of course? Our suggestion has been that relevance-guided inferential comprehension of ostensive stimuli is a human adaptation, an evolved sub-module of the human mind-reading ability.

5. Conclusion

Considering that weak scalar terms can be comprehended according to their lower-bound/logical meanings or their pragmatic enriched (upper-bound) meanings, experimental studies on the subject offer the possibility of evaluating participant's transition between logical/literal and inferential processes of linguistic interpretation.

However, slight methodological lapses might lead to misleading conclusions concerning the opposition between logical or pragmatic interpretation and this seems to be the case in Noveck (2001): strong contextual terms were presented as the result of a logical equation about the experimental material and not clearly presented as contextual alternatives, as in Papafragou & Tantalou (2004), among others studies that were successful in demonstrating children's ability in scalar implicature calculation.

Based on Relevance Theory's sub-tasks of the comprehension process, we assumed an inferential model composed by a verbal premise (the explicit verbal
content), a contextual premise (relevant contextual information being considered by the speaker) and a conclusion (speaker's communicative intention). In these terms, children's access to the contextual premise might have been blocked in Noveck's (2001) experiment if they were not able to solve the contextual logical problem about the content of the closed box. If that was the case, then children failed in scalar implicature interpretation for being less logical and not more logical than adults, as suggested by the author.

We ran an experiment with the purpose of testing children's ability to infer both scalar implicatures and missing pieces of contextual information through logical reasoning. The results corroborated previous studies (e.g. Papafragou & Tantalou (2004) and Skordos & Papafragou (2016)) by indicating children's ability to extract scalar implicatures in adequate contexts and reinforced our hypothesis on children's difficulty with inference of certain contextual non-explicit but logically correct information.

Being so, children's mastery of pragmatic inferences like scalar implicatures points to an advanced development of communicative intention-reading even in early ages, in contrast with the difficulty with logical consequence reasoning presented even by the 9-year-olds tested by us and, we believe, by Noveck (2001).

References
