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# Effect of theory of the mind on the pragmatic reasoning of scalar implicatures<sup>1</sup>

Efecto de la teoría de la mente en el razonamiento pragmático de implicaturas escalares

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## ABSTRACT

*Background:* Different authors argue that for pragmatic reasoning can occur, it is necessary to activate a mental module that allows reasoning about the mental states of oneself and others, this is known as theory of mind. However, the empirical evidence is not conclusive. *Objective:* We investigate the effect of the theory of the mind on the pragmatic reasoning of scalar implicatures, these are a special type of pragmatic inferences based on the linguistic expression "some". *Methodology:* For this, a 2x2 within-subject experimental design was carried out with a sample of 111 individuals between 20 and 45 years of age. Mentalistic and non-mentalistic stimuli were presented, and then the accuracy and speed of response was measured according the sentence verification task. *Results:* Significant differences were found in the response time of pragmatic sentences to mentalistic stimuli versus non-mentalistic stimuli. *Conclusions:* This allows us to infer that the theory of the mind plays a significant role in pragmatic reasoning, thus supporting the postgricean approach.

**Keywords:** Cognition, language behavior, psychological effects, psycholinguistics.

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## RESUMEN

*Antecedentes:* Diferentes autores discuten que para que el razonamiento pragmático pueda ocurrir, es necesaria la activación de un módulo mental que permite razonar acerca de los estados mentales propios y de los demás, esto se conoce como teoría de la mente. Sin embargo, la evidencia empírica no es concluyente. *Objetivo:* Determinar el efecto de la teoría de la mente en el razonamiento pragmático de implicaturas escalares. *Metodología:* Mediante un diseño experimental intrasujeto 2x2 se evaluaron 111 individuos entre 20 y 45 años edad. Se les presentaron estímulos mentalistas y no mentalistas y se midieron los tiempos de respuesta y la precisión de esta según la tarea de verificación de oraciones. *Resultados:* se encontraron diferencias significativas en el tiempo de respuesta de oraciones pragmáticas de acuerdo con la presentación de estímulos mentalistas vs no mentalistas. *Conclusiones:* Esto nos permitió inferir que la teoría de la mente cumple un rol significativo en el razonamiento pragmático, apoyando así el enfoque postgriceano.

**Palabras clave:** cognición, comportamiento lingüístico, efectos psicológicos, psicolingüística.

## INTRODUCTION

This article seeks to test the hypothesis that the theory of the mind (ToM) has effects on pragmatic reasoning, one of the cognitive processes associated with language. It has been postulated that for an individual to process pragmatic information it is a necessary condition that a mental module linked to the reasoning of the mental states on oneself and on others be activated (Sperber & Wilson, 2002), this is known as the theory of mind. Despite the conceptual argumentation, the empirical evidence is not conclusive against this effect, there are several investigations that have established mainly that there is a relationship between theory of mind and pragmatics but neither the explanatory specificity, nor the phenomena surrounding the pragmatic interpretation are completely clear.

While there is an increase in empirical research in pragmatics, it is necessary to go further in the cognitive and neurological processes that influence the use of utterances in contexts.

One of the most studied cases is the pragmatic interpretation of scalar implicatures (Noveck & Sperber, 2007; Bonnefon, Fenney & Villejoubert, 2009; Lopa de Carvalho, 2012), this is, the phenomenon that shows the tendency to interpret the

existential quantifier "some" as the negation of the universal quantifier "all". For example: Some psychology students learn about statistics.

There are two types of interpretation for scalar implicatures: the *narrow* interpretation and the *broad* interpretation. In the *narrow* interpretation, the quantifier "some" leads to understand "not all", while in the *broad* interpretation it is understood as "possibly all".

According to Grice (1989), most adult speakers make the interpretation of the sentence as " **not all** students of psychology learn about statistics" instead of " **Possibly all** students of psychology learn about statistics". The above, explained the author, happens because speakers use the maxim of quantity in their sentences because it is the only epistemic state they have. Saying "all" implies that the speaker knows that all students learn about the subject, as it is not so the listener interprets "not all".

From a theoretical perspective, there are two approaches that explain this phenomenon: the *general* and the *particular*. The first postulates that inference is an implicature interpreted by default and that it is canceled in some contexts (Levinson, 2000); the second argues that implicatures are a pure function of context (Sperber & Wilson, 1995). As proof of this, the particular approach shows that broad interpretations should be quicker and easier to interpret because they tend to be wrong, this position has had enough support (Bott & Noveck, 2004; Noveck and Posada, 2003; De Neys & Schaeken, 2007; Breheny, Katsos & Williams, 2006).

To further expand this approach, Bonnefon et al (2009) indicate that interpretation should be faster when the specific interpretation is inappropriate to the context. This is how the importance of context in these interpretations is strengthened. Bonnefon et al (2009) and Bonnefon, De Neys and Feeney (2011) found that Face-Threatening Context increase the broad interpretation, changing the trend toward specific interpretation. The explanation for this is that the receiver considers the possibility that the speaker wants to be kind. They also found that, in these cases, specific interpretation requires less time and effort than broad interpretation.

From the perspective of the theory of relevance, it is explained that the specific interpretation is not optimally relevant for the receiver in the situations of face threatening and that it is precisely the broad response that obtains optimal relevance since it is the answer that is contextually appropriate (Bonneton et al., 2011).

This modification of the interpretation according to the context specifically emphasizes an interpersonal context, where there is an emotional affectation in the receiver, which shows that it is not only a modification of a general context but a modification of mental states, leading to the question by the processes that are at the basis of this pragmatic interpretation.

Sperber and Wilson (2002) pointed out that what underlies pragmatic interpretation is the recognition of intentions. Accordingly, the pragmatic interpretation is ultimately an exercise in metapsychology (p. 7). Although the relationship between cognitive and pragmatic factors is not entirely clear, nor specific, a capacity is needed in the interlocutors to understand what their counterpart intends to say (Astington & Baird, 2005), it is not only to reveal the direct meaning of the sentence (the semantic), but the other aspects that accompany this meaning, such as cultural, social, affective, among other aspects. This capacity has been called in many ways, named as intersubjectivity, social perception, social intelligence, perspective taking, attribution of mental states, reasoning of desires, meta-representation, understanding of false beliefs, mentalism, mentalist capacity or theory of the mind (Astington & Baird, 2005, p.5), always considering that there is a close link between this capacity and language. However, language has multiple components (such as phonetics, syntax, and semantics) and the specific role of mentalist capacity in linguistic processes is not delimited. There are even developments that address the need for language for the development of the theory of mind and vice versa (Astington and Baird, 2005; San Juan & Astington, 2017; Westra & Carruthers, 2017).

Sperber and Wilson (2002) add that the “interpretation of communicative behaviors is mediated by the attribution of an informative intention” and suggest that this pragmatic processing is supported by a specific cognitive module (p.15). Such a module would be theory of mind (ToM), however, clarified that it could not be a more specific module within the complexity of mindreading general ability (Wilson, 2012), but even suggest that a good

candidate for this sub-module would be the ability to infer what people are seeing from the direction of their gaze.

Horton and Brennan (2016) also establish an important role for this skill in referential expressions in the context of a conversation. They say that this mentalistic information is simple and subject to the same aspects that define the attention and memory that influence other types of cognitive representations.

This reasoning has had empirical evidence with the study of Southgate, Chevallier and Csibra (2010), in which they found that children of 17 months old were able to recognize the epistemic states of the communicator and that they used this to infer what they were trying to refer to. In addition, they managed to show that this interpretation of the pragmatic was not due to other aspects such as the literal interpretation of the sentence.

Wampers, Schrauwen, De Hert, Gielen and Schaecken (2018) also found similar evidence with patients with psychosis. When separating patients into two groups according to ToM ability, they found that the group with the best ToM had better ability to derive scalar implicatures. Similar findings were reported in Schaecken et al (2018), Mazzaggio & Surian (2018) and Mazzaglio, Foppolo, Job and Surian (2019).

However, there are also counterclaims in which it is stated that pragmatic processing without theory of the mind is possible (Chevallier, Wilson, Happé & Noveck, 2010; Hochstein, Bale & Barner, 2018; Kissine, 2016, p.4). In addition, it presents evidence that people with autism spectrum disorders could interpret different sentences pragmatically (van Tiel & Kissine, 2017). The explanation for this is that there would be three strategies to achieve pragmatic interpretation (Kissine, 2016): egocentric relevance, allocentric relevance and sophisticated interpretation or “Gricean”. In the first, the theory of the mind would not be necessary, while in the others it would be necessary. In the egocentric, only content limited to primary meanings, material implications and some indirect speech acts would be needed.

It could also be understood from the theory of two levels of Recanati (2004) in which it establishes primary and secondary pragmatic processes, for the primaries the theory of mind would not be needed. These would be based on lexical items subject to

saturation, enrichment, loss, or free transfer. It also states that secondary processes are based on the former.

There is thus inconsistent evidence about the role of the theory of mind in the pragmatic reasoning of scalar implicatures, this study seeks to test the hypothesis that the theory of the mind has effects on such reasoning.

This leads to the consolidation of the following research question: What is the effect of the theory of the mind on the pragmatic reasoning of scalar implicatures?

This research allows provide explanations on the development of language in its pragmatic dimension. Also achieve more joint appearances in linguistics and cognition, where they could understand much better the interaction between theory of mind, pragmatic, and communicative aspects (Bosco, Tirassa & Gabbatore, 2018).

This characteristic could be exemplified by addressing multiple contexts such as education, politics, business, among others, where problems can be observed in communication processes, both from production, as well as the understanding of what was transmitted. In these problems, it is possible to understand what was affected within the communicative process, such as the channel, the transmitter, the receiver or even, if it were too much noise (Shannon, 1948); in addition, it is possible to delve into each of the above aspects, which would allow studying processes such as semantics or pragmatics. Beyond these dimensions of language, there would be other processes such as the theory of the mind, which has established itself as one of the most solid phenomena to explain human social behavior in general (Gazzaniga, 2010).

Establish these relationships and the effects of theory of mind in the pragmatic reasoning, positive repercussions in the field of cognitive science, not only seeks to understand a phenomenon in a particular discipline such as linguistics, but in phenomena other links disciplines of the cognitive sciences, in particular cognitive psychology. In this sense, it is not only using methods or techniques from other areas, but also the relationships between different phenomena that have traditionally been disconnected.

However, this research not only generates contributions to the issues or disciplines immersed there, but could generate significant contributions to society, since the possibility of explaining pragmatic aspects enables the subsequent understanding of multiple communicative processes, with the possibility of intervening specific problems or strengthen these processes. In the case of the problems, one could intervene both superficially and deeply, depending on the present difficulty; in the case of empowerment, strategies such as a speech could be improved, making the lecturer more attractive; a therapeutic dialogue, intentionally improving the patient; or even an advertising phenomenon, making the product more pleasing to consumers.

## **METHODS**

### **Design**

This is a quantitative research with a within-subject experimental design. We consider the pragmatic reasoning of scalar implicatures as a dependent variable and theory of mind as independent variable.

### *Participants*

In this within-subject experimental design we selected the population of adults between 20 and 45 years old from the city of Medellín (Colombia) and its area of influence which is estimated at approximately 1031840 people. This population is object of study considering that it is the rank where there is greater cognitive maturation. It is estimated that at approximately 20 years old, basic cognitive processes are consolidated and, starting at age 45, cognitive decline begins (Salthouse, 2009).

The sample was calculated using the software G\*Power version 3.1.9.2 and was carried out according to the size of the *a priori* effect where it is established that you want to have a medium high effect size (0, 4 and up). This indicated a sample of 111 individuals. The data specified were the following:

**F tests - ANCOVA:** Fixed effects, main effects, and interactions



**Analysis:** A priori: Compute required sample size

<b>Input:</b>	Effect size $f$	= 0.4
$\alpha$ err prob	=	0.05
Power (1- $\beta$ err prob)	=	0.80
Numerator df	=	10
Number of groups	=	2
Number of covariates	=	1
<b>Output:</b>	Noncentrality parameter $\lambda$	= 17.7600000
Critical F	=	1.9194667
Denominator df	=	108
Total sample size	=	111
Actual power	=	0.8032763

### **Selection criteria**

For a person to be included in the study, they should not have cognitive impairment or develop mental disorders. In addition, they had to express their voluntary participation in the study. This information was discriminated through questions about the history of mental disorders and through the Montreal Cognitive Assessment (MoCA) when cognitive problems were suspected (Pedraza, et al., 2016).

### **Materials**

*Sentence Verification Task* (De Neys & Schaeken, 2007). The participants had to answer in a dichotomous way (false / true) for 10 underinformative sentences. The content of these sentences refers to categories and examples (for example, some "exemplar" are "category"). As other studies (Bott & Noveck, 2004; De Neys & Schaeken, 2007), no specific interpretation was imposed. The only instruction is that they respond according to what they believed in the sentence. The e-prime 3.0 software was used for the presentation of the

experiment and the answers were given with the numeric keypad (1 for true and 2 for false).

The participants also had to judge 10 trials in which clearly true sentences were presented (example: some birds are eagles) and clearly false (example: some tigers are fish). Both types of sentences were randomly presented. Participants were presented with two groups of verification tasks (10 underinformative and 10 filler sentences), one with the presentation of theory of mind and another without theory of mind. All trials in a counterbalanced situation and with an equal number of presentations.

Some words were modified to be related to the cultural context, for example, carps (*carpas*) are not common fish in Colombia, so the term catfish (*bagre*) was used.

## **Design and procedure**

The within-subject experimental study had the following considerations:

- The participants were evaluated with the sentence verification task and were exposed to two types of stimuli: mentalists and non-mentalists.
- All the sessions had the same structure, they began with a demonstration of the task and two practices were carried out, one with a mentalist stimulus (i.e. Peter thinks that the cat is happy) and the other with a non-mentalist stimulus (i.e. The cat is black). The instructions indicated that it was very important to perform this task correctly.
- In the non-mentalist stimulus, we began with a brief presentation whose duration was 800 ms, afterwards, the sentence verification task was presented and remained on the screen until the participant gave a response.
- As for the mentalist stimulus, the participants were presented for 800 ms and then a question of the verification task was presented.
- The scheme of the experiment was as follows in figure 1:

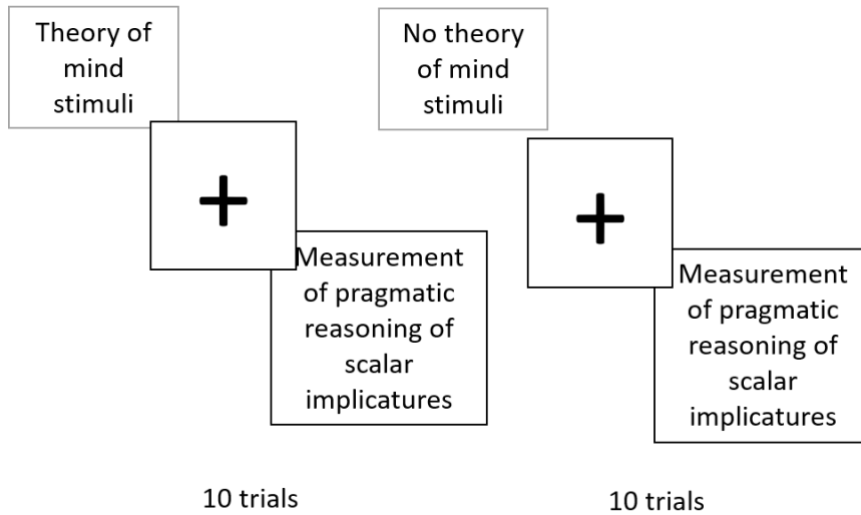


Figure 1. Experiment scheme.

Source: Authors

### **Ethical considerations**

According to the Colombian law 1090 of 2006 that establishes the ethical guidelines for psychological research in humans, this investigation fulfilled all the necessary requirements to prevent a person from being violated in his dignity. For this there are several controls:

1. Explanation of the purpose of the study.
2. Signature of informed consent.
3. Maintenance of anonymity.
4. Contact by the researcher in a situation previously authorized by the doctoral group or whoever performs the times to control the research of the doctorate in cognitive sciences.

In addition to this, all the components stipulated by the current law were contemplated.

## Statistical analysis

According to the methodological design, the comparison analysis of two groups with the Fisher's F test was carried out using the ANCOVA procedure. This analysis was performed with the SPSS 25 software. Post hoc test was performed with JASP 0.13.1.

## RESULTS

It was found that pragmatic sentences differ very little in the average response time according to the presence of a mentalist stimulus, that is, when there is a mentalist stimulus the response time is greater (table 1); however, in the standard deviation the value is lower when there is a mentalist stimulus. From these data, it was found that there are no effects of the theory of the mind on the pragmatic reasoning of scalar implicatures,  $F(1, 1876) = 1.925$ ,  $sig = 0.165$ , implying independence of one variable over another.

However, it is necessary to separate the speed of reasoning from the accuracy of the answer (Bott, Bailey, & Grodner, 2012), which is why only an analysis of the response times was carried out only when the answer was correct as in Bott et al paper (ibid). In this case, a significant effect was found,  $F(1, 933) = 6.109$ ,  $sig = 0.014$ ,  $\eta^2 = 0.006$ ,  $Power = .899$ , showing influence of the theory of the mind on the pragmatic reasoning of scalar implicatures. Consistent with this finding, response times in pragmatic reasoning decrease in the presence of a mentalistic stimulus and the standard deviation is reduced, indicating a decrease in the variability of speed reasoning (Figure 2). Post hoc comparison using the Holm test indicated that the mean score for mentalism condition prime was significantly than the no mentalism condition,  $t = 2.338$ ,  $p_{Holm} = 0.039$ .

Table 1

*Means of response times of underinformative sentences*

Type of response	Stimuli	Mean	Std. Deviation	N
True	NoToM	2428,89	1100,314	406
	ToM	2676,57	1352,923	385

	Total	2549,44	1235,204	791
False	NoToM	4087,65	1650,676	54
	ToM	3524,47	1830,188	81
	Total	3749,74	1775,989	135
Total	NoToM	2623,61	1291,736	460
	ToM	2823,95	1480,302	466
	Total	2724,43	1392,692	926

Source: Authors

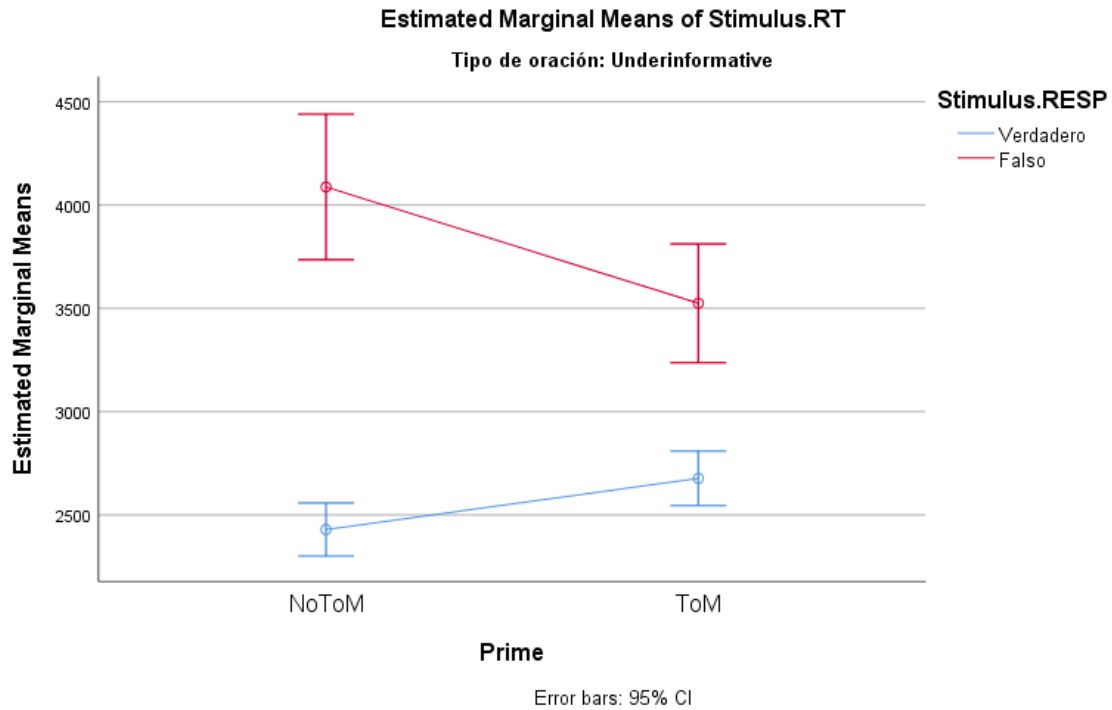


Figure 2. Response times of underinformative sentences.

Source: Authors

## DISCUSSION

This finding confirms the previous hypothesis of the effect of the theory of the mind on the pragmatic reasoning of scalar implicatures, giving support to the relevance theory of Sperber and Wilson (2002). By requiring an additional processing module, the cognitive

process is more delayed but optimal, that is, the greater time necessary for the processing of information is what would guarantee the appropriate response in the context.

This could be complemented with the lexical access hypothesis, in this case, it is established that the scalar implicatures are associated with a cost in the processing because their computation includes a parameterization of the available lexicon (Wampers et al., 2018). If this is the case, it is predicted that the processing cost disappears in situations in which the relevant parameters are clear, and, on the other hand, the processing cost increases in situations where the parameters are not completely clear, as in mentalist situations. The previous hypothesis would explain the finding of the decrease in response time in filler sentences; this is that since the parameters are completely clear and evident, the processing of the information decreases considerably.

The support of the relevance theory means that Levinson's neo-gricean approach is discarded in the context of the present investigation; the default interpretation would not imply effects of the theory of the mind on the pragmatic reasoning of scalar implicatures. However, Mazzarella (2015) says that the longer response time would be explained by both the default approach and the relevance theory, it says in relation to image threat contexts associated with courtesy, although it is not strictly speaking theory of the mind, it involves considering mental states of the speaker or issuer.

This work could controvert the work of Kissine (2016) and Recanatti (2004), in which different levels of pragmatic processing function need not theory of mind in the most basic levels of processing. This would occur whenever the pragmatic reasoning of scalar implicatures is considered at a basic level since it would obey lexical processing. At other levels they would be the processing of metaphors and ironies, although Sperber and Wilson (1995) consider that this type of figures is not part of different levels of processing nor that a higher level of competence is required to process them.

### **Limitations and further research**

This work is a within-subject research, that although it eliminates the bias of interindividual variation by making the subjects their own controls, it could generate a

possible learning minor effect for the types of responses depending on the stimulus. Therefore, an inter-subject study is recommended.

Additionally, the independent variable is addressed as one-dimensional, according to the related research tradition, however, the latest advances in the area suggest that the ToM It should be considered in two dimensions: explicit and implicit. An upcoming study should address these aspects.

Despite the above limitations, this research clearly shows that the pragmatic reasoning of scalar implicatures has cognitive processing effects from the theory of the mind.

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