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THE REAL INTERPRETATIONS OF 'IF' IN ACADEMIC TEXTS: A STUDY OF THE POSSIBILITIES CORRESPONDING TO THE CONDITIONAL IN A PSYCHOLOGY PAPER

[AS INTERPRETAÇÕES REAIS DE 'SE' EM TEXTOS ACADÊMICOS: UM ESTUDO DAS POSSIBILIDADES CORRESPONDENTES AO CONDICIONAL EM UM ARTIGO DE PSICOLOGIA]

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ABSTRACT: Johnson-Laird and Byrne proposed in 2002 that, beyond the two traditional interpretations that are assigned to *if*, that is, the material and the biconditional ones, eight more combinations of possibilities related to their meaning can be attributed to this kind of sentences. The initial hypothesis in the present study is that not all of those ten interpretations should be usual in academic texts, since some of them resort, for example, to figurative language or irony. In this way, a study of a psychology paper is carried out in order to check that hypothesis. The results are that, at least in that paper, the uses of *if* tend to be linked to the interpretation that both Johnson-Laird and Byrne and the literature in general relate to the biconditional.
KEYWORDS: biconditional; conditional; if; interpretation; semantic possibility

RESUMO: Johnson-Laird e Byrne propuseram em 2002 que, além das duas interpretações tradicionais que são atribuídas a *se*, isso é, a material e a bicondicional, oito combinações mais de possibilidades relacionadas a seu significado podem ser também atribuídas a este tipo de sentenças. A hipótese inicial do presente estudo é que não todas essas dez interpretações devem ser usuais em textos acadêmicos, já que algumas delas recorrem, por exemplo, à linguagem figurativa ou à ironia. Desta maneira, um estudo de um artigo de psicologia é revisado para verificar essa hipótese. Os resultados são que, pelo menos nesse artigo, os usos de *se* tendem a estar ligados à interpretação que ambos Johnson-Laird e Byrne e a literatura em geral relacionam ao bicondicional.
PALAVRAS-CHAVES: bicondicional; condicional; se; interpretação; possibilidade semântica

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INTRODUCTION

Johnson-Laird and Byrne (2002) showed, under the framework of the theory of mental models (e.g., KHEMLANI; JOHNSON-LAIRD, 2019), that it is possible to think about ten interpretations (understood as semantic combinations of possibilities) for the conditional, that is, for the sentences including

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if. This means that, in addition to the material one and the biconditional one, which are the interpretations classically more linked to this type of sentences in logic, people can use them with eight more senses.

There is no doubt that the categorization has been very useful. In fact, it has been used in several works and from different perspectives (see, e.g., LÓPEZ-ASTORGA, 2016). However, one might suspect that, given that some of the interpretations refer to elements such as irony, double meanings, or metaphors, all of them may not be used in all of the communicative situations.

In this way, this paper is aimed to check this last point with regard to academia. For that, it will try to review how many of those interpretations appear in a text describing a study in a scientific journal. The title of the study is "Cheater detection is preserved in autism spectrum disorders," authored by Rutherford and Ray (2009) and random selected. And the idea is basically to identify all of the cases in which *if* appears in it in order to discover then which of the ten interpretations provided by Johnson-Laird and Byrne (2002) corresponds to each of these appearances.

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Following that goal, first what the theory of mental models really states about *if* will be explained. Then, the ten interpretations indicated will be described, as well as the method that will be used in this paper to review them. Finally, the results found will be shown.

THE THEORY OF MENTAL MODELS AND ITS COMBINATIONS OF POSSIBILITIES FOR IF

Actually, it is hard to speak about the theory of mental models. The reason for that is that the framework presented decades ago (see, e.g., OAKHILL; GARNHAM, 1996) is not exactly the one that its proponents present today (e.g., BUCCIARELLI; JOHNSON-LAIRD, 2019; KHEMLANI; BYRNE; JOHNSON-LAIRD, 2018; QUELHAS; RASGA; JOHNSON-LAIRD, 2019). However, it can be thought that the ten interpretations proposed by Johnson-Laird and Byrne (2002) keep being coherent with the last developments of the theory, and hence that they can be considered as valid from its current particular approach.

Thus, a very important idea of the theory of mental models is that sentences are linked to semantic possibilities or, strictly speaking, to combinations of such possibilities (see also, e.g., LÓPEZ-ASTORGA, 2016; QUELHAS; RASGA; JOHNSON-LAIRD, 2017). Nevertheless, those combinations are not always the same for the same connective (see also, e.g., QUELHAS; JOHNSON-LAIRD, 2017). There is really a large literature in this way addressing the different traditional connectives (see also, e.g., ORENES; JOHNSON-LAIRD, 2012). But, as mentioned, the one that is interesting here is *if*.

Of course, *if* many times refers to the material interpretation, that is, to the interpretation that is often assigned to it in classical logic. A clear example can be this one (all the examples in this section and the interpretations attributed to them are taken from JOHNSON-LAIRD; BYRNE, 2002):

1 "If the patient has malaria then she has a fever" (JOHNSON-

> LAIRD; BYRNE, 2002, p. 663; see also, e.g., LÓPEZ-ASTORGA, 2016, p. 285).

If it is considered 'P' to stand for the antecedent or *if-clause* in (1), 'Q' to represent its consequent or *then-clause*, '&' to be conjunction, and '¬' to mean negation, it can be said that the semantic possibilities for (1) are the following:

2 [P & Q] & [¬P & Q] & [¬P & ¬Q]

The exact manner the theory of mental models understands possibilities such as those in (2) and the particular role that conjunction plays in them are accounted for in many works (see also, e.g., KHEMLANI; HINTERECKER; JOHNSON-LAIRD, 2017). Nonetheless, maybe what is relevant for this paper is that, as indicated, according to Johnson-Laird and Byrne (2002), (2) is not the only combination of possibilities that can be related to sentences with *if*. As it is well known, this last connective is often linked to a biconditional interpretation. That is so in standard logic and there is also an extensive literature dealing with this point, which includes some works that are already classic in areas such as linguistics or philosophy of language (see, e.g., AUWERA, 1997; GEIS; ZWICKY, 1971; MOLDOVAN, 2009). However, the theory of mental models has an account in this regard too. It is obvious that the missing pair in (2), that is, [P & ¬Q], is not possible, since malaria, among other symptoms, is characterized by producing a fever. But the pair [¬P & Q] can be impossible in other cases as well, which can lead to a biconditional interpretation. That is what happens with (3).

> 3 "If she owes money then she must repay it" (JOHNSON-LAIRD; BYRNE, 2002, p. 663; see also, e.g., LÓPEZ-ASTORGA, 2016, p. 289).

As pointed out by Johnson-Laird and Byrne (2002), it is difficult to accept that (3) is compatible with pairs such as [P & ¬Q] and [¬P & Q]. So, it can be stated that its combination is:

4 [P & Q] & [¬P & ¬Q]

But, beyond logic, following Johnson-Laird and Byrne (2002), there are more combinations of possibilities that can be thought for *if*. One of them, called *Relevance* in their paper, is the one corresponding to (5).

> 5 "If you are interested in seeing Vertigo then it is on TV tonight" (JOHNSON-LAIRD; BYRNE, 2002, p. 663; see also, e.g., LÓPEZ-ASTORGA, 2016, p. 291).

Because, according to (5), that *Vertigo* is on television tonight is a fact, the combinations are in this case:

6 [P & Q] & [¬P & Q]

And other instance, in which figurative language is used, can be as follows:

> 7 "If it works then I'll eat my hat" (JOHNSON-LAIRD; BYRNE, 2002, p. 663; see also, e.g., LÓPEZ-ASTORGA, 2016, p. 292).

Given that what the speaker seems to want to say with (7), which, according to Johnson-Laird and Byrne (2002), is an example of *Tollens*, is that it is absolutely sure that it will not work, as indicated by them, only one possibility can be assigned to (7):

8 [¬P & ¬Q]

Those are four examples of the ten interpretations Johnson-Laird and Byrne (2002) provide (see especially their Table 4). The six remaining combinations are presented in the next section. However, examples will not be used to do that, since those commented on are illustrative enough and to describe some corresponding to the other interpretations can be, as it can be checked below, unnecessary to explain the results and hence a trivial task.

The ten interpretations identified by Johnson-Laird and Byrne (2002) as predetermined categories

Based upon the way (2), (4), (6), and (8) has been expressed, it is possible to indicate, by using the same symbols, which all of the interpretations proposed by Johnson-Laird and Byrne (2002) are. Those interpretations (which, as said, have been used in several works; e.g., LÓPEZ-ASTORGA, 2016) are listed then keeping the names that were originally given by Johnson-Laird and Byrne (2002). Evidently, they called *Conditional* to the interpretation matching the material one in classical logic.

- *Tautology*: [P & Q] & [P & ¬Q] & [¬P & Q] & [¬P & ¬Q]
- *Conditional*: see (2) above
- *Enabling*: [P & Q] & [P & ¬Q] & [¬P & ¬Q]
- *Disabling*: [P & Q] & [P & ¬Q] & [¬P & Q]
- *Biconditional*: see (4) above
- *Strengthen antecedent*: [P & Q] & [P & ¬Q]
- *Relevance*: see (6) above
- *Tollens*: see (8) above
- *Ponens*: [P & Q]
- *Deny antecedent and affirm consequent*: [¬P & Q]

This list follows what is pointed out in Table 4 in Johnson-Laird and Byrne (2002), and what will be made below is essentially, as also stated, to review all of the sentences with *if* that appear in the paper by Rutherford and Ray (2009) in order to detect which of these ten interpretations corresponds to each of them. Therefore, it can be claimed that the ten interpretations listed will be deemed in a way akin to the one as the *predetermined categories* (e.g., BOYATZIS, 1998; EFRAT EFRON; RAVID, 2013) are usually considered in qualitative research.

Nevertheless, one more category will be taken into account too. In English, there are uses of *if* in which the real function of this last word is not to establish a conditional relation. They are the cases in which *if* is equivalent to *whether*, and, obviously, those cases will be classified as irrelevant for the study.

The next section shows the sentences found, the category attributed to them, the reasons for those attributions, and some quantitative analyses of the results based upon binominal distributions.

Analyses of the sentences found

In total, 25 sentences with *if* were found in the paper by Rutherford and Ray (2009). 16 of them were irrelevant, 8 of them corresponded to the biconditional interpretation, and just one of them was clearly a conditional, that is, its combination of possibilities clearly matched the material one.

The 16 cases of irrelevance are obvious, though not all of them were considered in that way because in them *if* was equivalent to *whether*. They are the following:

> 9 "*If* P then Q" (RUTHERFORD; RAY, 2009, p. 106; italics added).

If does not play in (9) the same role as *whether*. Nevertheless, it was considered as irrelevant because Rutherford and Ray (2009) resort to it just for explaining their research, which addresses the conditional reasoning in people with autism. So, (9) cannot be taken into account to analyze it by means of the ten categories indicated, and, basically, because it is mentioned and not used in the discourse (in fact, in the paper it appears between simple quotes).

Nonetheless, it does be equivalent to *whether* the two times it appears in (10).

> 10 "Participants were asked to pretend they really had to investigate the situation and determine *if* the information on the other side of the pictured cards must be shown in order to see *if* the rule presented in the question has been broken" (RUTHERFORD; RAY, 2009, p. 110; italics added).

Indeed, (10) is a fragment of the part of the paper in which the procedure of an experiment is described, and, undoubtedly, the two uses in it play the same role as the conjunction *whether*.

But the situation in (11) is very similar to the one in (9).

> 11 "*If*-then" (RUTHERFORD; RAY, 2009, p. 112; italics added).

Again, if the distinction between *use* and *mention* is taken into account, it is clear that, although (11) is not a case of equivalence to *whether*, it is also irrelevant (furthermore, it also appears in the paper between simple quotes).

In the rest of its appearances, nonetheless, *if* is evidently exchangeable with *whether*.

> 12 "So some of your friends may have broken this rule, you must find out *if* they have broken this rule" (RUTHERFORD; RAY, 2009, p. 114; italics added).

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> 13 "One side tells you *if* your friends brought a dish to the party, the other side tells you *if* you friend could make it to your dinner party" (RUTHERFORD; RAY, 2009, p. 114; italics added).

> 14 "Indicate only those card(s) you would definitely need to turn over in order to see *if* these people are violating the rule" (RUTHERFORD; RAY, 2009, p. 114; italics added).

> 15 "So some of your friends may have broken this rule, you must find out *if* they have broken this rule" (RUTHERFORD; RAY, 2009, p. 115; italics added).

> 16 "One side tells you *if* they brought a food dish, the other side tells you *if* you friend could make it to your dinner party" (RUTHERFORD; RAY, 2009, p. 115; italics added).

> 17 "Indicate only those card(s) you would definitely need to turn over in order to see *if* these people are violating the rule" (RUTHERFORD; RAY, 2009, p. 115; italics added).

> 18 "So they may have broken this rule, you must find out *if* they have broken this rule" (RUTHERFORD; RAY, 2009, p. 116; italics added).

> 19 "Indicate only those card(s) you would definitely need to turn over in order to see *if* these people are violating the rule" (RUTHERFORD; RAY, 2009, p. 116; italics added).

> 20 "So they may have broken this rule, you must find out *if* they have broken this rule" (RUTHERFORD; RAY, 2009, p. 117; italics added).

> 21 "Indicate only those card(s) you would definitely need to turn over in order to see *if* these people are violating the rule" (RUTHERFORD; RAY, 2009, p. 117; italics added).

As it can be noted, beyond the fact that *if* appears twice in (13) and (16), the texts are very repetitive. The reason for that is that cases (12) to (21) are fragments of Appendix A in the paper. That appendix reproduces the exact tasks used in the research, which, as it can be noted after reviewing the fragments, were versions of the well-known Wason Selection Task (e.g., WASON, 1966, 1968). However, the main point here is that it seems evident why cases (9) to (21) were ignored in this study.

Nevertheless, as said, eight cases of biconditional interpretation were also detected. In this way, the first use of *if* to which (4) can be assigned is as follows:

> 22 "…those with ASD can detect intentionality only *if* it is relevant to cheater detection,…" (RUTHERFORD; RAY, 2009, p. 105; italics added).

Two aspects are important to highlight in (22), which is included in the abstract of Rutherford and Ray's (2009) paper. First, *ASD*, as explicitly said there, refers to *Autism Spectrum Disorders*. Second, one of the words of the sentence is also *only*, a word that is often linked to *if* when the biconditional interpretation is considered, especially in classical logic. Thus, beyond what the entire sentence of which (22) is a part means, there is no doubt that the relation in this appearance of *if* is biconditional, since it is clear that, if (22) were true, the impossible situations would be two: that people with ASD can detect intentions and that is not relevant to their process of cheater detection, and that people with ASD cannot detect intentions and that is relevant to their process of cheater detection.

Something similar occurs with (23).

> 23 "*If* so, this would be further evidence for the modularity of the cheater detection mechanism" (RUTHERFORD; RAY, 2009, p. 107; italics added).

In the sentence previous to (23) in the text written by Rutherford and Ray (2009), it can be noted that the antecedent of (23) refers to the possibility that the cheater detection mechanism (a mechanism postulated by them in the human mind) works in exactly the same way in people with and without autism. Hence, their idea is that, if the mechanism can be used by people with autism without difficulties, that can be one more proof that it exits and is actually a module in the human mind. From this perspective, if it is assumed that (23) is correct, it also has to be accepted that its interpretation is (4), since none of its two clauses can be true if the other one is not.

The third case is as follows:

> 24 "Each Wason Selection Task was scored as correct *if* the participant indicated that the "P" card and the "not-Q" card needed to be turned over…" (RUTHERFORD; RAY, 2009, p. 110; quotes in text, italics added).

Obviously, (24) corresponds to the section of the paper devoted to the explanation of the results. In it, the answers to the task given by the participants that were deemed as correct are mentioned. They were those in which certain cards were chosen. So, it is clear that, if the answer was considered as correct, those cards were selected, and that, if those cards were selected, the answer was considered as correct. Undoubtedly, this is a biconditional relation too.

And the same appears to happen in (25).

> 25 "*If* this weren't the case, it would be hard to explain dramatic differences in performance on what is essentially the same logic problem,…" (RUTHERFORD; RAY, 2009, p. 112; italics added).

Now, the sentence previous to (25) is speaking about hypothetical mental processes that can be triggered when the reasoning task is of a deontic nature. In this way, the meaning of (25) seems to be that, if those possible processes did not exist, it would be very difficult to account for the differences in the results of certain problems with, in essence, the same logical structure. Accordingly, from

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this, it can be deduced that, if the processes exist (i.e., 'if this is the case'), it is not hard to account for the differences in the results, and that, if it is not hard to account for the differences in the results, the aforementioned processes should exist. Of course, one might argue that the fact that certain results can be explained easily does not necessarily imply the acceptance of particular processes, since alternative explanations for the same results can always be proposed. In turn this might lead one to think about an interpretation such as (2) for (25). Nonetheless, the truth is that the context of the discussion in which Rutherford and Ray (2009) includes (25) is very clear, and their argumentation appears to be precisely that there are no alternative accounts better than the idea that those mental processes really exist to explain the differences in the results. Hence, it can be said that, regardless of whether or not they are right, their use of *if* in (25) has a biconditional sense and intention.

The two following appearances are very akin:

> 26 "***If* you want to come to my dinner party, you must bring a food dish to the party**" (RUTHERFORD; RAY, 2009, p. 114; bold in text, italics added).

> 27 "***If* you want to come to my party, then you must bring a food dish to the party**" (RUTHERFORD; RAY, 2009, p. 115; bold in text, italics added).

These two sentences appear in Appendix A and, hence, are rules used in the tasks presented to their participants. However, that (4) is the best combination of possibilities for them is easy to see if it is thought that, in both cases, if one does not want to come to the party, he or she does not have to bring a food dish, and, if one does not have to bring a food dish, that is because he or she does not want to come to the party.

Finally, the two last sentences that can be linked to the biconditional interpretation are completely identical:

> 28 "***If* you go to the concert, then you have to work a four-hour shift digging ditches**" (RUTHERFORD; RAY, 2009, p. 116; bold in text, italics added).

> 29 "***If* you go to the concert, then you have to work a four-hour shift digging ditches**" (RUTHERFORD; RAY, 2009, p. 117; bold in text, italics added).

(28) and (29) are in Appendix A too and, therefore, are rules given to the participants in the experiment carried out by Rutherford and Ray (2009) as well. Its biconditional nature is obvious because nobody may go to the concert without working digging, and one can understand that, if somebody works digging ditches (which is a hard work) he or she makes that effort to get the prize for going to the concert (in fact, in both cases, the rule is accompanied by a story making it clear that the right way to interpret (28) and (29) is attributing (4) to them).

But, as indicated, one case for which the most appropriate interpretation is

the material one, that is, (2), was also found. It is this one:

> 30 "*If* a person with ASD is unable to appreciate whether a character in a story has acted intentionally or mistakenly, then this factor would not be expected to affect performance on a Wason Selection Task" (RUTHERFORD; RAY, 2009, p. 107; italics added).

One might think that (30) is a material conditional because the only possibility that is not allowed by it is that people with ASD are not able to note intentions and that a factor such as that one is expected to have an influence on their execution of a reasoning task such as Wason Selection Task. Nevertheless, it can be admitted that they are not able to note intentions and the influence of that factor is not expected, that they are able to note intentions and the influence of that factor is not expected (in this case, they could, e.g., resolve the task by virtue of other reasoning abilities preserved somehow in people with autism), and, of course, that they are able to note intentions and the influence of that factor is expected.

So, as mentioned, between the nine appearances that are not irrelevant, eight refer to (4), that is, to the biconditional interpretation, and one to (2), that is, to the material interpretation. The concept of predetermined category is more characteristic in qualitative than in quantitative research. Nonetheless, that does not prevent to consider these numbers in order to provide binominal distributions. They reveal that, if the ten possible interpretations of *if* proposed by Johnson-Laird and Byrne (2002) are taken into account, it is not probable that the interpretation of one of its appearances is the material one, since, in that case, $p = 0.3874$ ($N = 9$; $X = 1$). However, if it is assumed that the material and the biconditional interpretations are those that usually are related to *if* in logic, that, accordingly, to interpret *if* in one of those ways is a positive case, and that the other eight combinations represent eight possible types of negative cases (which means to consider the probability of success to be 0.2), the result does be significantly positive, as $p = 0$ ($N = 9$; $X = 9$). And the numbers can be good from other perspectives too, because it can also be supposed that the probability de success is ½ (it is enough to keep the positive case being both the material and the biconditional interpretations and to deem any of the other combinations as the only negative case). Thus, $p = 0.002$ ($N = 9$; $X = 9$), which continues to be a positive result in a significant way.

The consequences of all of this are commented on below. However, an important point to highlight before can be that, although one might challenge some of the interpretations above and argue, for example, that some of the sentences between (22) and (29) are really material sentences, or that (4) is a better combination of possibilities for (30), the fact of deeming the material and the biconditional interpretations as one only type of case, as made in the last two statistical calculations, removes difficulties such as those ones. And this is so because, ultimately, it allows thinking that, at least in scientific papers, the interpretations corresponding to *if* are the ones that classical logic and the literature often associates to it, that is, as stated, the material and the biconditional ones.

Conclusions and general discussion

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Effectively, the clear trend towards the biconditional and material interpretations is a very important point, since it enables to link the results here to what is provided by standard logic and the literature about *if*. The nine cases found refer to one of those two interpretations, and, although the material interpretation is only evident in one of those nine cases, it is obvious that the biconditional interpretation has been classically related to *if* as well (as it can be checked in, e.g., several of the references indicated in this paper).

However, of course, this study also has limitations. It has addressed just one paper, and, while the results lead to few doubts, different writing styles and subject matters should be dealt with too. In this way, perhaps the analysis here needs to be complemented with more psychology texts written by other people and works about other scientific areas or subject matters.

Likewise, it would be interesting to check whether the results keep being similar in languages others than English. One might expect that the possible differences between languages should not be important. Nevertheless, there is no doubt that a verification with regard to this point would be relevant as well.

But, if the results achieved with this study are extrapolated, it can be said that the tendency is, as indicated, to interpretations given by classical logic. It also remains to address the discussion about which the most natural interpretation of *if* is, the material one or the biconditional one. That discussion has been ignored here because, on the one hand, as pointed out, which of these two interpretations is the correct one in a particular case of a particular sentence is not always evident, and, on the other hand, in the end, as also claimed and is well known, it can be said that both of them are classical combinations of possibilities attributed to *if*. Nonetheless, even leaving that discussion to one side, what undoubtedly requires an explanation is why the other eight interpretations given by Johnson-Laird and Byrne (2002) do not seem to be usual in academic papers.

Maybe the key is that several of those interpretations resort to a figurative language or metaphors, a clear example in this way being (7). Thus, a possible account can be that the eight other interpretations different from (2) and (4) proposed by Johnson-Laird and Byrne (2002) are generally used (beyond, of course, cases such as literature or poetry) just in colloquial conversations or situations of informal communication. When the language that is needed is rigorous and exact, as it is the case whenever scientific or academic papers are written, the interpretations of *if* are obviously the standard ones, that is, those that correspond to it in standard logic (as indicated, the material and the biconditional ones). If *if* is not used in one of these two senses, that is because the situation is not formal enough (leaving aside, of course, as said, literature and poetry).

And this hypothesis could apply even in the case of (5), a sentence without metaphors and in which the language is not figurative. Thus, (5) can be understood as an example of a quick manner, characteristic in informal conversations, to express messages in which what is actually transmitted is a different content. In this way, it can be thought that, strictly speaking, there is no real conditional relation in (5). The speaker simply informs that there is *Vertigo* on television because the listener can be interested in watching it. But the fact that the listener is (or is not) interested in watching *Vertigo* is not a condition for *Vertigo* to be on television (this

sentence has been analyzed in a similar direction in several papers; see also, e.g., LÓPEZ-ASTORGA, 2016).

Of course, explanations akin to the previous ones could also be offered for *Tautology*, *Enabling*, *Disabling*, *Strengthen antecedent*, *Ponens*, and *Deny antecedent and affirm consequent*. Nevertheless, given the arguments above, that task could seem unnecessary, since it is not hard to note (and this has been made in a more or less explicit manner in the literature too; see, e.g., LÓPEZ-ASTORGA, 2016) that the examples provided by Johnson-Laird and Byrne (2002) for these six last interpretations do not truly establish conditional relations between their clauses (i.e., between their apparent antecedents and consequents) either. So, the provisional hypothesis, which, perhaps, could be supported at least while the process of overcoming the limitations mentioned does not prove the contrary, can be that, except for areas such as literature and poetry, when the language is used in an absolutely correct manner, *if* usually only have the two senses related to it in classical logic. As seen in the paper by Rutherford and Ray (2009), beyond the cases in which it can be replaced by *whether*, this is what, at a minimum, appears to happen in scientific papers published in peer-review journals.

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