Interpretation and use of disjunction in natural language: A study about exclusivity and inclusivity

Interpretación y uso de la disyunción en lenguaje natural: un estudio sobre exclusividad e inclusividad

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Abstract

The literature shows that people tend to interpret disjunctions as exclusive. From that fact, this paper describes a study intended to check whether or not that trend can also be observed when disjunction is used. The study was mainly based on an analysis of the semantic possibilities of the disjunctions appearing in a philosophical text. The method of analysis was akin to the one proposed by the theory of mental models to explore reasoning. The results revealed that the number of exclusive disjunctions employed in that text is exactly the same as the one of inclusive disjunctions in it. Hence, it is hard to claim that, in addition to what happens in the interpretation processes, disjunction is often exclusive when used as well.

Keywords: disjunction; exclusivity; inclusivity; model-based analysis; semantic possibilities

Resumen

La literatura muestra que se tiende a interpretar las disyunciones como exclusivas. A partir de ese hecho, este artículo describe un estudio destinado a comprobar si esa tendencia también puede observarse cuando se utiliza la disyunción. El estudio se basó principalmente en un análisis de las posibilidades semánticas de las disyunciones que aparecen en un texto filosófico. El método de análisis fue similar al propuesto por la teoría de modelos mentales para explorar el razonamiento. Los resultados revelaron que el número de disyunciones exclusivas empleado en ese texto es exactamente el mismo que el de las disyunciones inclusivas. Por tanto, es difícil afirmar que, además de lo que ocurre en los procesos de interpretación, la disyunción suele ser también exclusiva cuando se utiliza.

Palabras clave: disyunción; exclusividad; inclusividad; análisis basado en modelos; posibilidades semánticas.

1. INTRODUCTION

As it is well-known, classical logic tends to consider disjunction to be inclusive (e.g., Deaño, 1999). Of course, that does not mean that standard propositional logic cannot deal with exclusive disjunction (e.g. López-Astorga, 2015). However, it is striking that classical logic deems inclusive disjunction as the primary disjunction, since the literature on cognitive science appears to show that people usually interpret disjunction as exclusive (e.g., Khemlani, Orenes, & Johnson-Laird, 2014).

Without challenging that literature, one might think that it could be interesting to review whether or not, in addition to interpret disjunction as exclusive, people also often use that very kind of disjunction when producing linguistic messages. Thus, the idea would be to check whether what has been indicated in the literature on cognitive science has a parallel in the processes of information transmission.

This is exactly the aim of the present paper. To achieve it, it presents an analysis of the appearances of 'or' in an academic paper in order to verify to what extent its disjunctions are exclusive. In this way, first, the logical characteristics of exclusive and inclusive disjunction are described, specifically indicating what differentiates them. Likewise, it is explained why the psychology literature seems to prove that disjunction is naturally understood as exclusive. Then the methodology used in the study is accounted for. Finally, the results obtained are shown and some conclusions that can be derived from them are commented on.

1.1. Exclusive versus inclusive disjunction

There is an important specialized literature about the possible interpretations of disjunction (e.g., López-Astorga, 2019; Orenes & Johnson-Laird, 2012; Quelhas & Johnson-Laird, 2017; Quelhas, Rasga, & Johnson-Laird, 2019). However, what is important here at this moment is that, while classical logic acknowledges the existence of exclusive disjunction, as said, it often considers disjunction as mainly inclusive. This means that, in that logic, there are usually three cases in which (1) can be true.

(1) P or Q

Those cases are when both P and Q are true, when P is true but Q is false, and when P is false but Q is true. The only circumstance in which a disjunction is generally deemed as false in standard logic is, accordingly, when its two disjuncts are false.

Nevertheless, there is another way to understand disjunction. It can be considered to be exclusive, and the possibility of it being true when both P and Q are that can be eliminated. That can be the case of a disjunction such as (2).

(2) Today is Tuesday or today is Wednesday.

This disjunction can be true if today is Tuesday and not Wednesday and if today is Wednesday and not Tuesday. Nonetheless, (2) cannot be true in two situations: if today is neither Tuesday nor Wednesday and, by virtue of semantics, if today is both Tuesday and Wednesday. The

former is the negation of (2) and the latter refers to an semantically impossible scenario (the same day cannot be both Tuesday and Wednesday).

An experimental study showed that, irrespective of whether the semantic content of the sentences leads to an exclusive interpretation of disjunction, as it happens in (2), where, as pointed out, the inclusive interpretation is impossible, people always tend to understand disjunction as exclusive in most occasions (Khemlani et al., 2014). That study had several experimental conditions. However, the one that is interesting for the present paper is that in which a disjunction with thematic content that did not necessarily cause an exclusive reading was presented. Thus, it was asked about the combinations of possibilities that could be accepted if that sentence was true. The sentence referred to wearing a yellow shirt (P) or blue trousers (Q), and the possibilities offered were:

(3) P & Q
(4) P & not-Q
(5) Not-P & Q
(6) Not-P & not-Q

Most participants chose just (4) and (5) as possibilities compatible with the initial disjunction. That means that they understood the sentence as exclusive (if they had interpreted it as inclusive, they would have selected (3) as well). Nevertheless, what experiments of this type really show is that, when receiving linguistic messages, individuals often deem disjunctions as exclusive. On the other hand, what the study below tried to check is whether, in a natural way, the trend to exclusivity also occurs in other situations. The case analyzed was that of the text of an academic paper. It was attempted to find out whether or not, when writing the text, the author tended to exclusivity too. Therefore, it was a study that can offer very relevant information, as it can complement experiments such as that described in this section, and reveal to what extent the basic interpretation of disjunction in human language is not the habitual in classical logic, but the exclusive one. The next section explains the methodology of the study in details.

2. METHODOLOGY

A text randomly selected was reviewed by the author of the present paper. That text was the paper by Lukowski (2013). That is a logic paper addressing a well-known logical problem: the problem of monotonicity in logic. The procedure followed was simple. Given that the document was in PDF format, when open, it offered a search option for words inside the document. Thus, by using that option, all the sentences with 'or' appearing in the text could be identified. Once the sentences were obtained, they were classified in two groups: those whose disjunction was exclusive and those whose disjunction was inclusive. So, exclusivity and inclusivity were the two categories to consider in the classification.

It is true that a disjunction can have an interpretation different from the two ones mentioned (e.g., López-Astorga, 2019). Nevertheless, such interpretations are usually observed only when people resort to figurative, metaphoric, colloquial, or daily life language. Because the text analyzed was an academic paper (about philosophy, and, in particular, logic), it was unlikely that interpretations of that kind were found. In any case, the idea was that, if an interpretation different from the exclusive one and the inclusive one appeared, it would be, of course, considered as an additional category. However, that did not happen.

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Furthermore, to decide which the suitable interpretation of each appearance of 'or' was, a methodology similar to the one of the theory of mental models (e.g., Bucciarelli & Johnson-Laird, 2019; Byrne & Johnson-Laird, 2020; Khemlani & Johnson-Laird, 2019) was used (for different purposes, that kind of methodology has been already adopted in several papers; see, e.g., López-Astorga, 2019). Beyond the fact that the theory of mental models tries to describe and predict reasoning in human beings, what is interesting from it here is one of its core theses, which was taken (as, e.g., in López-Astorga, 2019) as methodological tool. That is its idea that the sentences refer to possibilities that can be detected by virtue of semantic and pragmatic factors. For example, it is clear that (2) only allows (4) and (5) as possibilities. As mentioned, (6) would make (2) false and (3) is semantically impossible. However, the case of (7) is different.

> (7) "There is beer, or there is wine…" (Byrne & Johnson-Laird, 2020:761).

Obviously, now it is possible (3), since there is no reason why there could not be beer and wine at the same time.

But the theory claims the action of modulation phenomena too, that is, of processes that can alter the possibilities of a sentence. That is the case of, for instance, (8).

> (8) "…Pedro tried 'the chocolate cake' or he tried the dessert…" (Orenes & Johnson-Laird, 2012: 375; quotation marks in text).

A sentence such as (8) refers to (3) and (5). A chocolate cake is a dessert. So, it is not, from the semantic point of view, possible to have a chocolate cake and not to have a dessert. This leads to ignore not only (6) but also (4). Accordingly, (8) is related to a combination of possibilities different from both exclusive and inclusive disjunction. Nevertheless, as pointed out, the possibility of these situations was taken into account. Studies about other interpretations (beyond the exclusive and inclusive ones) of disjunction were considered (such studies are generally based, to a greater or lesser degree, on the theory of mental models as well; see, e.g., López-Astorga, 2019). Besides, it was assumed that, if necessary, additional categories would be accepted. Nonetheless, as also said, interpretations other than the exclusive and the inclusive ones were not found in the paper by Lukowski (2013).

3. RESULTS

In total, 12 sentences with 'or' were found in the text corresponding to Lukowski's (2013) paper following the procedure indicated. 6 of them could be classified as exclusive disjunctions. The other 6 could be deemed as inclusive disjunctions. Then, what those sentences are exactly is indicated, as well as the justification why they were considered as belonging to a category and not to the other one. First, the exclusive disjunctions are presented.

> (9) "Thus, there is a question, if the inference used in human thinking is monotonic or not" (Lukowski, 2013:63).

Justification: this disjunction is exclusive because monotonicity is a technical term related to systems in fields such as logic and artificial intelligence. It refers to the impossibility that a conclusion in an inference can change its truth value by, for example, adding extra information

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to the premises. Thus, in general, the systems are considered to be monotonic or nonmonotonic, but not both of them at the same time. In addition, the sentence includes 'or not', which also leads to an exclusive reading from the logical point of view.

(10)   "Moreover, if the inference will be monotonic (it does not matter, whether classical or not), the reasoning basing on this inference will be monotonic too" (Lukowski, 2013:64).

Justification: obviously, the disjunction between brackets is also exclusive. Something can be classical or not classical, but not both classical and not classical at once. Besides, 'or not' is used again.

(11)   "An acceptance of $(p_1 \wedge \ldots \wedge p_n) \to z_1$ is possible (or not) thanks to inductive reasoning applied to a big amount of sentences expressing many observed and recorded individual facts" (Lukowski, 2013:66).

Justification: beyond the exact meaning of the logical formula appearing in (11), and the fact that 'or not' appears once again, it is absolutely clear that 'or' in its second brackets is linked to two incompatible scenarios: something is possible or not. Nothing is both possible and impossible.

(12)   "Maybe he will go to the hospital or just stay at home" (Lukowski, 2013:67).

Justification: somebody can be at the hospital or at home, but not at the two places at the same time.

(13)   "…We could change logic to be defeasible, or we could allow some premises of the logical argument that may not be allowed when new information is received" (Lukowski, 2013:69).

Justification: (13) actually corresponds to a literal quote from Poole (1994:189) presented by Lukowski (2013). It describes two ways to resolve a problem. Each disjunct refers to one of them. One might think that the two possible solutions are consistent, and hence that both of them can be used at once. Nevertheless, the first disjunct explicitly names defeasible logic and the second one is related by Poole to default logic. This is a key point, since defeasible logic and default logic are often deemed as opposite approaches (e.g. Antoniou & Billington, 2001).

(14)   "…saying 'A is a species of the genus B' or 'B is a species of the genus A'" (Lukowski, 2013:70; quotation marks in text).

Justification: the relation between genus and species is different in each disjunct. So, it is clear that the two relations cannot be right.

On the other hand, the sentences in which disjunction was inclusive were the following:

(15)   "One way or another, the physician chooses z_1 knowing that also another illnesses could be associated with these symptoms" (Lukowski, 2013:66; italics in text).

Justification: the expression 'one way or another' is linked in the paper to examples such as "…the knowledge about frequency of illnesses $z_1,…,z_k$ in this area, the probability of appearance of these illnesses, etc" (Lukowski, 2013:66; italics in text). There is no doubt that those examples describe possibilities that can be taken into account by a physician at once.

(16)   "No-one can exclude the situation that some test or other research will give an unambiguous result" (Lukowski, 2013:67).

Justification: it is easy to think about cases in which a test and another type of research can be carried out at the same time, about the same topic, dealing with the same problems, and given similar results.

(17)   "John or Mark could forget about the meeting..." (Lukowski, 2013:68).

Justification: given (17), three situations are conceivable: John forgot about the meeting, Mark forgot about the meeting, and both John and Mark forgot about the meeting.

(18)   "…John or Mark could be ill…" (Lukowski, 2013:68).

Justification: as in (17), the possible scenarios in (18) also match with (3), (4), and (5). It is possible that John is ill, it is possible that Mark is ill, and it is possible that both John and Mark are ill too.

(19)   "That is why, nonmonotonicity bases on some manipulation with either A or ⊢" (Lukowski, 2013:72).

Justification: 'A' stands for a set of premises in (19) and '⊢' is the symbol of logical deduction, which is being used in that very sentence to denote the inference rules in logic. Therefore, the sentence speaks about a manipulation in either the set of premises or the set of inference rules. Undoubtedly, both manipulations can be made together, and they do not preclude each other.

(20)   "…in the second step of reasoning it is already either 'not exactly the same set A' or 'not exactly the same set of rules of inference ⊢'" (Lukowski, 2013:72; quotation marks in text).

Justification: 'A' and '⊢' have the same meaning as in (19) here. Hence, again, it can be said that the changes in the premises do not prevent from changes in the inference rules, and vice versa. Accordingly, (20) can also be deemed as an inclusive disjunction.

So, as indicated, in Lukowski's (2013) paper, the number of exclusive disjunctions is exactly the same as the one of inclusive disjunctions. Thus, the numbers obtained do not allow claiming any tendency. It can be assumed that people do tend to interpret disjunction as exclusive when receiving information (Khemlani et al., 2014). Nonetheless, the results of the previous study seem to show that, when producing linguistic messages, that is not necessarily the case. The amount of both kinds of disjunctions appears to be similar. In this way, although it may not even be relevant to indicate it, a binomial distribution reveals that the results achieved are far from statistical significance. The number of events can be the number of appearances of 'or' in

the text, that is, 12. Likewise, the number of exclusive disjunctions, that is, 6, can be considered as the number of successes, and it can be assumed that the probability of success is ½ (there are just two possibilities: either the disjunction is exclusive or inclusive). Accordingly, p = 0.2256 (N = 12; X = 6).

CONCLUSIONS

Therefore, in brief, as said, the numbers of appearances of exclusive and inclusive disjunctions are identical and, obviously, there is no statistical significance. So, there is no trend to use exclusive disjunction more than inclusive disjunction. The literature is clear and shows that, when the messages are received, individuals often interpret disjunctions as exclusive (Khemlani et al., 2014). However, that does not mean that, in addition, the type of disjunction preferred by people when they build linguistic messages is also that. At least, the data obtained with the study presented in this paper do not seem to enable to affirm that exclusive disjunction is the basic and essential kind of disjunction in the human mind.

Nevertheless, the study here does not reveal definitive results. More researches to move forward in the same direction are possible. Such researches would complement this study because, evidently, the previous analysis has limitations.

First, a very important point is that the paper selected, that is, the one by Lukowski (2013), is a logical text published in a logical journal. As mentioned, classical logic favors inclusive disjunction over the exclusive one. Thus, one might argue that, given that the author that wrote the text was working under a logical framework, that circumstance could have had an influence on him. This could lead to think that, for this reason, it is possible to find in the paper reviewed more inclusive disjunctions that those that would be found in a text coming from another academic field.

It is clear that, in Lukowski's (2013) paper, there is an evident difference between the logical language used and the metalanguage to which the author resorts to speak about that logical language. That metalanguage, in this particular case, is a natural language, English, and, hence, a priori, would not have to follow the requirements of logical language. In this way, it could be thought that the metalanguage uses disjunctions in the same manner as it is done naturally. Nevertheless, as indicated, it is also possible to think that the fact that the writer works under that discipline has an influence on the expression of his ideas and the way he presents his arguments.

Perhaps this objection could be removed in a relatively easy manner. It would be enough to carry out a study akin to the present one focused on a paper related to a field other than logic and addressing other problems. Thus, the results could be compared and even summed to make analyses from that sum and to check whether or not that leads to different conclusions.

Furthermore, the other obvious limitations this paper has, and analyses similar to the one described here often have too, would not be hard to overcome either. For example, there is no doubt that it would be also interesting to verify whether or not the situation found in the paper by Lukowski (2013) is repeated as well in other texts -both logical studies and papers related to other fields- in languages other than English. But it is evident too that the work in this direction would not be particularly complicated.

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So, researches such as those pointed out could be progressively carried out in the future. In any case, at the moment, from the data obtained here, it cannot be stated that, in addition to understand disjunctions as exclusive, people tend to use disjunctions of that very kind when they try to express their ideas.

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