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Inherent directionality of "even if" counterfactual conditionals

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ABSTRACT

In this research, we investigate whether semifactual conditionals such as "even if there had been an A, there would have been a B" are understood by thinking initially of the antecedent "A", as was found with factual conditionals. The "inherent directionality" hypothesis assumes that for the comprehension of most relational statements, a presuppositional element (i.e. the "relatum") is initially established. For "even if", both terms could work as "relatum". This is because on the one hand, people tend to infer "B" from "A" and "not-A" and, on the other hand, "B" could work as a pragmatic presupposition. In the present experiment, semifactual and factual conditionals were tested with a sentence-picture verification task. Results were consistent with the "inherent directionality" hypothesis: only "if then" factual conditionals, but not semifactuals, showed a preference for reasoning from the antecedent, with faster verifications.

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Conditionals; semifactuals; directionality effects; inherent directionality hypothesis

Introduction

Most relational expressions have a preferred order for processing their terms. This depends on the way they are represented and can facilitate integration with other premises during reasoning (see Oberauer, Hörnig, Weidenfeld, & Wilhelm, 2005). In the present research, we study the inherent order of representation of the elements mentioned in the antecedent and in the consequent for semifactual "even if" expressions such as,

(1) "even if there had been a circle (A), there would have been the number 3 (B)", compared to "if then" statements like
(2) "if there was a circle (A) then there was the number 3 (B)".

Oberauer and Wilhelm (2000) investigated which direction of verification was preferred for different kinds of relations formulated with various types of connectives and quantifiers. Thus, they tested a factual "if then" statement like (2). In the verification task, participants saw a sentence such as "if there was a circle then there was a 3", followed, sometimes, by a set of cases that made the sentence true (e.g. a circle and a 3; a square and a 3) and sometimes by a set with cases that made the sentence false (e.g. a circle and a 4; a square and a 3). Participants had to decide as quickly as possible if the sentence was true or false by regarding the display. However, the crucial manipulation was whether the cases were displayed in the congruent order that appeared in the sentence (first the shape, then the number) or in the incongruent order (first the number, then the shape). The logic was that if the inherent order of the conditional was first antecedent and then consequent, participants were faster verifying those "if then" conditionals when the screen showed first shapes and then numbers than in the opposite order. The authors then compared the verification response times for congruent and incongruent presentations of different logical cases according to the order of presentation of the terms in the previous sentence.

Using different studies with this procedure, Oberauer et al. (2005, p. 1226) proposed the "inherent directionality" hypothesis, maintaining that some directionality effects on comprehension are produced when reasoners construct mental models (see Johnson-Laird & Byrne, 2002) in working

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memory. Thus, for certain relational statements, reasoners prefer to start with one term (the "relatum" term) rather than the other (the "target" term) according to their semantic structure (see Gernsbacher, 1991). Thus, in a first step, people establish a mental context or foundation, taking one element of the statement, so it works as a presupposed reference or relatum. In a second step, the remaining information or target is understood in relation to this presuppositional element (Oberauer & Wilhelm, 2000, p. 1703). For example, Oberauer and Wilhelm (2000, Experiment 3) found faster verification times in the congruent order of "if A then B" statements (A first and then B) and in the incongruent order for reverse "A if B" conditionals (B first and then A). The relatum term seemed to be the "if" term. However, for exclusive "A only if B" and biconditional "if and only if A then B", the authors found forward and lack of directionality, respectively. This suggests that the specific meaning of every conditional connective, but not its common syntactic structure, permits us to predict its inherent directionality.

Oberauer and Wilhelm (2000) did not examine other kinds of relational statement for which an "epistemic" representation had been proposed. For example, according to the mental model theory, semifactual and counterfactual conditionals, like factual conditionals, refer to a hypothetical "A & B" situation, but also include a presupposition: telling us there was a different factual situation (see Byrne, 2002, 2005; Byrne & Tasso, 1999). Counterfactual conditionals are a kind of counterfactual expression, an example being:

(3) "if there had been a circle (A), there would have been the number 3 (B)".

For counterfactual conditionals, the actual fact is "not-A & not-B" and for semifactuals "not-A & B" (see McCloy & Byrne, 2002).

There are several studies on how semifactuals are represented that support the previous assumption about comprehension of semifactual conditionals. Santamaría, Espino, and Byrne (2005), Gómez-Veiga, García-Madruga, and Moreno-Ríos (2010) and McCloy and Byrne (2002) support the double representation of counterfactual and semifactual conditionals during comprehension with a priming task. Moreno-Ríos, García-Madruga, and Byrne (2003, 2008, Experiment 1) proposed from the mental model account that "even if" statements like (1) are represented with two initial mental models derived from the meaning: one corresponding to the literal conjecture expressed in the sentence "A & B" and another representing what really happened "not-A & B". Moreno-Ríos et al. (2003, 2008, Experiment 1) found that inferences with "even if" were consistent with this double representation. Higher working memory load was expected than for "if then", with only one initial model, and more difficulty accessing an alternative model. Accordingly, more asymmetric responses were given for DA inferences (e.g. to infer "B" given "not-A") and fewer "modus tollens" inferences that required accessing a third model "not-A & not-B" were obtained for "even if". Handley and Feeney (2004, 2007) replicated the results with an inference task, but they give an alternative explanation based on the suppositional account (see also Feeney & Handley, 2011).

Following Oberauer and Wilhelm's (2000) logic, the directionality of "even if" can be predicted based on their predictions for "B only if A" and "if and only if A then B" statements. Inclusive statements with "even if" have the opposite meaning to exclusive "only if" conditionals. For both statements, the consequent could play the role of a pragmatic presupposition and the antecedent could work as the "target" element (see the example given by the authors about the light and the alarm, p. 1708). With "B only if A", the antecedent identifies a necessary condition or prerequisite. For "even if A, B", in turn, the antecedent corresponds to an unnecessary condition. Thereby, "only if" statements suggest that "A & B", but not "not-A & B", is a possible situation, while "even if" means that both situations are possible. For "only if", the authors proposed that if the value "not-A" is given for the antecedent, an eventual second step from "not-A" to "not-B" is produced in order to ensure the truth of the statement. However, the situation "not-A & B" does not falsify the "even if" statements. This second step is not expected for semifactuals. However, according to Oberauer and Wilhelm (2000), the frequency of the inferences also permit us to predict the directionality effects for a given relational statement. The "even if" statements usually lead us to infer "B" from "A" and "not-A". Thus, it is possible that the "pragmatic" backward directionality and the opposite "semantic" forward preferences neutralise each other. This possibility is also consistent with the lack of inherent directionality found for biconditionals in Oberauer and Wilhelm's (2000) study, which was explained by authors arguing that both forward and backward preferences were given.

Method

Participants

Eighty-eight students in the 2nd year of Psychology (University of Granada) participated in the experiment. They participated voluntarily in return for a course credit. Their average age was 20.01 years ($SD = 2.32$), ranging from 19 to 33. None of them had previous training in logic and all of them were native speakers of Spanish.

Materials and procedure

Seventy-two sentence verification trials were displayed on a computer screen, following the experimental design methodology used by Oberauer and Wilhelm (2000, Experiments 2–3b). The sentences were conditionals of two kinds, relating a geometrical shape to a number: (a) "If there was a circle then it contained a three"; and (b) "Even if there had been a circle, it would have contained a three". Half the trials began with an "if then" conditional and the other half with a semifactual "even if" conditional. Also, in half the trials, in the congruent condition, the shapes were presented before the numbers (keeping the order in the conditional: antecedent, then consequent) and in the other half, in the incongruent condition, the numbers were shown before the shapes.

Half the sentences were true with respect to the picture of the three items and half were false. Conditionals such as "if A then B" or "even if A, B" are false when in the set of cases there is one "A & not-B" case (e.g. "if there was a circle then it contained a 3" is false if there is a circle that does not contain a 3 but, e.g., a 2). Following Oberauer and Wilhelm's (2000) procedure, all the trials contained two fixed cases that made the conditionals true: "A & B" and "not-A & B" (e.g. a circle with a 3 and a square with a 3). The third case was the critical one, which could make the conditional true "not-A & not-B" (e.g. a square with a 2) or false "A & not-B" (e.g. a circle with a 2). A third of the trials were fillers with a repetition of one of the two fixed cases ("A & B" and "not-A & B"). The three items were shown randomly. Therefore, three factors were manipulated within-participants: the conditional relation ("if then" and "even if"), the congruence between the order of the terms in the sentence and the order of appearance in the picture (congruent and incongruent) and the critical logical case ("not-A & not-B" and "A & not-B").

Participants were invited to sit comfortably in front of a computer screen. In the task, participants read a story in which a teacher asked her students to say a "true sentence" regarding three shapes with numbers in them. Every trial displayed the sentence until the participant pressed a key to indicate s/he had read and understood its meaning. No time limit was set to read the previous relational sentence, so the participant had to press the spacebar key to continue the trial. Then, three geometrical shapes appeared in a row and, after 1000 ms, a number was shown inside each shape. Participants had to evaluate whether the sentence was true based on the three cases by pressing the keys "*h*" (Yes) or "*j*" (No) (see Figure 1). The instructions were presented verbally and on an initial screen before each experimental session. The stimuli were randomly chosen from a set of five shapes (circle, semicircle, triangle, square and cross) and five numbers (1, 2, 3, 4 and 5). Key responses and response times were recorded. The presentation and the data recording were performed with *E-prime 2.0* (Psychology Software Tools, Sharpsburg, PA).

Results

Response times data

The response times were logarithmically transformed and filtered by participant and condition using 2.5 standard deviations (2.81% of trials were eliminated). The participants with more than 90% identical responses (9.09%) were eliminated from the analysis. With the resulting data, a repeated measures analysis of variance (ANOVA) was carried out including the following factors: 2 relation ("if A then B" and "even if A, B"), 2 congruence (congruent and incongruent) and 2 differential logical cases ("not-A & not-B" and "A & not-B"). The latency data are summarised in Table 1.

Results showed faster response times for the congruent condition and no other main effect (1543 ms vs. 1697 ms, $F(1, 79) = 21.14$, $p < .001$, $\eta p^2 = .21$). This congruence factor interacted with relation ($F(1, 79) = 7.10$, $p < .01$, $\eta p^2 = .08$) and with the logical case ($F(1, 79) = 15.50$, $p < .001$, $\eta p^2 = .16$). The congruent order was significantly faster than the incongruent order for "if then" (1468 ms vs. 1700 ms, $F(1, 79) = 32.73$, $p < .001$, $\eta p^2 = .29$) but not with "even if" ($F(1, 79) = 3.14$, $\eta p^2 = .04$). Differences were obtained in the congruent condition only for the true case "not-A & not-B" (1480 ms vs. 1736 ms, $F(1, 79) =$

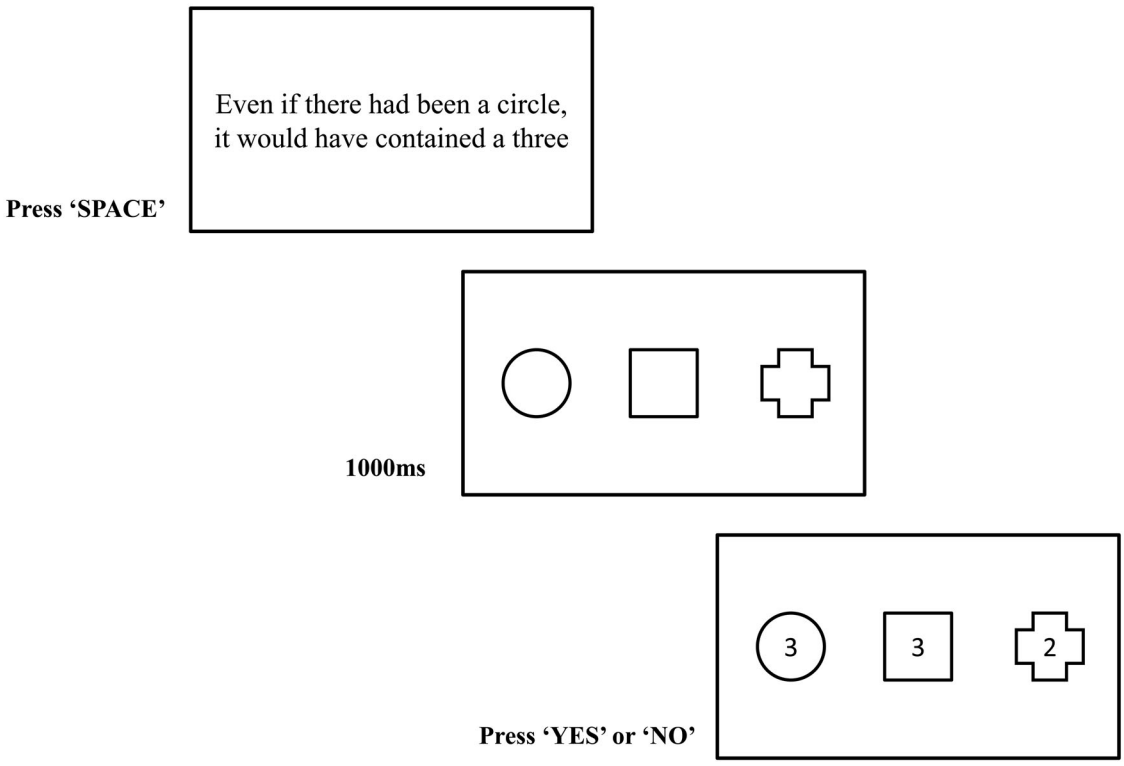

Figure 1. Example of the sequence for a trial.

35.17, $p < .001$, $\eta p^2 = .31$) and no differences were obtained for the false case "A & not-B" ($F(1, 79) = 1.23$, $\eta p^2 = .01$). The three-factor interaction was also significant ($F(1, 79) = 5.76$, $p < .05$, $\eta p^2 = .07$), showing that there was only one "fast" condition significantly different to the others: the congruent condition in "if then" conditionals and for the case that made the conditional true. That is, the analysis of the interaction showed no effect or interactions for the case that made the conditional false, "A & not-B" ($F(1, 79) = 0.03$, $\eta p^2 = 0$). The interactions were shown for the case that made the conditionals true: "not-A & not-B" ($F(1, 79) = 11.96$, $p < .01$, $\eta p^2 = .13$). Only for the "if then" conditionals was the congruent condition faster (1353 ms vs. 1747 ms, $F(1, 79) = 49.27$, $p < .001$, $\eta p^2 = .38$). No significant effect of congruence was shown for "even if" conditionals ($F(1, 79) = 3.37$, $\eta p^2 = .04$).

Accuracy data

Following Oberauer and Wilhelm's (2000) procedure, accuracy data were analysed to test for a possible speed-accuracy tradeoff. The accuracy data are summarised in Table 2. The results showed that responses were more accurate for "if then" (76% vs. 67%, $F(1, 79) = 30.21$, $p < .001$, $\eta p^2 = .28$), and that the congruent condition was more accurate (73% vs. 70%, $F(1, 79) = 4.63$, $p < .05$, $\eta p^2 = .05$). The congruence factor interacted with case ($F(1, 79) = 5.59$, $p < .05$, $\eta p^2 = .07$) and relation interacted with the logical case ($F(1, 79) = 22.71$, $p < .001$, $\eta p^2 = .22$). For the "not-A & not-B" case, more correct verifications were given with the congruent order (71% vs. 65%, $F(1, 79) = 13.79$, $p < .001$, $\eta p^2 = .15$) and with "if then" (80% vs. 57%, $F(1, 79) = 38.44$, $p < .001$, $\eta p^2 = .33$). For the "A & not-B" case, no significant effects of congruence ($F(1, 79) = .04$, $\eta p^2 = 0$) and conditional relation ($F(1,$

Table 1. Mean response times (ms) according to relation, congruence and logical case. Values in brackets show standard deviation.

Congruence	Congruent		Incongruent	
Logical case	not-A & not-B	A & not-B	not-B & not-A	not-B & A
If A then B	1357 (621)	1578 (715)	1747 (784)	1652 (716)
Even if A, B	1605 (945)	1635 (822)	1725 (900)	1665 (709)

Table 2. Accuracy data (%) according to relation, congruence and logical case.

Congruence	Congruent		Incongruent	
Logical case	not-A & not-B	A & not-B	not-A & not-B	not-B & A
If A then B	84 (24)	71 (31)	75 (28)	75 (30)
Even if A, B	59 (40)	78 (29)	56 (37)	75 (27)

Note: Values in brackets show standard deviation.

79) = 1.75, ηp^2 = .02) were shown. As in the verification time analysis, there was a three-way interaction ($F(1, 79) = 6.81$, $p < .05$, $\eta p^2 = .08$): only for "if then" conditionals, not for "even if" ($F(1, 79) = 1.29$, $\eta p^2 = .02$), the true case "not-A & not-B" was evaluated faster and more accurately in the congruent condition than in the incongruent one (84% vs. 75%, $F(1, 79) = 17.37$, $p < .001$, $\eta p^2 = .18$). No other effect was significant ($p > .05$).

Discussion

The main interest of this research is to evaluate the directionality effect of "even if" expressions in comparison to "if then" statements. The inherent directionality of the premises is one of the main factors responsible for facilitating the integration of premises in deduction. Knowledge of it could help us explain and predict how people make inferences with "even if". Results replicate previous findings of forward directionality for "if then" conditionals (Oberauer & Wilhelm, 2000), and are consistent with lack of directionality for "even if" conditionals.

The hypothesis for the existence of an inherent directionality came from how relational expressions are represented and what is represented first. For example, Oberauer and Wilhelm (2000) affirmed, based on their results, that "if A then B" and "B if A" conditionals are represented with "A" as the relatum, that is, as the reference object in the sentence, and this is represented first. When the order for displaying the elements in the verification task picture matches the order of relatum-target in the sentence, the evaluation time is faster than in the opposite order. From this view, the term from which the inferences are usually made (either the antecedent or the consequent) is what acts as relatum, except when the meaning (or the context) induces a belief in a different state of affairs. The authors assume that this is what happens with exclusive "A only if B" and biconditionals "if and only if A then B", for which forward directionality and lack of directionality, respectively, were found. Thus, the mental model theory proposes that semifactual as well as counterfactual conditionals are represented by two kinds of epistemic representation: the factual or presupposed model and the counterfactual or conjectured possibility (Byrne, 2002, 2005; Byrne & Tasso, 1999). Therefore, they provide a way of testing the extensibility of Oberauer and Wilhelm's (2000) proposal to other relational statements. This is the first time (to our knowledge) that the inherent directionality of semifactual "even if" expressions has been evaluated.

We investigated directionality in the comprehension of semifactuals by comparing their performance in a sentence-picture verification task with the "if then" statements, with only one initial mental model "A & B". With both "if then" and "even if", forward directionality is predicted, given that the MP, and MP and DA, respectively, are their most frequent inferences. But "even if", in contrast with "if", also elicits a presuppositional meaning for the consequent. So, as Oberauer and Wilhelm (2000) assumed for biconditionals, neutralisation of the two opposite preferred directions is to be expected. Therefore, no directionality is predicted for "even if" and forward directionality for "if then".

Results showed that the conventional order was faster for "if then", but not for "even if". Accuracy was analysed by Oberauer and Wilhelm (2000) to discard a speed-accuracy tradeoff. Results were not compromised by tradeoff. Actually they mirror the main results of the time analysis: no differences in correct responses were obtained for congruent and incongruent order for "even if". Again, the only significant difference was obtained for "if then".

This task, like Oberauer and Wilhelm's (2000) study, was not designed to evaluate or compare the different cases and therefore does not provide a systematic manipulation of them (and maybe that is why the author analysed this variable only to discard tradeoff). There is only one set of true cases (as well as false ones) and it is fixed from the beginning. However, it is possible to test whether the results provided by the task match the authors' theoretical logic. We therefore included in the analyses true cases (consistent with the representation of the conditional) and false cases (there is a case inconsistent with the conditionals: the "A & not-B" case) as independent factor, the reason being that only the true case is present in the set of mental (implicit or explicit) models. According to the mental model theory (see Johnson-Laird & Byrne, 2002), the false case is not represented by the meaning of the conditional, and therefore, participants should just discard it. We cannot see any reason to expect differences of congruence when the case is not represented. Accordingly, results showed no difference for false cases, only for true ones.

Moreover, we can go beyond the objective of this research and interpret the results of accuracy and response times regarding the semantic of "even if". Access to an alternative but consistent "not-A &

not-B" situation was easier with "if then" statements than with "even if", in accuracy and latencies. These results regarding the content of the representation support the idea that "even if" conditionals are represented with two initial representations "A & B" and "not-A & B", while "if then" are represented with only one, "A & B". Previous studies with a priming task suggest this view (Gómez-Veiga et al., 2010; Santamaría et al., 2005). Also, fewer correct responses were obtained for "even if" than "if then". This result is also consistent with the results of inference tasks using arbitrary, neutral and thematic contents, in which fewer endorsed and correct inferences were obtained with "even if" than with "if then" (Handley & Feeney, 2004, 2007; Moreno-Ríos et al., 2003, 2008; Moreno-Ríos & García-Madruga, 2002).

The standard measure of directionality of relational expressions based on the verification task could be limited in some way. For example, based on the suppositional approach, Feeney and Handley (2011) maintained that people interpret semifactual conditionals by computing the probability of occurrence of the consequent, given the presence and absence of the antecedent. Using a truth table task, they found that the probability of accepting a semifactual is greater when the causal relationship established in the conditional is intermediate, that is, not too strong but not too weak. This happens in indeterminate contexts (Byrne, 2005). The context, the contents and the nature of the task have an influence on the representations (see also, Johnson-Laird & Byrne, 2002, p. 658). The standard verification task includes arbitrary contents, and therefore there is no previous relationship between antecedent and consequent. Therefore, the results of absence of directionality could be limited to this kind of relationship.

Together with these pragmatic effects, directionality in deduction could also depend on other additional factors, such as what other relational expressions are present as premises, how the elements in the sentence are shown (figural effects), etc. There are interesting studies that try to provide general ground rules based on the role of the relatum (e.g. Espino & Hernández, 2009; Oberauer et al., 2005). One possibility is that, different relata are acting at different levels of representation or at different times. At a low level, the initial representation could be made from one term to the other. At a pragmatic level, the presuppositional model could work as a reference in an integrated representation of the two initial models. The factual model "not-A & B" could then be working as "relatum" or foundational element in relation to which the counterfactual model "A & B" is thought of as the "target" situation. This last alternative is consistent with Stewart, Haigh, and Kidd's (2009) studies with counterfactuals in which they demonstrated that presenting a presuppositional scenario makes the comprehension of counterfactuals easier. Future research could clarify whether all these factors, such as processing time, kind of task and previous knowledge about causal relationships, could alter the basic directionality shown by the verification task.

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