

The Semantics, Pragmatics and Processing of Conditional Connectives -

German *wenn*, *wur Wenn*, and *wenn und nur wenn*

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Conditionals are one of the most studied topics in cognitive science. This paper focuses on the semantics, pragmatics and processing of conditional connectives (CCs) such as *if*. While in logic *if* is treated as a binary truth-functional connective of material implication (see criticisms in [2], [3] and [4]), [6] proposes to treat the natural language *if* as a restrictor with no conditional meaning. Follow-up studies show that the interpretation of conditionals is subject to semantic/pragmatic modulation, but the modulating role of CCs remains unclear. In this paper, we deal with the lexically related German CCs *wenn* ‘if’, *nur wenn* ‘only if’ and *wenn und nur wenn* ‘if and only if’. The last one is usually taken as biconditional, i.e. both the modus ponens (MP) and the affirmation of the consequent inference (AC) are valid. Biconditional sentences entail both of the inferences in (2).

(1) MP: Premise1 – $p \rightarrow q$. Premise2 – p . // Conclusion – q .
AC (via contraposition): Premise1 – $p \rightarrow q$. Premise2 – $\neg p$. // Conclusion – $\neg q$.

(2) a. $p \rightarrow q$: all p -cases are q -cases b. $\neg p \rightarrow \neg q$: all not- p -cases are not- q -case

Wenn or *nur wenn* is different. First, logically, MP should be valid for all conditional sentences. Secondly, based on the semantics proposed for *only* in [8], *nur-wenn* sentences should entail (and asserts) the negative proposition as in (2b). However, [7] argues that sentences such as (3) “do not presuppose that all (normal) instances of hard work will be rewarded by success”, which casts doubt on its biconditional status. In comparison, MP is valid for bare *wenn*-conditionals for which AC is not valid, but such sentences as (4a) can be perfected via (4b) to biconditionals in (4c), pragmatically, see [5] and subsequent work.

(3) *Only if you work hard do you succeed.*

(4) a. *If you mow the lawn, I will give you 5 dollars.* ($p \rightarrow q$)
b. *If you don't mow the lawn, I won't give you 5 dollars.* ($\neg p \rightarrow \neg q$)
c. *If and only if you mow the lawn, I will give you 5 dollars.* ($p \leftrightarrow q$)

We present four experiments investigating *wenn/nur wenn/wenn und nur wenn* – our corpus search in the Detusches Referenzkorpus (DeReKo-2020-I) shows that the last one is rarely used. Using a sentence completion task (Exp. 1), an acceptability rating task (Exp. 2), a self-paced reading task (Exp. 3) and a sentence production task (Exp. 4), we investigate the extent to which each of the CCs is amenable to a biconditional reading.

Experiment 1 ($N_{\text{subjects}} = 102$, $N_{\text{items}} = 48$, $N_{\text{fillers}} = 48$): participants read short scenarios such as (5) including a context sentence (S1), a conditional sentence (S2) with *wenn* or *nur wenn* (*if/only if* p , q), and a third sentence (S3) containing the affirmative or negated antecedent proposition (p / *not* p). They were then presented with an incomplete fourth sentence (S4) containing a reference to the subject of S3 and prompted to produce a suitable continuation. We checked whether the continuations are negative (i.e. downward-entailing) or not.

(5) S1: Kristian las die Zeitung und dachte sich: (*K. read the newspaper and thought:*)
S2: Wenn/Nur wenn die Artikel interessant sind, schneide ich einen aus.
(*If the articles are interesting, I'll cut one out.*)
S3: Wie sich zeigte, waren die Artikel (nicht) interessant.
(*As it turned out, the articles were (not) interesting.*)
S4: Von denen schnitt er ... (*of those he cut [to be completed]*)

Both in the CC_{wenn} and the $CC_{\text{nur-wenn}}$ condition, <1% of responses after a confirmed antecedent (*if* p , q ; p) contained a negated consequent (*not* q). After a negated antecedent (*if* p , q ; *not* p), however, considerable proportions of sentence completions contained a negated consequent (15% in CC_{wenn} ; 11% in $CC_{\text{nur-wenn}}$). These results suggest that for both CCs MP is valid but neither of them was strictly treated as biconditional.

Experiment 2 ($N_{\text{subjects}} = 100$, $N_{\text{items}} = 48$, $N_{\text{fillers}} = 48$): Participants were presented with sets of three sentences. S1 contained a conditional sentence (*if* p , q .) with *wenn* or *nur wenn*; S2 contained either the true antecedent (p) or the true consequent (q); S3 contained a question about the truth of either the consequent (MP) or the antecedent (AC), respectively. Participants were asked to rate S3 on a 5-point Likert scale. A Bayesian ordinal mixed model with CC and Inference (MP/AC) plus their interaction revealed that the

biconditional interpretation is most prominent overall. However, *nur wenn* lent itself more to a biconditional reading than *wenn*, with probabilities of complete acceptance in AC almost at ceiling in *nur wenn* but not in *wenn*. In contrast, acceptance rates in MP were at ceiling for *wenn*, as expected, but lower for *nur wenn*, casting doubt on the biconditionality of the latter. An analysis of decision times for ratings mirrored the results obtained in the ratings, with conditions of lower ratings showing longer reaction times.

Experiment 3 ($N_{\text{subjects}} = 24$, $N_{\text{items}} = 108$, $N_{\text{fillers}} = 24$): We presented participants with scenarios of the same structure as in Exp. 1 for self-paced reading, except that S2 always contained a negated antecedent and that S4 was a complete sentence relating to a negated or non-negated consequent ($q / \text{not } q$), such as *Von denen schnitt er **einen/keinen** aus und las weiter* ('Of those he cut one/none off and read on.'). A Bayesian mixed effects regression model with CC (*wenn/nur wenn*) and q (positive/negative) plus their interaction revealed that reading times (RTs) of the positive quantifier *einen* in S4 were statistically equivalent, whereas the negative quantifier *keinen* was read decisively faster in the *nur wenn*-condition than in the *wenn*-condition (see Figure 2). These results indicate that the meaning $\text{not } p \rightarrow \text{not } q$ is activated more strongly by *nur wenn* p, q than by *wenn* p, q .

Experiment 4 ($N_{\text{subjects}} = 100$, $N_{\text{items}} = 6$): Participants created sentences using the three CCs *wenn/nur wenn/wenn und nur wenn*, two for each CC. Introspective qualitative analyses of the collected data show that both MP and CP are valid for all sentences using *wenn und nur wenn*, indicating its biconditionality. In terms of MP, the same general pattern holds for *wenn* sentences (90%), whereas in only about 63% of *nur wenn* sentences MP is valid. As for CP, the inference $\text{not } p \rightarrow \text{not } q$ is qualified as valid for all sentences with *nur wenn*, whereas it is valid only in about 35% of the produced *wenn* sentences.

Conclusion: First, *wenn und nur wenn*, for which all p -cases are q -cases ($p \rightarrow q$) and all not- p -cases are not- q -cases ($\text{not-}p \rightarrow \text{not-}q$), is semantically biconditional. *Nur wenn* and *wenn*, on the other hand, are not biconditional connectives. While for *wenn* all p -cases are q -cases, only some not- p -cases are not- q -cases (where "some" can turn to "all" by conditional perfection, in some contexts, see [1]). While for *nur wenn* all not- p -cases are not- q -cases, only some p -cases are q -cases (compatible with [8]), a novel empirical finding calling for further analytic description.

Figure 1. Mean ratings in Exp. 2.

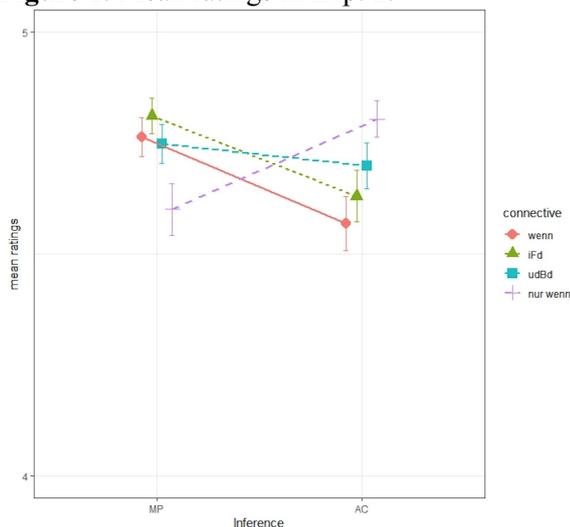
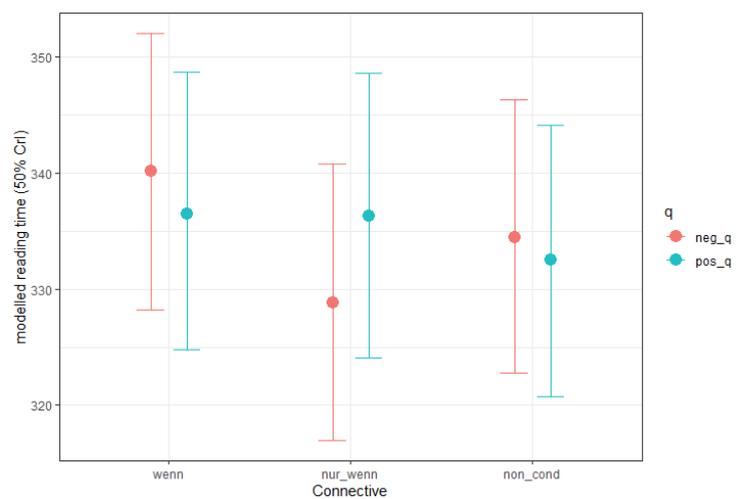


Figure 2. Modelled RTs for *keinen/einen* in Exp. 3



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