Simple downward entailment is not strong enough!
An ERP study on Negative-Polarity-Items (NPI) in German
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I. The issue
We provide evidence from an event-related brain potentials (ERPs) study on NPI-processing that a notion of simple downward entailment is too weak to correctly analyze various NPI-licensing environments. Licensing strength seems to offer a more promising analysis. The results confirm the insights of the recent theoretical discussion (cf., among others, Zwarts 1993, van der Wouden 1997, Giannakidou 1998, 2001, also Krifka 1995, Szabolcsi 2002), and at the same time they allow us to discriminate between alternative proposals. Our evidence favours an approach based on (non)veridicality (Giannakidou 1998, 2001) as well as a pragmato-semantic approach along the lines proposed by Krifka (1995).

II. Theoretical background and aim of the study
One of the most important results on NPIs in the last decade is the observation that not all NPIs are always licensed in all negative polarity contexts, thus showing that a characterization of negative polarity contexts in terms of a simple ‘downward entailment’ (Ladusaw 1979) is not precise (‘strong’) enough (Zwarts 1993, van der Wouden 1997). Negative polarity contexts are not equally ‘negative’ (i.e., not equally ‘downward entailing’), but rather they vary according to their ‘negative strength’. The strength of negative expressions is measured on the basis of how many of De Morgans’s rules they satisfy (Zwarts 1996, van der Wouden 1997). The more De Morgan’s rules a given expression satisfies, the stronger it is. Accordingly, negative expressions can be organized hierarchically with antimorphic expressions (e.g., sentential negation), being the strongest form of negation, anti-additive contexts (e.g., negative quantifiers like no man), being the second strongest form of negation, and finally downward monotonic or downward entailing expressions (e.g., quantifiers like few men), representing weak negative contexts. However, it is not clear whether all negative polarity contexts can be defined in terms of monotone decreasing, anti-additive or antimorphic functions. Questions constitute a perfect example of a context that cannot be easily defined as downward monotonic. Various proposals have been suggested to define questions in terms of downward monotonicity (cf., e.g., van der Wouden 1997, referring to Victor Sánchez Valencia, or Gutiérrez-Rexach 1997). Conversely, Giannakidou (1998, 2002) proposes an account based on (non)veridicality (which is defined in terms of truth), whereby negation represents an antiveridical operator and question are defined as nonveridical. Both approaches (based on downward monotonicity (algebraic functions) or based on (non)veridicality (truth values)), differentiate between negation (or negative quantifiers) and questions in that the latter context is a weaker licenser. One aspect that so far has not been addressed is whether this theoretical distinction between ‘a strong’ and ‘a weak’ licenser has also psycholinguistic reality. Thus, we conducted an online study. Previous ERP studies on the NPI-licensing (Shao&Neville 1998, Saddy et al. 2004, Drenhaus et al. 2004, 2005, in press) have primarily focused on processing effects when a NPI fails to be licensed either because there is no licenser at all or there is a licenser but it is structurally not accessible. The investigated contexts only included negation (or lack of negation). However, no online study so far has posed the question of whether ERP effects found in the processing of NPIs in canonical negative contexts will also be found in other negative polarity contexts such as, e.g., questions. This question is important since it has direct implications for the recent linguistic theorizing.

III. Experiment
Our experiments focused on the processing of the German NPI jemals ‘ever’ in four types of constructions: two licensing contexts, including (a) negation kein X ‘no X’ and (b) WH-questions with welcher X ‘which X’, and two non-licensing contexts, including (c) contexts with definite der ‘the’-DPs, and (d) contexts with indefinite ein ‘a’-DPs.

(a) Kein / (b) Welcher / (c)*Der / (d) *Ein /Lehrer hat den Schüler jemals geschlagen./?
(a) No / (b) Which / (c) *The / (d) *A /teacher has ever hit the schoolboy./?
The following ERP patterns (measured from the onset of the critical word ('jemals 'ever')) have been found: 1) the incorrect conditions (c) and (d) show a negativity around 400 ms (N400 component) followed by a positivity around 600 ms (P600 component) compared to the correct condition (a); 2) the incorrect conditions (c and d) differ in that the indefinite condition (d) showed a significantly weaker N400 effect than the definite condition (c) compared to (a); 3) both incorrect conditions (c) and (d) show a P600 compared to the correct condition WH condition (b), however, only the condition definite condition (c) displays an N400 effect; 4) the comparison of the two licensing contexts (a and b) shows that the WH-condition (b) is much more negative going than the (a) condition.

VI. Discussion/Interpretation of the results The first and most important result of our study is that the nature of licensing strength is directly reflected in the ERPs. This shows that the difference between ‘strong’ and ‘weak’ licensing contexts is not only a theoretic construct but something that has a psycholinguistic reality. We take this result as direct evidence that a characterization of licensing contexts in terms of a simple downward entailment is not enough since otherwise we would expect not to find any difference in the ERPs between the negation-and the wh-context (a and b). Our study provides some arguments for favouring the (non)veridicality-based approach to licensing strength over that based on downward monotonicity. The relevant evidence comes from the comparison of the definite (c) versus indefinite (d) condition. In negative contexts, the indefinite condition induce a weaker N400 compared to the definite condition; in wh-contexts, the indefinite condition does not show any N400. The observed ERPs can be interpreted as follows. The definite determiner can be interpreted as ‘referential’ in the sense that it requires that the denotation of the NP argument be nonempty (existential presupposition). In contrast, the indefinite determiner does not require that the denotation of the NP argument be nonempty. Assuming that referentiality or presuppositionality in the determiner domain correlate with veridicality (see Giannakidou 1998 for a detailed discussion), we can define the definite determiner as ‘veridical’ and the indefinite determiner as ‘nonveridical’. Given these characterizations, the ERPs receive a straightforward explanation. A definite determiner, being itself ‘veridical’, is incompatible with an ‘antiveridical’ (negation) and ‘nonveridical’ (question) environment. This incompatibility manifests itself in both cases in the N400s. In contrast, an indefinite determine, being itself ‘nonveridical’, suits another ‘nonveridical’ environment (here: questions). Since in the latter case there are no opposite ‘veridicality’ properties, no N400 was attested. Moreover, an indefinite (‘nonveridical’) determiner is also (weakly) compatible with a stronger ‘antiveridical’ environment (here: negation) since – unlike the definite determiner – it does not induce the opposite veridicality value, but rather represents in a sense a weaker form of ‘antiveridicality’. This difference in the strength of ‘nonveridicality’ (‘nonveridical’ versus ‘antiveridical’) manifests itself in form of a weak N400. Crucially, the effects induced by definite and indefinite determiners can be accommodated in a (non)veridicality-based approach. Under a downward monotonicity-based approach it is not obvious how they could be accounted for since the definite determiner (due to its referential status) does not presumably have any monotonic properties, and the indefinite determiner is upward monotonic at best (Zwarts 1996). Further evidence of varying licensing strengths can be seen in the modulation of the P600 component. Following Drenhaus et al. in press we interpret the P600 component as a marker of interpretational complexity: in order to correctly process an NPI, not only its semantic structure has to be taken into account but also the independently motivated pragmatic principles (Krifka 1995). According to this analysis, NPIs introduce alternatives and the alternatives in turn induce the ordering relation of semantic specificity. Hence, the computation of NPIs requires complex interpretational rules which can handle structured meanings. The complexity of this task – in our view – is reflected in the P600 component and the observed modulation in the P600 reflects the differing interpretational loads associated with the definite and indefinite expressions.
**Figure 1.** ERP effects on the negative polarity item "jemals" (ever) from the onset up to 1000ms thereafter at the PZ electrode. Negativity is plotted upwards. The solid line displays the grammatical negation-condition (a), the dotted line displays the incorrect definite condition without any negation (b) and the broken line displays the incorrect indefinite condition without any negation (c).

**Figure 2.** ERP effects on the negative polarity item "jemals" (ever) from the onset up to 1000ms thereafter at the PZ electrode. Negativity is plotted upwards. The solid line displays the grammatical WH-condition (d), the dotted line displays the incorrect definite condition without any negation (b) and the broken line displays the incorrect indefinite condition without any negation (c).

**Figure 3.** ERP effects on the negative polarity item "jemals" (ever) from the onset up to 1000ms thereafter at the PZ electrode. Negativity is plotted upwards. The solid line displays the grammatical negation-condition (a) and the dotted line displays the incorrect definite condition without any negation (d).