Processing affirmation and negation in contexts with unique or multiple alternatives

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Negative sentences are syntactically more complex than their affirmative counterparts, which is expected to have impact on the comprehension processes. Accordingly, it has been observed that sentences containing negation are harder to process then affirmative sentences (e.g. Just & Carpenter, 1971; Carpenter, Just, Keller, Eddy, Thulborn, 1999; Lüdtke, Friedrich, de Filippis, Kaup, 2008), i.e. they involve longer reading times, higher error rates and longer response times in a truth-value judgment task. It has been a matter of an intense debate in linguistics and philosophy how negated concepts are represented and how negation is integrated into the sentence meaning. For instance, the *Two-Step-Simulation-Hypotheses* by Kaup, Lüdtke & Zwaan (2006) predicts that negation is integrated into the sentence meaning in two steps: At the first step, the comprehender simulates the negated state of affairs, whereas the actual state of affairs is simulated only at the second step. Hence, according to this model, in order to process a sentence such as *The door is not open* one needs to simulate first the open door before simulating the actual situation (closed door). However, polar adjectives such as *closed* vs. *open* allow for the identification of the negative of a predicate (e.g. *not open*) through its affirmative opposite (*closed*). Thus, in the case of polar predicates it is possible to represent a unique type of referent corresponding to the negated predicate (i.e. *not open door* is identified with *closed door*). In contrast, for such predicates as *red* that lack unique opposites there is no unique referent type that could be identified with its negative (e.g. *not red* can be either *blue,* or *green,* or *yellow, etc.*). The two-step model does not explain how the simulation of the actual situation should look like in the case when negation of a given predicate cannot be identified with a unique referent type. In their eye-tracking experiment, Orenes, Beltrán & Santamaría (2014) showed that in scenarios where the negative predicate (such as *not green*) can be identified with a unique, contextually provided, referent (e.g. *red* where the choice is only between red and green objects only) the comprehenders indeed focus on the affirmative alternative. In contrast, in scenarios that offer multiple affirmative alternatives (the choice is between green, red, yellow and blue objects and thus *not green* cannot be uniquely identified with neither *red* nor *blue,* nor *yellow*), the comprehenders focus on the negated predicate (green objects), which suggests that the second step of negation processing postulated in the two-step model might be suspended.

In our two experiments we addressed the question of whether the processing of affirmation and negation is facilitated in those cases where the context offers a unique referent relative to the cases where the context offers multiple referents. We ran our studies using the method of event-related potentials, which has a high temporal resolution and therefore is frequently used for the investigation of sentence processing. The experiments had the form of a sentence-picture-verification paradigm. The subjects were informed that they observe a person's moves in a game where she or he selects or unselects objects. There were always three items presented on the screen and then a virtual agent selected or unselected one or two of them. A green frame was used to indicate that the framed object was chosen and hence the unframed one(s) is/are unchosen by a virtual agent. A red frame was used to indicate that the framed object was not chosen and hence the unframed one(s) is/are chosen. Subjects were informed about the meaning of the frames' colors. After each move of the virtual agent the subjects had to evaluate whether the given affirmative or negative sentence truly describes the agent's move.

We used a 2 x 2 design with the factors: (i) **context model** (unique vs. multiple referent(s)) and (ii) **polarity** of the target sentence (affirmative vs. negative). First, the pictures were presented creating the context model and afterwards the target sentence was presented word-by-word on a screen while

the EEG was recorded. The pictures depicted three different objects (all of same gender)[1] out of which either one or two were then marked with a red or green frame. The target sentence always stated which object was chosen (**affirmative conditions**), e.g. *Julia hat die Pflaume ausgewählt* (*Julia has chosen the plum*) or which object was not chosen (**negative conditions**), e.g. *Julia hat nicht die Pflaume ausgewählt* (*Julia has not chosen the plum*). In the first experiment the sentence always referred to **unframed** objects. In the two conditions with a **unique choice** only one of the three objects was unframed and hence only one object could function as a truth-maker for the sentence (e.g. the plum in the example below for the conditions *Affirmative Unique and Negative Unique*). In the conditions with **multiple choice** two out of three objects were unframed and hence the context provided multiple referents (e.g. the plum and the cat for the conditions *Affirmative Multiple* and *Negative Multiple*).

Conditions in the First Experiment[2]:

Julia hat die Pflaume ausgewählt.

Julia hat nicht die Pflaume ausgewählt.

In the second experiment we reversed the framing[3] to make sure that the results are not affected by the framing color. Thus, the critical words always referred to the framed objects (in the affirmative conditions to the objects framed green and in the negative conditions to the objects framed red). Everything else was kept identical in both experiments. All target sentences gave true information with respect to the pictures. Subjects had to respond by clicking a button whether the sentence was true or false with respect to the previously observed move of the virtual agent. To balance out the material and the required responses we added filler sentences that were false as well as filler sentences that used choice between two objects only. Note that placing the negative marker in front of the critical noun was crucial for our design for two reasons. First, only this structure gave us the possibility to measure subject's expectations for the critical word that were based on the use of the negation. Second, this structure allowed for a comparison between two *Polarity* conditions and the two *Choice* conditions. Furthermore, the negation in this design takes scope over the object and therefore a wide sentential scope (as in *Julia hat die Pflaume nicht ausgewählt*) is avoided resulting in the number of possible readings of the sentence being reduced.

Results:

Picture 1 shows the Grand Averages (N=24) at the position of the critical word for all four conditions of Experiment 1. The preliminary analysis indicates a clear N400 effect for the multiple conditions compared to the unique ones, which is independent of the sentence polarity. This effect indicates that the processing of the unique referent is facilitated relative to the case when there are multiple referents available in the context model. Whereas it can be argued that the *Two Step Simulation Hypothesis* predicts that the contrast between multiple and unique cases should be larger for negative than affirmative sentences, our study does not support this claim. Furthermore, this result supports the view

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[1] The experiment was done using German sentences and with German natives speakers.
[2] The critical word is underlined.
[3] E.g. in the condition *Affirmative Unique* the chosen object was now framed green while the other two objects had no frame.

that the N400 is inversely correlated with the expectancy of the critical word in a context (Kutas et al., 1984), since the presence of several truth-makers in a scenario leads to higher N400 ERPs recorded for the noun referring to one them compared to cases where subjects can make a straightforward prediction regarding the sentence's truth-maker. Additionally, we observed a late positivity effect for the negative compared to the affirmative conditions, which is in line with the claim that negation is harder to process than affirmation. Therefore, our study provides an interesting insight into the question of how negative sentences are processed. Picture 2 shows the Grand Averages (N=24) at the position of the critical word for all four conditions in Experiment 2. We observe similar effects as in the first experiment clearly showing that our effects are not caused by a framing bias.
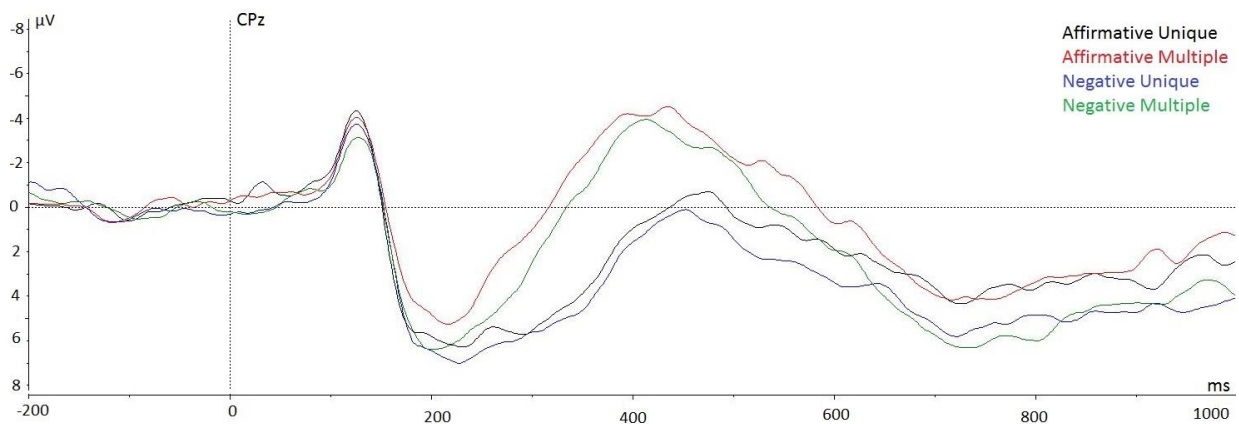
Picture 1: Experiment 1: Grand Averages at the critical noun
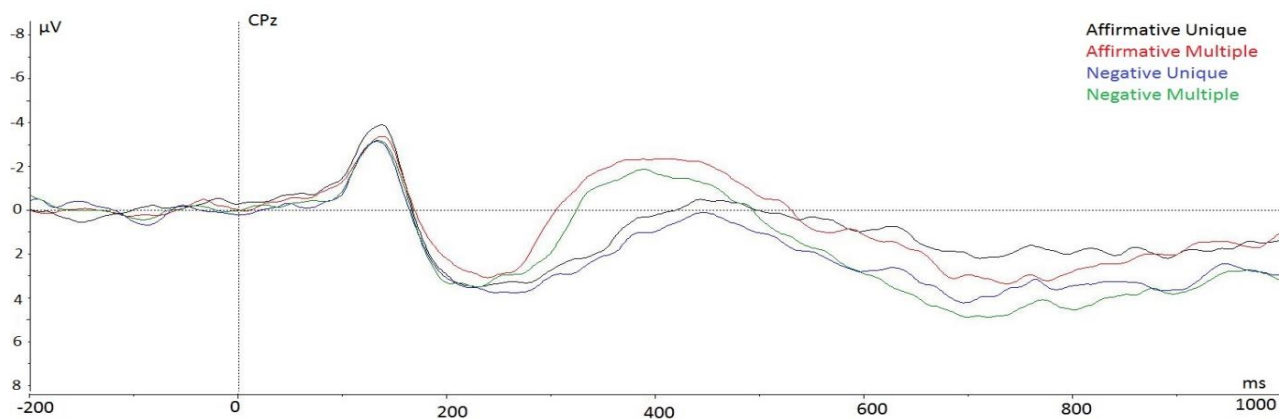
Picture 2: Experiment 2: Grand Averages at the critical noun

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