Effects of negation on visual processing capacity

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How does negation influence attention? This question has rarely been asked in research, even though one may easily assume that instructions using a negation might consume some of a listener's attention. In the present research, we aimed to answer this question based on the theoretical concept of Pragmatic Frames and a quantitative method to estimate attention. The concept of Pragmatic Frames allows us to formalize the task requirements that are raised in an interaction. According to Rohlfing and colleagues (2016), Pragmatic Frames can be defined as sequences of collaborative actions that involve operations on the cognitive as well as communicative and pragmatic level. The concept let us assume that depending on a joint task, different cognitive operations need to be performed in a sequence. One of the cognitive operations can reside in a focus on visual material. Visual attention is an important precondition for many actions. For instance, when someone explains a procedures or knowledge that includes visual material, they need to understand where the attention of the person to whom they talk is directed to or how attentive this person is. In everyday explanations, explainers often have an intuitive grasp on the attention of other persons, and these others may "backchannel" features of attention by, for instance, by gaze and verbal or nonverbal cues. In machine-to-human explaining, attention has to be estimated by other means, and our aim is to contribute to this research line.

For our purpose, we will use a method based on the theory of visual attention (Bundesen 1990), TVA, and originally developed by Tünnermann and colleagues (2015). Among others, this method yields a measure of overall visual processing capacity called C as well as attentional weights for particular stimuli, w. In order to measure the influence of negation, the participants had to direct their attention to a target pair of visual stimuli and avoid attending to a distractor pair. Both pairs were surrounded by grey background elements. This formal theory has been successfully used to measure visual processing capacity with high precision in basic research and clinical studies alike. In short, a high visual processing capacity leads to high precision in the order judgment.

We hypothesized that an instruction containing a negation may be more demanding on the cognitive resources than a semantically equivalent instruction without negation. More specifically, we assumed that negation will reduce measurable overall processing capacity C because some capacity will be devoted to the irrelevant pair mentioned in the negation. This assumption was motivated by psycholinguistic research concerned with sentence processing and showing that negation involves the processing of the positive argument in the first stage. For example, shortly after reading a negative sentence, participants simulated the positive argument of it (e.g., Kaup et al., 2007). However, some investigations yielded the possibility that processing of negation not always requires the simulation of the positive argument (Tian et al., 2016). It is possible that the context, i.e., framing the task, provides specific requirements that have crucial influences on the processing, and already the change of linguistic form might bring it about.

Method

26 subjects were tested in this pilot study. They were recruited via email and participated who received course credit for up to four sessions or without compensation. The instruction was offered in German (22 participants) and English (4 participants).

Procedure

The study was run via an online experiment. When clicking on the link, participants read an introduction to the experiment, and could then continue with 460 trials. In general, participants were asked to judge the order of two visual events. In each trial of the experiment, participants saw two pairs of flickering stimuli separated by a brief interval of up to 100 ms. More specifically, the respective visual stimulus vanished for a tenth of a second and thus appeared to flicker. The pairs had different salient colors chosen randomly among red, green, blue and yellow.

Attention was directed verbally. The instruction indicating which pair had to be judged either did so with the use of negation (e.g., “not blue” [nicht blau]) or without negation (e.g., “now green” [jetzt blau]). The colors and the instruction type changed randomly on a per-trial basis to keep expectancy low. Attention is assumed to be distributed evenly between the targets within a pair because both targets are visually similar. The weights (assumed to be .5 which corresponds to an even distribution of attention) are nevertheless computed because they are a free parameter in the model and may serve as a validity check.

From the judgments of participants (which stimulus flickered first), a formal theory of visual attention allows estimation of the overall visual processing capacity and distribution of attention for the processing of the two involved events.

Results

The analysis was conducted using a Bayesian statistical model for estimating the individual parameter values for all participants and comparing the resulting mean distributions. In line with our hypothesis, the mean overall visual processing capacity was severely reduced in the negation condition in comparison to the neutral condition: Whereas the neutral condition showed a processing capacity of 37 Hz which is comparable to previous studies, only three quarters of this capacity, 28 Hz, was available if the instruction contained negation. The mean distributions were not overlapping indicating that the same mean for both distributions is highly unlikely. The individual results reveal that only three participants deviate from this pattern so that they had more resources available in the negation condition. As expected, the mean attentional weight was equal (.5) for both targets in each condition meaning that neither had a processing advantage over the other. We can thus conclude that visual attention is highly likely to be negatively affected by the increased cognitive demands of a negation in instructions.
In our further research, we will extend the concept of Pragmatic Frames to our investigation by analyzing the sequence of cognitive operations that might vary in dependence on the task requirement (negation vs. assertion).

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