

# EVENT-RELATED POTENTIALS REVEAL TASK-DEPENDENCE AND INTER-INDIVIDUAL DIFFERENCES IN NEGATION PROCESSING DURING SILENT LISTENING AND EXPLICIT TRUTH-VALUE EVALUATION

C. HERBERT<sup>a,b,c,\*</sup> AND J. KISSLER<sup>d</sup>

<sup>a</sup> Department of Psychiatry, University of Tübingen, Germany

<sup>b</sup> Department of Biomedical Magnetic Resonance, University of Tübingen, Germany

<sup>c</sup> Department of Psychology I, University of Würzburg, Germany

<sup>d</sup> Department of Psychology, University of Bielefeld, Germany

**Abstract**—In sentences such as *dogs cannot fly/bark*, evaluation of the truth-value of the sentence is assumed to appear after the negation has been integrated into the sentence structure. Moreover negation processing and truth-value processing are considered effortful processes, whereas processing of the semantic relatedness of the words within sentences is thought to occur automatically. In the present study, modulation of event-related brain potentials (N400 and late positive potential, LPP) was investigated during an implicit task (silent listening) and active truth-value evaluation to test these theoretical assumptions and determine if truth-value evaluation will be modulated by the way participants processed the negated information implicitly prior to truth-value verification. Participants first listened to negated sentences and then evaluated these sentences for their truth-value in an active evaluation task. During passive listening, the LPP was generally more pronounced for targets in false negative (FN) than true negative (TN) sentences, indicating enhanced attention allocation to semantically-related but false targets. N400 modulation by truth-value (FN > TN) was observed in 11 out of 24 participants. However, during active evaluation, processing of semantically-unrelated but true targets (TN) elicited larger N400 and LPP amplitudes as well as a pronounced frontal negativity. This pattern was particularly prominent in those 11 individuals, whose N400 modulation during silent listening indicated that they were more sensitive to violations of the truth-value than to semantic priming effects. The results provide evidence for implicit truth-value processing during silent listening of negated sentences and for task dependence related to inter-individual differences in implicit negation processing. © 2014 IBRO. Published by Elsevier Ltd. All rights reserved.

**Key words:** language processing, negation processing, cognition, event-related brain potentials, N400, LPP.

\*Corresponding to: C. Herbert, Department of Psychiatry, University of Tübingen, Osianderstr. 26, Tübingen 72076, Germany. E-mail address: [cornelia.herbert@med.uni-tuebingen.de](mailto:cornelia.herbert@med.uni-tuebingen.de) (C. Herbert). **Abbreviations:** EEG, electroencephalogram; ERPs, event-related potentials; FN, false negative; ISI, inter-stimulus intervals; ITI, inter-trial interval; LPP, late positive potential; SOAs, stimulus onset asynchronies; TN, true negative.

## INTRODUCTION

Language comprehension comprises a sequence of processes. Some occur automatically, whereas others involve higher-order cognitive functions. Electroencephalogram (EEG) event-related potentials (ERPs) can be used as signatures of these processes. When participants listen to sentences, ERPs reveal a cortical negativity, the so-called N400 potential, whose amplitude is more negative for target words that are semantically unrelated with the sentence content (e.g., I drink coffee with shoes) compared to semantically related targets (e.g., I drink coffee with milk). Since first described by Kutas and Hillyard (1980), N400 effects have been studied as an index of semantic processing and contextual integration in a variety of experimental tasks such as reading, word, picture, face or odor processing (Kutas and Federmeier, 2000, 2011; Lau et al., 2008). The N400 is often followed by a positive potential, the P600 or late positive potential (LPP). Amplitudes of the LPP are more pronounced for stimuli whose encoding requires more processing resources due to memory updating or, for instance, due to processes of syntactic integration (Norris, 1986; Neely and Keefe, 1989; Foss and Speer, 1991). Although traditionally linked to syntactic processing (Gunter et al., 1997), LPP or P600 effects in language processing have also been demonstrated in semantics (Munte et al., 1998). Like the N400, the LPP has been determined in a variety of tasks with verbal and non-verbal stimuli. Its elicitation has been demonstrated to be dependent on attentional processes, possibly even the conscious awareness of the presented stimuli (Dehaene et al., 1998).

Nevertheless, the extent to which processes reflected by ERPs such as the N400 or the LPP are associated with active comprehension of sentence meaning is still debated (Kutas and Federmeier, 2011). Negation processing may represent a particularly interesting testing case, discriminating active language comprehension from automatic lexical or semantic processes. Recent psycholinguistic models assume negation processing to rely on two processing steps (Kaup, 2001; Kaup et al., 2007). First, the sentence is processed without the negated expression, then the enclosed negation term is integrated into the sentence structure and evaluated to compute the expression's truth-value. Previous research therefore aimed to investigate the different task and processing conditions in which the negation term will be integrated

into the sentence content and at which levels of language processing as reflected by ERPs such as the N400 and LPP, these processes might occur.

An early ERP study by [Fischler et al. \(1983\)](#) found that when presented acoustically, final target words in true negative sentences (TN) like in the sentence “a sparrow is not a building”, just like target words in false affirmative sentences (FA, e.g., a sparrow is a building), elicit larger N400 amplitudes than target words in false negative sentences (FN, e.g., a sparrow is not a bird), that violate people’s knowledge from everyday life experience. Thus, [Fischler et al. \(1983\)](#) found no evidence that the N400 as a cortical indicator of information processing already reflected processes related with negation or truth-value processing per se. Their N400 modulation pattern could be fully explained by differences in the semantic relatedness between subject and object in the chosen sentences.

More recent ERP negation studies, however, found that in active truth-value evaluation tasks, the N400 can vary as a function of a sentence’s truth-value. Amplitude modulations of both the N400 and the LPP driven by the target’s truth-value have been reported in studies which presented negated sentences in the sentence-picture verification task ([Lüdtke et al., 2008](#)) or in an active truth-value evaluation task ([Ferguson et al., 2008](#); [Staab et al., 2008](#)). For instance, in a very recent study participants listened to true and false negative sentences such as *dogs cannot fly (TN)/bark (FN)* and received the instruction to silently evaluate them for their truth-value while their EEG was recorded ([Herbert and Kübler, 2011](#)). Silent evaluation of the sentences’ truth-value elicited a N400-like frontal negativity, whose amplitudes were more pronounced for target words in FN sentences (e.g., dogs cannot bark) compared to target words in TN sentences (e.g., dogs cannot fly). This pattern cannot be explained by the mere difference in semantic relatedness between words, as this would have predicted the opposite (as found by [Fischler et al., 1983](#)). In addition, the amplitude of a centro-parietally distributed LPP was larger for final targets in FN sentences than in TN sentences, indicating that participants were more engaged in evaluating false than true sentences. Also, this modulation cannot be explained by the difference between targets in FN and TN sentences in semantic relatedness: due to their semantic relatedness, semantically related words (FN) should elicit less processing costs than semantically unrelated targets (TN). In this study, target words were presented at comparatively long stimulus onset asynchronies (SOAs) of more than 1 s between the negation and the target stimulus which might have facilitated negation processing and expectancies about the upcoming target word. In line with this, previous studies have reported modulations of the N400 and the LPP by the target’s truth-value (FN > TN) only with comparatively long SOAs in sentence-picture verification or when negated sentences were presented together with an appropriate discourse context (e.g., [Nieuwland and Kuperberg, 2008](#); [Staab et al., 2008](#)), which allowed participants to form concrete expectancies about the upcoming sentences that later on could be violated or not during subsequent sentence evaluation (e.g.,

During his long flight Joe needed a snack. The flight attendant could only offer him pretzels and cookies. Joe wanted something salty. So he didn’t buy the pretzels (FN). So he didn’t buy the cookies (TN), cited from [Staab et al., 2008](#), page 6; see [Staab et al., 2008](#) for details and an overview). Without an appropriate context and with very short stimulus evaluation times, previous studies found the opposite pattern or no difference between false and true targets ([Fischler et al., 1983](#); [Ferguson et al., 2008](#); [Lüdtke et al., 2008](#)). Moreover, especially in the N400 time-window truth-value processing has not been observed in all subjects in spite of active evaluation ([Herbert and Kübler, 2011](#)) or a preceding discourse context ([Staab et al., 2008](#)), indicating inter-individual variability in the way individuals process negated sentences.

Fundamental questions, the present study is aimed to answer, therefore are whether negation processing can occur at all under naturalistic processing conditions of silent listening and how this could affect active evaluation of negated sentences during later sentence verification. That is, the study addresses the question of how the brain processes true and false negative sentences implicitly during passive listening when no instruction but sufficient processing time is given and determine its consequences on truth-value processing during subsequent active evaluation.

Participants first listened to negated sentences and then evaluated them for their truth-value in an active evaluation task. Within each sentence, truth-value was closely linked with negation processing and inversely related with semantic relatedness. When listening to such sentences, the listener can access the trueness of the sentence only if he/she is attending to the negation term and including it into the sentence structure. If the negation term is ignored and not included into the sentence structure, sentence processing will be based entirely on the semantic relatedness of the words. Ample previous evidence indicates that semantic relatedness is parsed automatically, and that this is reflected in the N400 effect. Thus, during silent listening, one would expect that at least the N400 will be modulated by the semantic relatedness of the sentences. Theoretically, this would be in line with the first processing step of the negation models (i.e., processing of the sentence without including the negated expression). It is unclear, if N400 modulation to semantically-related targets in false sentences occurs during implicit processing of negated sentences. Moreover, these effects might be modulated by inter-individual differences in negation processing.

Furthermore, will implicit processing influence subsequent sentence verification and explicit truth-value evaluation? The relationship between implicit processing and later sentence verification might take two forms: Initial passive listening to true and false negative sentences might have no effect on later truth-value evaluation. In this case, no specific relationship between ERP patterns of both tasks is expected besides perhaps a general attenuation of ERP amplitudes during active evaluation due to stimulus repetition. This pattern would most likely occur in individuals, who do not implicitly

Download English Version:

<https://daneshyari.com/en/article/6273641>

Download Persian Version:

<https://daneshyari.com/article/6273641>

[Daneshyari.com](https://daneshyari.com)