On the non-incremental processing of negation:
A pragmatically licensed sentence-verification study with Italian adults

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The present study aims at contributing to the broad debate on the processing of negation trough an ERP investigation of negative sentences processing in Italian adults, still lacking in the literature on the topic. The last decades' behavioral studies have reported important evidence in favor of both incremental and non-incremental accounts of negation processing. According to the incremental, pragmatic view, negative sentence processing is not intrinsically different from that of affirmative sentences, except than for higher pragmatic sensitivity, which determines longer times in all cases in which negative sentences are not presented in adequately supportive linguistic contexts, as mostly happens in experimental studies. According to non-incremental, two-stage based models of negation processing, on the contrary, the interpretation of a negative sentence (e.g. *The boy is not running*) intrinsically differs from that of other linguistic structures in that it requires the comprehender to construct two different, subsequent mental simulations: a first representation corresponding to the negated state affairs (i.e., a boy who is running), and a second referring to the actual, negative meaning of the sentence.

More recently, the use of EGG techniques has permitted a more precise insight into the temporal dynamics of negation processing. In particular, ERP studies on negation have focused on the N400 component, a centro-parietally distributed, negative-going deflection with a peak at about 400ms after sentence onset, traditionally associated with stimuli integration, whose amplitudes have been reported to sensibly reflect integration difficulties (e.g., in language processing, the increased difficulty determined by the presentation of semantically incongruous words and/or false sentences). Lüdtke and colleagues (2008) analyzed ERPs associated with the execution of a sentence-picture verification task including both true and false affirmative and negative sentences. The results reported that early stages of negative sentences verification are not influenced by the actual meaning of the sentence, but rather by the matching between picture content (e.g., a ghost in front of a tower) and the entity mentioned in the preceding sentence, resulting in larger N400 amplitudes for non-priming conditions (i.e., false affirmative and true negative sentences, e.g., *In front of the tower there is a lion/there is no lion*) than for priming conditions (i.e., true affirmative and false negative sentences, e.g., *In front of the tower there is a ghost/there is no ghost*, and false negative sentences, *In front of the tower there is no ghost*). The fact that the entity mentioned in the sentence was not always depicted in the picture, however, determined a sense of pragmatic infelicity, possibly affecting event-related potentials in all cases in which the sentences involved predication about an entity not relevant to the following picture. To avoid this kind of influence, Nieuwland & Kuperberg (2008)'s ERP study focused on the interpretation of pragmatically licensed sentences, that is, affirmative and negative sentences introduced by a simple proposition restricting the conditions of validity of the following statement (e.g.*, With proper equipment, scuba diving is/is not very dangerous and often good fun*). In this latter study, N400 amplitudes reflected actual sentences' truth-value, reporting larger N400 amplitudes for false conditions than for true conditions, regardless of sentence polarity. Far from constituting a neutral discourse context, however, the short propositions inserted with the aim of ensuring pragmatic licensing determined a strong expectation for true sentences and, consequently, a sense of unnaturalness for false sentences which might represent the main cause of N400 amplitudes. In addition, the use of general world-knowledge related sentences does not allow experimenters to temporally distinguish the cognitive activity

connected with the processing of the strictly linguistic material from the activity connected to truth-value evaluation, both crucially associated to N400 component.

Our study aims at replicating Lüdke et al. (2008)'s findings through a sentence-picture verification task arguably free from the pragmatic infelicity characterizing Lüdke et al. (2008)'s stimuli. To this purpose, our pictures always represented two characters and two different activities, one of which corresponding to the one mentioned in the sentence (cf. Fig. 1). In the case of true sentences, the picture complied with the character-activity association expressed by the sentence (e.g., true affirmative: *Aladdin sta chiudendo la porta,* 'Aladdin is closing the door'; true negative: *Jasmine non sta chiudendo la porta,* 'Jasmine is not closing the door'); for false sentences, on the contrary, the picture contradicted the sentence (e.g., false affirmative: *Jasmine sta chiudendo la porta,* 'Jasmine is closing the door'*;* false negative*: Aladdin non sta chiudendo la porta,* 'Aladdin is not closing the door')*.*

Fig. 1

Four lists of sentences counterbalancing items and conditions have been constructed, for a total of 240 items each (60 true affirmatives, 60 false affirmatives, 60 true negatives, 60 false negatives). For each trial, participants were auditorily presented to the sentence and then, after an interval of 250 ms, to a picture displayed on a computer screen in front of them for 350ms. After that, they had no time limitation for expressing their truth-value judgment by pressing one button on the keyboard. After the participant had given her answer, the following trial was presented. During the whole task, EEG recording was continuously executed. The overall pattern of results is in line with two-stage based accounts of negation processing. Behavioral results report longer reaction times and higher error rates for negative than for affirmative sentences, suggesting major difficulties for the interpretation of the former with respect to the latter. Sentence polarity by truth-value interaction, in addition, results significantly relevant for both measures, showing that while the verification of false affirmative trials is more demanding than that of true affirmatives, negative conditions are characterized by the reverse pattern, with true negative sentences reporting higher error rates and longer response times than false negative sentences. Although confirming a long tradition of studies, this latter result comes unexpected in the present study, as the choice of always representing both the activity and the character mentioned in the sentence was expected to minimize the priming effect between the two stimuli usually invoked as main factor of facilitation for false negative sentences interpretation. The persisting asymmetry between negative conditions, therefore, suggests that the longer processing times traditionally reported for true negative sentences interpretation cannot be explained only in terms of sentence-picture priming, but has to be attributed to deeper differences in the pragmatic sensitivity of the two types of sentences. EEG analysis mainly confirms Lüdke et al. (2008)'s results, revealing a larger N400-like effect (starting at about 400ms and lasting until 1200ms from the onset of the picture) for false affirmative and true negative sentences than for true affirmative and false negative sentences, indicating no influence of negation in the first stages of sentence interpretation. As expected, true value effects emerged only in later time windows, about 200ms later.

Main references: Nieuwland & Kuperberg (2008). *Psych Sci*, *19*(12), 1213–1218;
Lüdtke et al. (2008). *J Cogn Neurosci, 8*, 1355–1370.