

Social abilities help us detecting jokes: An EEG study on the temporal dynamics of humor comprehension

Paolo Canal¹, Luca Bischiotti², Simona Di Paola^{1,3} & Valentina Bambini²

¹Laboratorio di Linguistica G. Nencioni, Scuola Normale Superiore, Pisa

²NETS, IUSS Institute for Advanced Study, Pavia

³DISFOR – Psychology Unit, University of Genoa

Introduction: Humor refers to anything that tends to make others laugh and is a universal aspect of human experience and communication [1]. Traditional theories of humor processing [2] posit that humor comprehension is a two-stage process in which the perception of an incongruity in a playful context is followed by its resolution. When the resolution is successful, one “gets” the joke and the typical feeling of mirth. Recent research in the Relevance Theory framework underlines how resolution is achieved through different types of inferential – pragmatic – processes filling the gap between what is coded and what is eventually interpreted [3]. As a useful technique to investigate the temporal sequence of cognitive mechanisms, Event-Related brain Potentials (ERP) generally found support for two-stage accounts of humor comprehension. However, the results are far from being consistent. Late positive effects (P600/LPC) have been discussed in many studies [4,5,6,7,8,9,10], sometimes linked to inferential processes [7,8,10]. These positivities were often accompanied by negative effects, interpreted as N400 effects [4,7,8,9,10], even though their scalp distribution was not canonical [7,8,9]. In addition, several studies reported sustained negative effects over frontal left electrodes, suggesting the involvement of the Left Anterior Negativity (LAN) [4,5,6]: because of these temporal and topographic differences, no agreement exists on the functional meaning of these effects. These discrepancies may be due to the inter-individual variability in the ERP response to humor. Researchers often dig into such variability by splitting participants into groups based on performance [4,9], sex [5] or verbal abilities [5]. However, these studies might have failed to characterize differences that could be due to more general cognitive or socio-cognitive abilities, which likely play a role in incongruity detection and resolution. Here we investigated the effect of verbal working memory and social skills on the ERP, using a relatively large sample of participants. We selected these abilities as predictors of the ERP response based on behavioral and neuroimaging studies [1,12].

Method: 70 jokes taken from Italian repertoires were included as materials. Each joke consisted of a three-sentence context (presented sentence by sentence) followed by a final punchline (presented word by word), including a humorous trigger word in a non-final position. For each joke, a non-humorous, straightforward-ending counterpart was created by replacing the humorous trigger word with a different word matched for frequency, length, and grammatical class, as in the following example: *A man goes to the grocery store to buy apples. / The grocer asks: “Would you like the red ones or the green ones?”/ And the man says: / “It doesn’t really matter, ‘cause I peel them anyway”* (humor) - *“It doesn’t really matter, ‘cause I pay them the same price”* (non-humor). Materials were rated for funniness on 7-point Likert scale [humor=3.97; non-humor=2.07] and cloze probability [humor=30.63%; non-humor=9.64%]. 52 right-handed participants (31F; 24y on average) took part in the study. We collected measures of verbal working memory through a sentence-span task and of social skills through the Autism-Spectrum Quotient (AQ). Single trial ERPs were analyzed with linear mixed models, focusing on 3 regions of interest (Frontal Left, Centro-Parietal and Parietal) and 3 time-windows (early – 300-500ms; middle – 500-700ms; late – 700-1000ms).

Results: Reliable effects of Humor emerged during the LAN [Frontal Left; early; $-0.75\mu\text{V}$, $t=-2.40$, $p<0.05$], sustained LAN [Frontal Left; middle; $-1.33\mu\text{V}$, $t=-4.05$, $p<0.001$], P600 [Parietal; middle; $+0.75\mu\text{V}$, $t=2.18$, $p<0.05$] and LPC [Parietal; late; $+1.46\mu\text{V}$, $t=4.27$,

$p<0.001$], but not during the N400 [Centro-Parietal; early; $+0.16\mu\text{V}$, $t<1$] (See Figure 1). AQ predicted the ERP response during the LAN time window [$\Delta\beta=-0.53$, $t=2.52$, $p<0.05$], revealing that the size of the negativity increased as AQ scores increased. No other effects were observed.

Discussion: Results further support the two-stage model of humor comprehension. Assuming that the detection of an incongruity precedes its resolution, the effect on the early time window suggests that it can take place as early as after 300ms, consistently with all previous investigations. The scalp distribution of the effect also suggests that the component involved in this processing stage is a LAN rather than an N400, in contrast with [4,7,8,9,10]. Indeed, the role of the N400 component was already questioned by studies finding no reliable effects [11] or frontally distributed negativities during the N400 time-window [7,8,9]. We thus argue that incongruity detection is associated with left-anterior negativities, whose functional characterization as sensitive to unexpected information might extend beyond the morpho-syntactic domain. Those studies reporting genuine N400 effects may have used kinds of jokes that not only presented an incongruity but were also strongly unpredictable. The later stage of resolution was mirrored by an enhanced positivity affecting the ERPs for a long time interval ranging from 500 to 1100ms, in line with previous research on humor and, more generally, with the view of the P600/LPC as reflecting interpretative efforts [13]. As for individual differences, verbal working memory does not seem to play a role in humor processing in the young healthy population, differing from evidence reported in patients and elderly people. Yet, the effect of AQ as predictor of the size of the LAN suggests that participants with less developed socio-cognitive skills pay more effort in the detection of the incongruence between setup and punchline. This finding matches with previous evidence on the interplay of AQ and irony – another inference-based process that might be associated with humorous effects [3] – showing that socially disinclined participants are less able to discern ironic utterances [14]. We speculate that socio-cognitive skills increase the ability to understand the playful context in which humor incongruity occurs. In sum, this study shed new light on the temporal dynamics of humor processing, linking its sequential stages to a LAN followed by a long-lasting positivity, and on the speaker-based variation of the early phase of such pattern, depending on the individual's socio-cognitive skills.

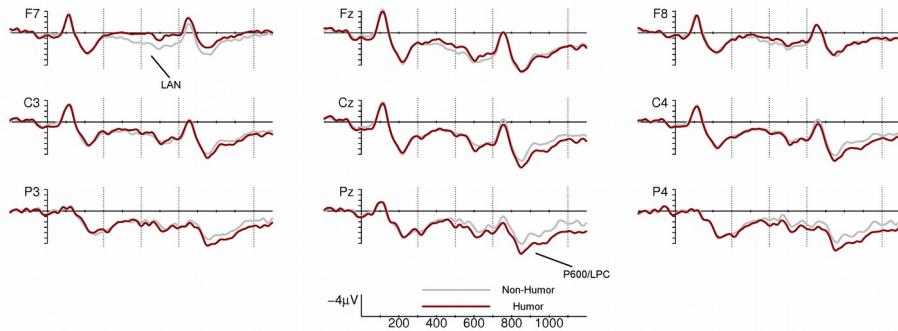


Figure 1. ERPs from nine representative electrodes: Grand Averages of Humor (dark red) and Non-Humor (grey) conditions.

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