



## High contextual sensitivity of metaphorical expressions and gesture blending: A video event-related potential design

Agustín Ibáñez<sup>a,b,c,d,\*</sup>, Pablo Toro<sup>e,g</sup>, Carlos Cornejo<sup>g</sup>, Hugo Hurquina<sup>a,b</sup>, Facundo Manes<sup>a,b</sup>, Matthias Weisbrod<sup>f</sup>, Johannes Schröder<sup>e</sup>

<sup>a</sup>Laboratory of Experimental Psychology and Neurosciences, Institute of Cognitive Neurology (INECO), Buenos Aires, Argentina

<sup>b</sup>Institute of Neuroscience, Favaloro University, Buenos Aires, Argentina

<sup>c</sup>Career of the National Scientific and Technical Research Council (CONICET), Buenos Aires, Argentina

<sup>d</sup>Neuroscience Laboratory, University Diego Portales, Santiago, Chile

<sup>e</sup>Section of Geriatric Psychiatry, University of Heidelberg, Heidelberg, Germany

<sup>f</sup>Section of Experimental Psychopathology, University of Heidelberg, Heidelberg, Germany

<sup>g</sup>P. Catholic University of Chile, Santiago, Chile

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### ABSTRACT

Human communication in a natural context implies the dynamic coordination of contextual clues, paralinguistic information and literal as well as figurative language use. In the present study we constructed a paradigm with four types of video clips: literal and metaphorical expressions accompanied by congruent and incongruent gesture actions. Participants were instructed to classify the gesture accompanying the expression as congruent or incongruent by pressing two different keys while electrophysiological activity was being recorded. We compared behavioral measures and event related potential (ERP) differences triggered by the gesture stroke onset. Accuracy data showed that incongruent metaphorical expressions were more difficult to classify. Reaction times were modulated by incongruent gestures, by metaphorical expressions and by a gesture–expression interaction. No behavioral differences were found between the literal and metaphorical expressions when the gesture was congruent. N400-like and LPC-like (late positive complex) components from metaphorical expressions produced greater negativity. The N400-like modulation of metaphorical expressions showed a greater difference between congruent and incongruent categories over the left anterior region, compared with the literal expressions. More importantly, the literal congruent as well as the metaphorical congruent categories did not show any difference. Accuracy, reaction times and ERPs provide convergent support for a greater contextual sensitivity of the metaphorical expressions.

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### 1. Introduction

Human interaction in a natural context implies a continuity of sense among actions (i.e., body language) and communication where gestures are combined with the spoken language and diverse contextual clues in a dynamic, temporal sequence (Cosmelli and Ibáñez, 2008; Ibáñez and Cosmelli, 2008). Verbal utterances are in fact tightly interwoven with gestural information and expressive context in ordinary conditions. This feature of language is particularly evident in figurative language, where a considerable amount of contextual information is required for its understanding (Gibbs, 1994; Giora, 2003). In the case of metaphorical expressions, evidence shows that

context and information beyond the lexical content are critical for comprehension (Pynte et al., 1996; Coulson and Van Petten, 2002). Thus, in opposition to the literal-first hypothesis, which considers metaphorical meaning as activating only after the contextual failure of the necessarily first literal meaning, many language researchers consider that metaphorical meaning can be as available as the literal one, depending on the expressive context (Giora, 2003). Context is also increasingly conceived as having a much more central role in meaning construction than simply serving as a test of viability for the literal interpretation of an expression (Coulson, 2006). Central for the traditional studies of metaphor is the distinction between the tenor (or “topic”) and the vehicle of a metaphor (Cornejo, 2004, 2007). Tenor or topic is what is described by the metaphor, while vehicle is the term used to describe the topic. So, in the metaphorical expression ‘Physicians are gods’, ‘physicians’ is the topic, which is described by means of the vehicle ‘gods’. We consider for our study short metaphoric sentences (called novels or unfamiliar; Pynte et al., 1996) with final words comprising the metaphoric meaning (i.e., “Those fighters are LIONS”).

\* Corresponding author. Laboratory of Experimental Psychology and Neurosciences, Institute of Cognitive Neurology (INECO) & CONICET, Castex 3293 (CP 1425), Buenos Aires, Argentina. Tel./fax: +54 11 4807 4748.

E-mail address: [aibanez@neurologiacognitiva.org](mailto:aibanez@neurologiacognitiva.org) (A. Ibáñez).

URL: <http://www.neurologiacognitiva.org> (A. Ibáñez).

In recent years the technique of event related potentials (ERPs) has approached the study of multimodal contextual blending of stimuli (Hurtado et al., 2009), figurative language and action sequences (i.e. videos) offering a more ecological approximation to the study of language and meaning. A component that has been studied intensely in relation to the more ecological clues of language is the N400. The N400 is an ERP characterized by a negativity generated about 400 ms after the presentation of semantically anomalous information (Kutas and Hillyard, 1980). The N400 modulation has been shown to be simultaneously context-sensitive and automatic (Ibáñez et al., 2006, 2010). Another component, the so-called 'late positive complex' (LPC, sometimes elicited together with the N400), has been related to a process of re-analysis of the incongruent situation produced by the inconsistent meaning (Sitnikova et al., 2003). The N400 has shown more amplitude in so far as metaphorical phrases are concerned (Coulson and Van Petten, 2002), as well as a reduction of its negativity when the metaphors are inserted in a previous congruent context with metaphorical sense (Pynte et al., 1996). Studies done with videos in other areas have shown a modulation of the N400 in response to incongruent or unexpected action (Sitnikova et al., 2003; Reid and Striano, 2008). Other studies have shown that the gesture in itself modulates the N400 component, producing more amplitude when the gesture is incongruent with the linguistic context (Gunter and Bach, 2004; Holle and Gunter, 2007). The N400 and LPC were modulated by videos of incongruent gestures (Neville et al., 1997; Kelly et al., 2004; Wu and Coulson, 2005; Kelly et al., 2007; Özyüreck et al., 2007; Wu and Coulson, 2007). All these studies from different perspectives suggest that a continuity of multimodal sense arises from the context, the action and the language, advocating that both N400 and LPC are sensitive to this continuity.

The N400 and the LPC have typically been reported in response to linguistic and static stimuli. Nevertheless, processing of extralinguistic information has also been investigated in terms of integrating information from pictures to previous context (Barrett and Rugg, 1990; Ganis et al., 1996; McPherson and Holcomb, 1999; Federmeier and Kutas, 2001; West and Holcomb, 2002). Recent studies have been reported of N400 and LPC components elicited by meaningful but non-linguistic stimuli such as faces (Hannula et al., 2006), objects (Ganis and Kutas, 2003), music (Daltrozzo et al., 2010); pictures (West and Holcomb, 2002; Guerra et al., 2009); gestures (Proverbio and Riva, 2009) and hand actions (Aravena et al., 2010). In addition, N400 and LPC are triggered by dynamic events without a time-critical window (e.g., videos of real life situations: Sitnikova et al., 2003; or video gestures: Cornejo et al., 2009). The N400/LPC reported from dynamic events seems to have a more left and anterior topography and a greater latency compared with the classical N400/LPC elicited by static and linguistic stimuli. Since it is not possible to clearly identify both kinds of ERPs as the same component with the same neural generators (N400/LPC elicited by static and linguistic stimuli and the N400/LPC elicited by dynamic and non-linguistic stimuli), we prefer to call these effects N400-like and LPC-like components.

In the case of the metaphor, there is a possibility that the influence of contextual clues, particularly gestures, presented in a dynamic and synchronized sequence with linguistic expressions modulates the N400 and LPC component. To our knowledge, only a study with ERPs has come close to this question. An N400 and an LPC modulation were related to video clips showing incongruent gestures with metaphorical meaning (Cornejo et al., 2009). This study is the first to relate the ERP investigation about the coordination between action sequences (gestures) and figurative language (metaphors). Nonetheless, this study presents limitations because of the absence of contrasts (between literal and metaphorical stimuli) that reduce the conclusions about the processing of metaphors and related topics (contextual sensitivity, figurative language and gesture integration).

Our study evaluates the contextual coordination between gesture and literal/figurative language. Previous research has suggested that

multimodal and co-occurring speech and gestures are integrated by the brain simultaneously into a preceding sentence context (Özyüreck et al., 2007). Understanding an utterance implies that the brain does not restrict itself to language information alone but also integrates semantic information conveyed through other modalities such as co-speech gestures (Özyüreck and Kelly, 2007; Willems et al., 2009). Previous research has shown that the stroke phase of gesture in particular conveys the meaning of a gesture (McNeill, 1992). Speakers produce the stroke simultaneously with the relevant speech segment (e.g. Levelt et al., 1985). Recently, this meaningful property of gesture stroke has been used in neuroscience. For example, functional magnetic resonance imaging (fMRI) studies have shown that unimodal (gesture only) and multimodal integration of gestures and speech increases activation in the classical left hemispheric language areas (Kircher et al., 2009). Although scarcer, recent ERP studies have triggered the N400 and LPC with the gesture stroke onset. For example, Özyüreck et al. (2007) used ERPs to assess the integration of speech and gesture simultaneously triggered by word onset and static gesture stroke onset. Despite the difference in modality and in the specificity of meaning conveyed by spoken words and gestures, the latency, amplitude, and topographical distribution of both word and gesture onset mismatches were found to be similar, indicating that the brain integrates both types of information similarly and simultaneously. Moreover, although the dynamic presentation of stimuli reduces early visual components such as P1/N1 due to a lack of discrete transient visual events separated by time (Sitnikova et al., 2003; Wu and Coulson, 2005), it seems to preserve similar effects of N400 and LPC (Sitnikova et al., 2003; Cornejo et al., 2009). Using the stroke of the gesture as a time-locking event allows the investigation of relevant semantic coordination processes drawn from a temporally dynamic event stroke gesture. In a previous report of co-gesture speech paradigms, N400 and LPC components elicited by gesture stroke onset resulted in strong modulation of congruent vs. incongruent stimuli compared with the N400/LPC component elicited by word onset (Cornejo et al., 2009). Since stroke occurs 200–400 ms after the relevant word onset, it constitutes a better temporal window compared with word onset because it implies the temporal integration between sentence meaning and gesture meaning. In brief, although N400 has been more frequently studied with word onset, recent neuroimaging and electrophysiological data suggest that speech and gesture convey related and similar information and that stroke expresses the meaning of the utterance and can be effective for studying the coordination between gesture and language in ERP paradigms.

With this in mind, the following questions arise: Does the gesture-expression interaction influence the metaphorical utterance differentially? (Thus, it might be in the case of the contextual sensitivity rather than in the literal expression). And therefore, the modulation of the N400/LPC-like components... would this be affected differentially by congruent/incongruent gestures of metaphorical expressions compared with literal ones? Our study proposes to respond to these questions to throw some light on the hypothesis of the linguistic nature of the metaphor. We therefore hypothesized that if the metaphorical expressions are highly dependent on the context of gestures/actions, the differences between the congruent/incongruent conditions would be larger in the metaphorical than the literal condition. This would occur due to the contextual blending of gesture and expressions that should act with more effect for figurative sentences, thereby incrementing the differences between congruent and incongruent actions for this condition. On the other hand, if the contextual blending of gesture and expressions had no effect of greater sensitivity in figurative expressions, then a differential effect would not be observed in the metaphorical expressions; the N400 modulation would be similar to the literal congruent condition. Otherwise, both categories (congruent and incongruent) should generate greater negativity than in the literal ones.

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