Analytical and Holistic Approaches Influence the Semantic Integration: Evidence from the N400 effect*

Influencia de la Disposición Analítica y Holista en la Integración Semántica: Evidencia del efecto N400

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Abstract

The present study explores the influence of the analytical and holistic approaches on semantic integration of literal and metaphorical sentences. We recorded ERP to compare brain responses to literal (e.g. Mosquitoes are insects) and metaphorical (e.g. Mosquitoes are vampires) sentences, preceded by two types of interpretative cues to encourage literal comprehension (e.g. 'By definition', analytical approach), or figurative comprehension (e.g. 'In some sense', holistic approach). Participants were asked to classify all sentences according to whether they made sense to them or not. The N400 effect elicited by the critical word in literal and metaphorical sentences was analyzed considering the induced approach. Additionally, the ERP activity elicited during the exposure of the stem sentence was also analyzed to evaluate the potential impact of both approaches on context processing. N400 effect usually reported for metaphorical words was only observed in the analytical comprehension condition, not in the holistic one, resulting in a significant interaction effect (Congruency x Approach) due to larger amplitudes for metaphors when analytically approached. The ERP response to the stem sentences was also affected by the approach, exhibiting a larger Contingent Negative Variation (CNV-like) in the analytical condition. The obtained results suggest (1) that the classically reported N400 effect for metaphoricity, can be affected by the subject's

approach to language comprehension, influencing semantic integration, and (2) CNV-like modulation before critical word reflects that the approach also affects processing of linguistic context, prior to target processing.

Key Words: Analytic approach, holistic approach, semantic integration, N400, CNV.

Resumen

El presente estudio explora la influencia de las disposiciones analítica y holista en la integración semántica de oraciones literales y metafóricas. Registramos los Potenciales Relacionados a Eventos (ERPs) para comparar la respuesta cerebral frente oraciones literales (p.e. Los mosquitos son insectos) y metafóricas (p.e. Los mosquitos son vampiros), precedidas por dos tipos de claves interpretativas para inducir una comprensión literal (p.e. 'Por definición', disposición analítica), o figurativa (p.e. 'En algún sentido', disposición holista). Los participantes debieron clasificar un conjunto de oraciones de acuerdo a si les hacían sentido o no. Se analizó el efecto N400 en las condiciones literal y metafórica, considerando la disposición. Adicionalmente, los ERPs evocados durante la presentación del cuerpo de la oración, previo a la palabra crítica, fueron analizados para evaluar la influencia de ambas disposiciones en el procesamiento del contexto lingüístico. El efecto N400 reportado tradicionalmente para palabras metafóricas, fue observado sólo en la condición analítica. Los ERPs evocados por el cuerpo de la oración también se vieron afectados por la disposición, mostrando una mayor amplitud en la Variación Contingente Negativa (CNV) bajo la condición analítica. Los resultados obtenidos sugieren que (1) el efecto N400 reportado clásicamente para metáforas, puede ser afectado por la disposición de los sujetos en la comprensión del lenguaje, influyendo en la integración semántica; y (2) la modulación de la CNV previa a la presentación de la palabra crítica, refleja que la disposición también afecta al procesamiento del contexto lingüístico antes del procesamiento de la palabra que determina la metaforicidad.

Palabras Clave: Disposición analítica, disposición holista, integración semántica, N400, CNV.

INTRODUCTION

In human cognition, the same piece of information can be processed in different modes according to the specific context or the individual strategy or approach to make sense of it (Cornejo, Simonetti, Aldunate, Ibáñez, López & Melloni, 2007; Basnakova, Weber, Petersson, van Berkum & Hagoort, 2014). There is evidence that 'analytic' and 'holistic' approaches may influence different cognitive processes like perception (Miyamoto, Nisbett & Masuda, 2006; Fifié & Townsend, 2010), thinking (Choi, Koo & Choi, 2007), learning (Ward & Scott, 1987), arithmetic (Yagoubi, Lemaire & Besson, 2003) or language comprehension (Bybee, 2014). It is known that this is specifically important to understand figurative language, as irony, where an analytic approach may even lead to lack of comprehension, due to the need of a more holistic strategy to make sense (Cornejo et al., 2007).

In naturalistic conversations, language is used flexibly. When people say things such as 'Mosquitoes are vampires' the context in which this sentence is uttered helps hearers to dynamically interpret the meaning of some otherwise anomalous linguistic expression (Cornejo, Simonetti, Ibáñez, Aldunate, Ceric, López & Núñez, 2009; Bambini, Bertini, Schaeken, Stella & Di Russo, 2016). Among the various contextual elements that help people to make sense of utterances and sentences, there are some clauses such as 'In a sense' or 'By definition', which are discourse particles that could prompt speakers to an analytic or holistic approach to predict incoming language. These kinds of clauses could act like cues helping them to apply their pragmatic knowledge to face the rest of the unfolding information. Since online language processing is strongly predictive (Van Petten, Coulson, Rubin, Plante & Parks, 1999; Kamide, 2008), the content of one of such clauses may influence people's expectations of what is to come.

When people approach linguistic inputs in an analytical fashion, language is processed as a set of lexical units bound by logical-semantic relationships, and the anticipations are based on the analysis of the conventional meaning of each word. Such approach prompts the assessment of sentences' adequacy considering the formal knowledge of language, which strongly constrains our predictions, reducing the range of options and increasing our expectations for something in particular. On the contrary, when our approach to communication is more holistic, everyday experiences and pragmatic knowledge play a more important role in sentence processing, opening new possibilities of meaning construction, which are not exhausted by formal conventions, reducing our expectations for something in particular. In our daily life, the transition between these two approaches occurs naturally and instantaneously, which allows us to adjust our linguistic understanding to the particular requirements of a given communicative situation. Several studies have shown that our cognitive activity can be influenced by both approaches, and that this influence can impact on different cognitive dimensions (Brunswik, 1966; Bastick, 1982; Ben-Zur, 1998; Cornejo et al., 2007). However, to our knowledge, all these reports have been with between-subjects designs, and no within-subjects studies have been conducted to explore the impact of the approach when people are engaged in comprehending sentences or single words.

Event Related Potentials (ERP) literature on semantic incongruity and N400 has shown that the meaning of a given critical word is constructed by integrating contextually available information. Numerous studies have been conducted in which different kinds of inconsistencies have generated N400 effects (Kutas & Federmeier, 2011). The N400 component, first reported by Kutas and Hillyard (1980a), is present as response when there is a meaningful element. This component is a negative ERP that starts around 250 ms after the onset of one incongruous stimulus, negatively peaking around 400 ms and most prominent in the central-parietal sites. In language

comprehension, the amplitude of this component has been shown to be directly linked with the degree to which the context facilitates understanding of the meaning associated with the word through predictability, with a larger negativity when it is difficult to semantically integrate the target word, given a particular context (for a review, see Kutas & Federmeier, 2011).

On figurative language studies, research has shown that less familiar metaphorical words generate more negative N400 peaks than literal words (Pynte, Besson, Robichon & Poli, 1996; Coulson & Van Petten, 2007; Schneider, Rapp, Haeußinger, Erns, Hamm, Fallgatter & Ehlis, 2014); however, N400 effects have been reported to decrease in amplitude when metaphors are preceded by relevant congruent contexts (Pynte et al., 1996; Coulson & Van Petten, 2007; Bambini et al., 2016) or simultaneously accompanied by more ecological contextual information such as gestures (Cornejo et al., 2009; Ibáñez, Manes, Escobar, Trujillo, Andreucci & Hurtado, 2010).

Although in experimental settings metaphors tend to elicit larger N400 component compared to literal sentences, our hypothesis is that logic and semantic incongruities disappear when expressions are embedded in everyday conversations. We propose that the N400 effect, observed in many ERP experiments, is tied to the immediate approach to language with which participants face the sentences they are asked to respond to. In natural conversations, when language unfolds, speakers can grasp the sense of utterances in their totality and establish new meanings for them, grounded on their personal experiences. All of this finally translates into a decreased N400 amplitude (Chwilla, Kolk & Vissers, 2007).

In line with this, some studies have explored how individual differences can impact on the processing of sentences and on meaning construction, suggesting that language processing is not exclusively related with the nature of linguistic stimuli (Olkoniemi, Ranta & Kaakinen, 2016; Shimizu, Lee & Uleman, 2017; Ye, Stolk, Toni & Hagoort, 2017). Beliefs, personal values, mood or gender and empathy can also influence semantic integration processes (Kutas & Federmeier, 2011). For instance, van Berkum, Holleman, Nieuwland, Otten and Murre (2009) reported differential N400 effects modulated by participants' beliefs when sentences' critical word generated a conflict with their personal values. Van Den Brink, van Berkum, Bastiaansen, Tesink, Kos, Buitelaar and Hagoort (2012), reported that gender differences can modulate the N400 component in expressions that convey relevant social information linked with participants' empathic skills. Some other studies have reported late components modulated by factors such as mood (van Berkum, de Goede, van Alphen, Mulder & Kersholt, 2013) or the particular cognitive strategy with which people approach language comprehension (Cornejo et al., 2007). All these studies suggest a certain flexibility of semantic integration that allows being influenced by factors at the personal level. Nevertheless, much less is known about a potential

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flexibility at the within-subject level. That is, changes in the way the same person approach to a same linguistic expression might also affect semantic integration.

In summary, above mentioned studies strongly suggest that semantic integration is not only based on the context, but on the personal characteristics too. However, language is dynamic and fluent, and all incoming words immediately become part of the context of upcoming words, generating particular expectations (van Berkum, Brown, Zwitserlood, Kooijman & Hagoort, 2005). This context shapes constraining forces that predict the upcoming words (DeLong, Urbach & Kutas, 2005). Since the first report of the N400 effect by Kutas and Hillyard (1980b) there was an indication that this effect was not only visible as an N400 amplitude modulation. A special relation was proposed between N400 and the Contingent Negative Variation (CNV), "which builds up in anticipation of significant stimuli and may be prolonged when those stimuli required more detailed processing" (Kutas & Hillyard, 1980b: 207). They even suggested that the effect seen at the N400 could be a phasic augmenting of the preceding CNV reflecting now complex linguistic processing.

CNV is related to stimulus anticipation and motor preparation, before a stimulus presentation (Walter, Cooper, Aldridge, McCallum & Winter, 1964; Jang, Jones, Milne, Wilson & Lee, 2016). There is evidence suggesting that this anticipatory process can differ depending on the cognitive effort or the mental fatigue induced by the task (Lorist, Klein, Nieuwenhuis, Jong, Mulder & Meijman, 2000; Frömer, Stürmer & Sommer, 2016). It can also be influenced by the different strategies we use to process information, for example to categorize concepts (Smith, Patalano & Jonides, 1998; Kononowicz & Penney, 2016). In this line, the same contexts could be approached in different ways, making differences in the anticipations.

For example, Bonnefond and Van der Henst (2009) showed that in a classical CNV paradigm when S1 constitutes a logical premise, S2 is anticipated with greater expectancy and results in a larger CNV than when S1 has no logical premise. Considering these antecedents, it seems plausible that when we operate in an analytical approach, stronger prediction and expectancy for resolution could occur while listening to a sentence, as in the case of a logical premise. That would result in a larger CNV and, if followed by an unanticipated word, in a larger N400 effect. On the contrary, a more holistic approach to the same stimuli may attenuate such effects, resulting in a smaller CNV, and in a decreased N400, reflecting an easier semantic integration.

The present study is aimed to explore how changes in the person's approach to language affect context processing and target word semantic integration. We used a within-subject experimental design to compare the EEG activity for the same linguistic stimuli (literal and metaphorical sentences) processed in an analytical

approach to language and in a holistic one. Two types of interpretative cues were used to encourage a literal comprehension (e.g. 'By definition', analytical approach), or a figurative comprehension (e.g. 'In some sense', holistic approach). Our aim was to know whether the N400 effect, usually reported for metaphorical language, is solely linked to the context or can also be influenced by the different approaches. Additionally, we inspected the whole ERP dynamics elicited by the contextual sentence processing that precedes the critical words. We predicted that the N400 effect for metaphoricity would be enhanced by the analytical approach, compared to the holistic approach, reflecting a more difficult semantic integration of target words. We also predicted differences in the ERPs elicited by the same contextual sentences depending on whether they were preceded by analytical clause or a holistic clause, reflecting that different approaches on language can also influence sentential context processing. Different electrophysiological correlates for contextual sentences depending on different approaches, might support the idea that linguistic context could be processed differentially during the language unfolding, ultimately impacting the way critical word is anticipated.

1. Methods

1.1. Participants

18 right-handed undergraduate students voluntarily took part in the study (mean age= 21.5; SD= 1.9); women= 13). All of them were native speakers of Spanish and none reported any history of neurological disease or psychiatric condition. All of them signed an informed consent form in accordance with the Declaration of Helsinki. The Ethical Committee of the School of Psychology at the Pontificia Universidad Católica de Chile authorized the present research. The sample size was determined in advance following the usual size reported in similar studies that use N400 amplitude modulations as dependent variable (Wu & Coulson, 2007). The statistical power was 0.84 for an expected effect with 0.75 Standard Deviation difference between conditions.

1.2. Materials

With the aim of obtaining valid linguistic stimuli, a preliminary study was conducted in which 113 undergraduates filled a 70 sentences questionnaire. Sentences contained a blank ending which undergraduates were asked to fill with a word of their own. Each sentence was presented in two modalities. One modality aimed at capturing conventional equivalence definitions (i.e. 'Mosquitoes are'), while the other one aimed at capturing relations based on likeness (i.e., 'Mosquitoes are like'). We chose a final set of 50 sentences, which were those that elicited less variable ending words and will be subsequently labeled as stem sentences. This final set was recorded with a condenser microphone AT2035 using the software Protools with a Chilean man's voice, in the Phonetics Laboratory of the Faculty of Letters of the Pontificia

Universidad Católica de Chile. Each stem sentence was recorded five times and a phonetist selected those that perceptually had the same intonation. To control the intensity of the recorded stem sentences, the selected signals were segmented and normalized in their amplitude by the Scale Peak algorithm with the software Praat (Boersma, 2001). Finally, to confirm the employed criteria to select the recorded stimuli, it was visually inspected with the Pitch Object Tool of Praat that all stem sentences have the same fundamental frequency curve. The mean length of the recorded stem sentences was 1,014.30 ms, SD = 93.40.

All of the 50 stem sentences presented to participants in the experiment were structured as neutral definitions (Mosquitoes are____). For each of these stem sentences, two critical words were selected: a word that would make the whole sentence literally congruous ('Mosquitoes are insects') and a word that would make the sentence literally incongruous but metaphorically congruous ('Mosquitoes are vampires'). Both sets of critical words (literal and metaphorical) presented the same frequency of use (t(98) = 0.58; p = 0.68) in a corpus of Chilean Spanish (Sadowsky & Martínez, 2012). As for the length, different word-lengths were equally represented in the compared conditions (Literal, M = 2.82, SD = 0.87 vs Metaphorical, M = 2.52, SD = 0.68), with no statistical differences (t(98) = 1.92; p = 0.58). This generated 100 sentences belonging to two conditions, a literal one and a metaphorical one. Two other conditions were implemented to encourage participants to face linguistic stimuli from either an analytical approach or a holistic one. To this end, two sets, of 10 introductory clauses each, were constructed. The chosen clauses were linguistic formulas commonly used in natural conversations to let hearers know that they are expected to interpret an upcoming utterance from a certain disposition or point of view. One set encouraged a logical-formal interpretation of the sentence to come, prompting participants to parse the stem sentence based on the literal meaning and their formal knowledge (analytical clauses). The other set prompted participants to understand sentences in a more flexible way, allowing new meanings to be spontaneously constructed as it happens in everyday life (holistic clauses). An example of the analytical clause is 'By definition', while an example of the holistic clause is 'In a sense'.

All stimuli, including the 'interpretative cues' were validated in a specific behavioral study conducted with this goal. Sixty participants were asked to report whether a list of literal and metaphorical sentences preceded by one of both types of 'interpretative cues' made sense to them. Two lists were constructed to validate each sentence with each 'interpretative cue'. Each subject was presented with a list composed by half of the literal and metaphorical sentences used in the final design, in order to avoid sentence repetition with a different 'interpretative cue'. The items were randomly ordered and subjects were asked whether the sentence made sense to them and why. The sentences preceded by analytical cue (i.e.: 'by definition') were interpreted from

the logic relations among the different parts (i.e.: Categorical correspondences). The sentences preceded by a holistic cue, on the contrary, were interpreted based on newly or figurative formed associations among the parts (i.e.: figurative linking). Metaphorical expressions, as expected made sense when preceded by a holistic cue but the response was mostly negative when preceded by an analytical cue. For example, 'dictionaries are bricks' made sense if preceded by 'in some sense' (Response: 'Yes, because they are the bricks to build knowledge'). If the cue was 'By definition' participants responded it made no sense to them (Response: 'No. Dictionaries are books to read, and bricks are building material'). The presence in the same list of literal sentences, we think, reinforced such pattern of responses. Only the combined sentences that were responded in the expected way 95% or more were included in the final design. Additionally, participants reported in the current manuscript were asked, at the end of the session, to respond a qualitative assessment of their experience. They consistently reported that, after an analytical cue, they prepared themselves to pay close attention in order to detect any anomaly or departure from reality. Meanwhile, when the cue was holistic, they were more open and waited to see how to interpret all possible senses of the expression.

All of the 100 previously generated sentences, grouped as literal and metaphorical, were presented twice, preceded by an analytical clause (analytical approach) and by a holistic clause (holistic approach). Thus, the final set of stimuli consisted of 200 sentences evenly grouped in 4 conditions with 50 trials in each one (for an example, see Table 1). Each stem sentence was presented four times combining clauses and endings (analytical clause + stem sentence + literal ending; analytical clause + stem sentence + metaphorical ending; holistic clause + stem sentence + literal ending; holistic clause + stem sentence + metaphorical ending).

Table 1. Example of stimuli per condition.

		LITERAL	METAPHOR
ANALYTICAL	'By definition' mosquitoes are	'insects'	'vampires'
HOLISTIC	'In some sense' mosquitoes are	'Insects'	'vampires'

To avoid possible buildup, stimuli were pseudorandomized controlling that sentences belonging to the same condition (analytical/holistic approach or literal/metaphorical ending) were presented only up to three times in a row. Stimuli were presented sequentially, although two breaks were introduced to allow participants to take a pause and resume the task at their convenience. One was set after trial number 100 and the other one after trial number 150. Participants' task was to determine whether each presented trial was understandable or not.

1.3. Procedure

Once in the laboratory, participants were briefed on some basics of the experiment and were handed an informed consent which all signed. Participants sat in front of a screen and were instructed about the task. We decided that the task would not be about a congruent/incongruent judgment since we did not want to bias participants by focusing them on the analytical approach, considering the literal meaning of the stimuli. There were no correct or erroneous responses. All they had to do was press one button if the sentence made sense to them or a different one if it did not. Lateralized motor response effect was controlled by counterbalancing response buttons.

Each trial was introduced by a fixation cross (1,000ms) and was split in three blocks. In the first block, the clause was presented on the screen during 2,000ms in a written form. In the second block, the screen only displayed a fixation cross on a black background during 3,000ms. During this block, an auditory stem sentence was presented 500ms after the onset of the block. Auditory modality was chosen to avoid eye movements, and to compensate for the written variable length of the stem sentences. Finally, in the third block the critical word was presented on screen during 350ms, preceded by a variable interval of 100-150ms (S.O.A.). Once the critical word had disappeared, participants had to press one of the buttons within a window of 2,000ms during which the screen was black. Interval between trials was fixed at 1000ms (see Figure 1).
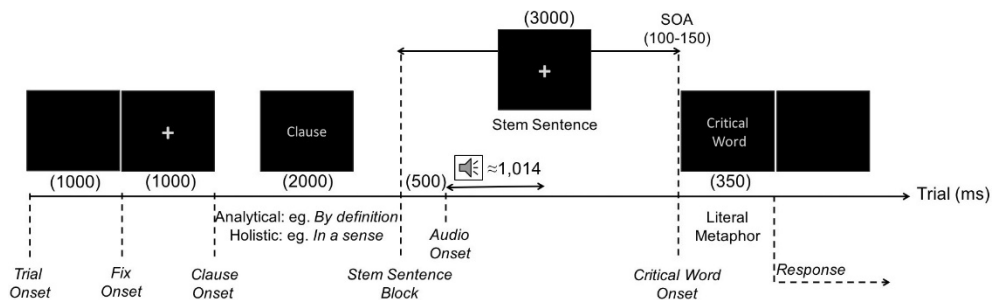

Figure 1. Trial timeline. ms: milliseconds; SOA: Stimulus Onset Asynchrony.

1.4. EEG recording and analysis

EEG was acquired with a BioSemi ActiveTwo system (www.biosemi.com), with 32 active Ag/AgCl electrodes linked mastoids reference. The cap used complies with the standards of the International 10-20 System for electrodes placement. Acquired data was processed and analyzed with EEGLAB 'toolbox' for MATLAB (Delorme & Makeig, 2004). After recording, data was sampled at 1000 Hz and signal was filtered between 0.01 Hz and 70 Hz and recalculated to the average reference. To control vertical and horizontal eye movements, two additional derivations were used (VEOG,

HEOG). All trials with amplitude fluctuations higher than 100 µV or values beyond 5 SD from the mean of the EEG signal; and segments contaminated by eye movements, blinks and other artifacts, were removed from further analysis. Fewer than 15% of the trials for each condition were rejected. To minimize the number of rejected trials, all participants were instructed to fix their eyes on the center of the screen during all the experimental session.

ERPs from two epochs were obtained from the continuous signal. One epoch was used to observe the N400 effect, starting 200ms before the onset of the final word, which could be a literal, or metaphorical one, and ending 800ms after the onset. The other one was used to inspect ERPs during the processing of the stem sentence, starting 200ms prior to the onset of the auditory-presented stem sentence and ending 2500ms after the onset. For both epochs (critical word and stem sentence), baseline correction was performed by subtracting the average of the 200ms before onset activity. Non-rejected trials were averaged to obtain ERPs for each participant and for each condition.

Subsequently, they were used to observe and statistically analyze the components of interest. Electrophysiological and behavioral variables were analyzed with the software Statistica. Repeated measures ANOVA, considering both approaches (analytic/holistic) and ending words (literal/metaphor) were conducted. A factor Laterality with three levels (Right, Center, Left) was also included in the N400 analysis. The electrophysiological data were analyzed including all trials, regardless of the participant responses. All reported results were calculated on averages per subject. The statistical power was computed using the G Power (Faul, Erdfelder, Lang & Buchner, 2007). Specifically, following G power calculation for F test from repeated measures within factors comparisons in ANOVA.

To analyze the N400 effect three regions of interest (ROIs) were defined considering the component scalp distribution. They were central-parietal Right (CP2, C4, P4), Center (Cz and Pz) and Left (CP1, C3, P3). For the stem sentence, a ROI was used comprising three adjacent electrodes situated in the central-parietal region (FC1, C3, Cp1), which presented more differences in ERPs between conditions. The time windows were delineated considering previous reports from the literature for each ERP Component. For the N400 a range was selected according to previous reports in the literature (300-500 ms) then the local minimum was identified and a symmetrical window of 74ms to each side was selected, considering the apparent beginning and ending of the component in the grand-average waveform. In the case of the CNV serial windows of 300ms each were used to compare the waveform between conditions from 1200 to 2500 ms. This approach has been previously used to analyze CNV (Ortega, López, Carrasco, Anllo-Vento & Aboitiz, 2013). Considering the nature of this component (a very slow and long lasting negative trend) a trade-off had to be

made in order to minimize multiple comparisons without extending the averaged window in such way that the amplitude increment is somehow missed.

2. Results

2.1. Sense-making

A 2x2 repeated measures ANOVA was conducted on the responses. 89% of literal sentences made sense to the participants, with no significant differences between the two types of approaches ($F(1, 15) = .29$, $p = .60$). Analytic approach –literal ending made sense on an 88.1% of the cases (SD: 9.6%). Holistic approach–literal ending made sense on an 89.2% of the cases (SD: 10.6%). However, metaphorical endings do exhibit differences as a function of the clause ($F(1, 15) = 7.15$, $p = .02$, partial $\eta^2 = .32$): when in an analytical approach, only 32.4% (SD: 24.7%) of sentences were reported as sense-making, while 44.5% (SD: 22.7%) of metaphorical endings made sense when were preceded by a holistic clause (see Table 2).

Table 2. Behavioral results. Mean reaction times in milliseconds (standard deviation –SD / standard error of measurement –SEM in brackets) and understandability rates in percent for ending words (literal / metaphorical) as a function of the Approach (Analytic vs Holistic).

		NANALYTICAL APPROACH (SD / SEM)	HOLISTIC aAPPROACH (SD / SEM)
LITERAL	*Reaction Time*	7122,3	7434,2
		(1780 / 419,7)	(2181,1 / 514,1)
	Understandability	88,1	89,2
		(9,6 / 2,3)	(24,7 / 5,8)
METAPHOR	*Reaction Time*	9238,6	8706,8
		(2453,6 / 578,3)	(2069,8 / 487,9)
	Understandability	32,4	44,5
		(24,7 / 5,8)	(22,7 / 5,4)

2.2. Reaction Times (RT)

RTs for literal endings are significantly faster than RTs for metaphorical endings ($F(1, 15) = 6.36$, $p = .03$, partial $\eta^2 = .29$) (see Table 1). However, this main effect is secondary to an interaction effect observed when considering the clause ($F(1, 15) = 6.00$, $p = .03$; partial $\eta^2 = .28$). There is a main effect with a significant difference for analytical clauses ($F(1, 15) = 22.84$, $p = .00$, partial $\eta^2 = .60$) which blurs when holistic clauses are observed ($F(1, 15) = 1.21$, $p = .29$).

2.3. Critical word N400

As shown in Fig 2A-B, the critical word in the metaphorical condition elicits an N400 component peaking in the 300-450ms windows, with a maximum over the right

central-parietal region. ERPs show that metaphorical endings elicited larger negativity than literal endings did (F(1, 17) = 16.35, p = .00, partial η^2 = .49).

(A) Grand average of the ERPs in scalp map with representative electrodes (red for literal words from an analytical approach; dark blue for metaphoric words from an analytical approach; soft blue for literal words from a holistic approach; green for metaphoric words from a holistic approach). Circle indicates the ROI's electrodes. (B) Grand average of the ERPs in one representative ROI (CP2, C4, P4): Approaches in literal or metaphoric conditions are represented by line-patterns and colors (solid lines for metaphorical endings, dashed lines for literal endings, red for the analytical approach and blue for holistic approach). Metaphorical endings elicit a larger N400 than literal ones in the 300-450ms window.
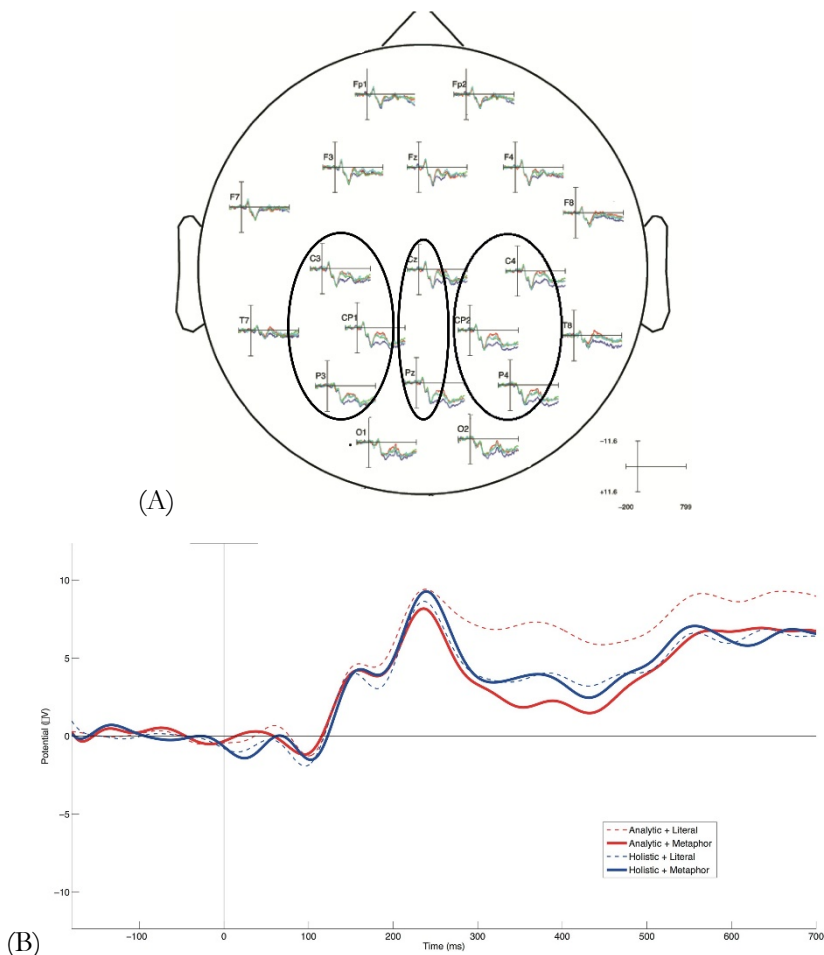

Figure 2. ERPs for metaphorical and literal endings grouped by approach.

However, when subtracting EEG elicited by metaphorical endings from the EEG activity for the literal ones, an N400 effect can be seen in the right central-parietal

region (see Figure 3A-B). A repeated measure ANOVA showed a significant main effect for the approach ($F_{(1,17)}$ = 12.71; p = .00, partial η^2 = .42), due to a more increased negativity for the analytical approach than for holistic one. Additionally, a significant interaction of approach by scalp site (ROIs: Right, Center, Left) was observed due to larger effect over the right ROI ($F_{(2,34)}$ = 8.02; p = .00, partial η^2 = .32).

(A) A red solid line represents the difference for the analytical approach, while blue solid line represents the difference for the holistic approach. An N400 effect can be observed in the analytical condition, absent in the holistic condition. (B) Topographical distribution of the difference ERP between analytical and holistic approaches at the 349ms latency. In the analytical condition, a much more negative effect for metaphoricity can be observed in the right central-parietal region. In the holistic condition, a slight negativity effect can be seen in the right central-frontal region.
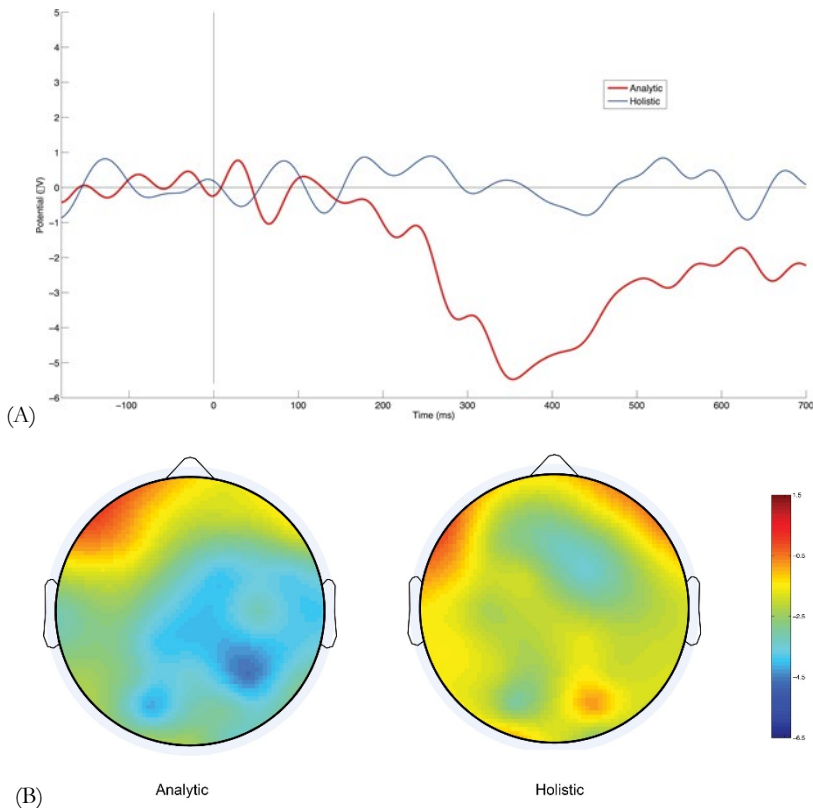

(A)

(B) Analytic Holistic

Figure 3. ERPs difference, calculated by subtracting literal endings' ERPs from metaphorical endings' ERPs.

In the analytical condition, the N400 effect is more negative for metaphorical endings compared to literal endings ($F(1, 17) = 22.58$, $p = .00$, partial $\eta^2 = .57$). Nonetheless, when they were introduced by holistic clauses, no significant differences are observed in the ERPs for metaphorical and literal endings ($F(1, 17) = 0.58$, $p = .45$).

2.4. Stem sentences

ERP activity evoked by stem sentences displays, for both approaches, a positive deflection peaking around 200ms, followed by a slow negative wave (see Fig 4 A-B). This negativity is observable through the whole central-parietal region with a maximum over right hemisphere. However, starting about 270ms after the onset, sentences introduced by an analytical clause elicited a larger negativity than sentences introduced by a holistic clause. In the time windows 1200-1500ms, 1700-2000ms and 2200-2500ms there was a significant main effect of approach (analytical vs holistic) ($F(1, 17) = 18.79$, $p = .00$, partial $\eta^2 = .52$). Although there were significant differences between time intervals ($F(1,17) = 4.85$, $p = .04$, partial $\eta^2 = .22$), there was no significant interaction between these two main effects ($F(1,17) = 1.28$, $p = .27$).

(A) Grand Average in one representative ROI (FC1, C3, CP1) of the ERPs elicited by the presentation of the stem sentence that preceded the critical word. Approaches are represented by line colors: analytical (red solid line) and holistic (blue solid line). When stem sentences were heard in an analytical approach, a late slow negative component exhibited larger amplitude compared to the one elicited in the holistic approach. (B) Topographical map of the difference between the analytical and holistic conditions in the time interval of 1700-2000ms. The main difference is observed over the left centro-parietal region.
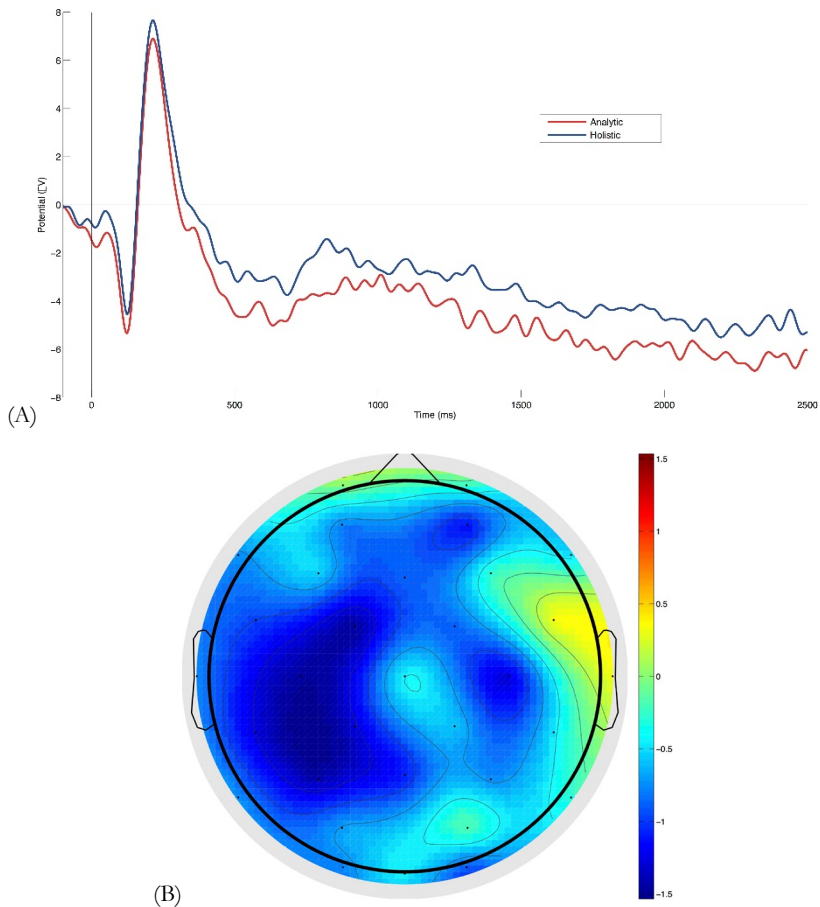
(A)

(B)

Figure 4. ERPs for stem sentences.

3. Discussion

Our results confirm a finding previously reported in literature: metaphors elicit a neural response which translates into a negative component peaking around 400ms and which is typically more negative than components elicited by non-metaphorical sentences (Pynte et al., 1996; Coulson & Van Petten, 2002, 2007). Also, as found in previous studies, literal sentences displayed faster RTs than metaphorical sentences (Bonnaud, Gil & Ingrand, 2002; Shibata, Abe, Terao & Miyamoto, 2007). Furthermore, we found a significant difference in the amplitude of the CNV like component elicited during the stem sentence processing, before critical word presentation, which was larger for the analytical approach.

Our findings deepen the understanding of language comprehension, inasmuch as we showed that, while metaphoric and literal expressions differ in target word, the N400 effect for metaphoricity is modulated by the immediate approach from which participants process linguistic stimuli. When participants were prompted to approach

sentences from an analytical stance and therefore they were focused on words' conventional meaning, a significant N400 effect could be observed when comparing literal and metaphorical endings. However, when participants were prompted to face the same sentences from a holistic approach, we found no statistical differences between metaphorical and conventional sentences, suggesting that words' meaning became more flexible. This effect was also visible in behavioral measures, with faster RTs and a higher percentage of sentences preceded by holistic cues that made sense. This, to our knowledge, has not been previously reported in studies comparing both literal and metaphorical sentences, and it could be related to a pragmatic approach to language (Shibata et al., 2007). Nevertheless, it is worth noting that participants were only asked for their judgement and there were not correct or incorrect answers. Consequently, these behavioral results should be interpreted with caution, and they need to be replicated to be fully understood. It is worth considering that N400 is capable of revealing semantic processing even when this analysis is orthogonal to the task being executed and not evident in the behavioral responses (Kutas & Federmeier, 2011).

Numerous studies have shown how context impacts on the sense making. As for metaphors, they are known to be influenced by co-speech gestures (Cornejo et al., 2009), and, of course, by linguistic contexts, especially when metaphors are somehow familiar (Pynte et al., 1996; Coulson & Matlock, 2001). In a recent study, it was shown that the amount of contextual information modulates N400 amplitude, in such a manner that metaphors' N400 effect was only present in minimal context conditions (Bambini et al., 2016). The authors concluded that N400 elicited by metaphors indexed contextual expectations on upcoming words that guide lexical access and retrieval. Our findings show that the N400 effect can be decreased by clauses that impact on the semantic integration, and therefor on the dynamics of sentence comprehension, which amounts to say that people can somehow direct the process by which they generate meaning. Our results indicate that in metaphorical comprehension there is an integration of the approach into an online knowledge-based prediction for upcoming words.

The analytical and holistic clauses affect the approach to language influencing the semantic integration of upcoming words. This influence has been reported in other studies with other kinds of cues, like negative quantifiers (Nieuwland, 2015a) or temporal terms (Nieuwland, 2015b). This is connected with the result for the holistic clause/literal sentence condition, which evokes a larger N400 than the analytical clause/literal condition. In this case, the holistic clause prompts the person to a more flexible processing of language. Particles like 'In some sense' implicate 'Not in every way'. And when we say 'In some sense mosquitoes are insects' we are suggesting that they are, but not in every way. This kind of affirmation is atypical for our world knowledge, because we know that in every sense mosquitoes are insects. Some

researches of language processing have introduced discourse particles that condition the truth value of the sentences in logic terms, creating under- informative sentences. For example, the introduction of particles like 'Some', which, in a scale of informativeness is less informative that 'All', forces to the persons to infer that utterance is false when this one is true in all cases in real world (for example, 'Some elephants have trucks') (Noveck & Posada, 2003). ERPs shown by these studies indicate that in the under-informative sentences case there is a smoother N400, suggesting that is more important the familiarity by associativity than the truth value judgment (Fischler, Bloom, Childers, Roucos & Perry, 1983; Kounios & Holcomb, 1992; Noveck & Posada, 2003; Tian & Breheny, 2018). However, when we compare literal and metaphor sentences, the difference in N400 effect for metaphoricity under both approaches (analytical and holistic) supports the idea that in metaphorical conditions, particles like 'In some sense' prompt persons to process language oriented towards some potential worlds based on our knowledge of similarities.

There are previous studies that support thinking of between-subject differences as relevant factors when it comes to process language. N400 studies have shown that world-knowledge (Hagoort, Hald, Bastiaansen & Petersson, 2004), the strategy followed to perform a task (Cornejo et al., 2007), empathy (Van Den Brink et al., 2012), pragmatic skills (Kulakova & Nieuwland, 2016) and personal beliefs and values (van Berkum et al., 2009) do impact on the N400 amplitude. However, our study highlights the fact that people can dynamically switch between different approaches to language and that these kinds of clauses, which change people's approach to linguistic inputs, can modulate the N400 component. All of this suggests that a particular approach may be a relevant factor for semantic integration on the online comprehension of language. Neuroscience studies focusing on this personal dimension might help shed light on the role of subjectivity on language comprehension.

In the current study, ERPs for stem sentences show that the immediate approach to language impacts on the dynamics of meaning construction. In the parietal region, a significantly more negative activity was observed for stem sentences preceded by an analytical clause, as compared to sentences preceded by a holistic clause. These slow negativities seem to be part of the family of negative components that mark anticipatory mechanisms (Gaillard, 1977; Van Rijn, Kononowicz, Meck, Ng & Penney, 2011; Jang et al., 2016). In this case, a larger CNV-like negativity could be interpreted as a sign of a greater allocation of cognitive resources (Ortega et al., 2013). Further research, with more specific designs, is required to clarify if this activity is also reflecting build-up processes on working memory, or access to long-term memory, or just attention and expectancy. However, this difference suggests that the person's approach on language influences the processing at the level of the stem sentence, which is the context for the critical word. A question that arises from the results

obtained in this research is whether the observed relationship between the N400 effect and the amplitude of CNV is linked to the restriction of the context that precedes the critical word. Our hypothesis is that context restriction also depends on the type of information processing (analytic vs. holistic), influencing the predictability of incoming words.

The observed results complement the initial observations made by Kutas and Hillyard (1980b) on the relationship of CNV and N400, who consider that both components are part of a complex of negativities linked to language processing. In addition, the larger amplitude of the CNV observed in the analytical condition is congruent with the results obtained by Bonnefond and Van der Henst (2009), who obtained higher amplitudes of this component after the presentation of logical premises. In a recent study, Van Berkum et al. (2013) show how ERPs for real time language processing are influenced by participants' mood. In our study, we observed how the immediate approach to language impacts on the fit between a metaphorical ending and a previous sentence, reflected on the N400 effect modulations. However, and in addition, CNV modulations show that analytical clause such as 'By definition' could activate a logical processing based on conventional meanings, anticipating critical words resorting to definitions based on categories and narrowing the possibilities of expectancies and anticipations. This is consistent with the fact that participants were engaged in analyzing and assessing whether sentences complied with the rules of logic and semantics, based on literal meaning and formal knowledge, which translates into more cognitive effort. However, when participants were prompted to approach sentences from a holistic approach with clauses such as 'In a sense', their expectations were based on the spontaneous use of language, with more flexible online predictions about the upcoming words. The dynamics of their expectations was different and seemed to require less cognitive control and effort.

CONCLUSIONS

Our study suggests that immediate approach on language plays a role in the semantic integration, so that a subjective dimension influences the fit of the sentence and the critical word. Consistent with this, we observed that the immediate approach to language impacts on the 'sense constancy', that is, the flux oriented towards the generation of a particular meaning from a given context (Hörmann, 1981). The subject's approach, manipulated by the interpretative cue, modifies the processing of the subsequent context stem sentence and semantic integration of the target word, resulting in a significant reduction of the N400 effect, classically associated with metaphoricity. This fact should be considered by studies focused on metaphorical language, since the N400 effect appears when speakers assess language in an analytic fashion, focusing on the individual parts of a sentence and losing sight of the sentence as a whole. Also, contextual factors reported in studies about meaning and comprehension (Holyoak & Stamenković, 2018) should be interpreted considering

that participants faced most of the requested tasks from a particular approach. Since most of the time laboratory settings favor analytical approach and very often participants perform their tasks under the impression of being somehow evaluated, it is perfectly plausible that their approach might impact on the obtained results.

Our results suggest that language study should be addressed from a more naturalistic standpoint, considering its dynamic nature and keeping in mind that it is not only permanently linked to contextual factors, but also constantly related to creation and novelty (Hörmann, 1981, 1986; Shanon, 1988, 1990a, 1990b, 1991). All of these points at viewing meaning as a contextual construction process tied both to personal and socially constructed dimensions. Thus, two factors must be considered in the meaning construction process: a) the situational context and b) the person itself.

Language comprehension not only depends on the stimuli to be processed and the context surrounding them, since within-subject factors must also be considered given its impact on the process by which people make sense of language. Speakers can be naturally inclined to predominantly consider language from a particular approach, considering pragmatic communication (Regel & Gunter, 2017). However, even if this inclination exists, speakers can still dynamically switch between approaches, which allow them to shift from one way of making sense to another, depending on the particular concrete context in which they approach language manifestations.

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