The iconic representation of metaphor

An event-related potentials (ERPs) analysis of figurative language

Michela Balconi - Serafino Tutino

Department of Psychology, Catholic University of Milan, Milan, Italy

michela.balconi@unicatt.it

Abstract

The aim of the study is to explore the iconic representation of frozen metaphor. Starting from the dichotomy between the pragmatic models, for which metaphor is a semantic anomaly, and the direct access models, where metaphor is seen as similar to literal language, the cognitive and linguistic processes involved in metaphor comprehension are analyzed using behavioural data (RTs) and neuropsychological indexes (ERPs). 36 subjects listened to 160 sentences equally shared in the variables content (metaphorical vs literal) and congruousness (anomalous vs not semantically anomalous). The ERPs analysis showed two negative deflections (N3-N4 complex), that indicated different cognitive processes involved in sentence comprehension. Repeated measures ANOVA, applied to peak amplitude and latency variables, suggested in fact N4 as index of semantic anomaly (incongruous stimuli), more localized in posterior (Pz) area, while N3 was sensitive to the content variable: metaphor sentences had an ampler deflection than literal ones and posteriorly distributed (Oz). Adding this results with behavioral data (no differences for metaphor vs literal), it seems that the difference between metaphorical and literal decoding isn't for the cognitive complexity of decoding (direct or indirect access), but for its representation format, which is more iconic for metaphor (as N3 suggests).

Keywords: Metaphor; Iconic Representation; Neuropsychology; EEG; Event-related Potentials

1. Introduction

The sentence “The fighters are lions” is a *common* metaphor, easy to understand by *common* people, that involves cognitive and linguistic processes.

The metaphor was defined as a process of correlation between two different domains: a structural and semantic transfer from a conceptual domain to another (Lakoff & Johnson, 1980). This definition implicates two levels of interest: the semiotic interpretation level (that concerns the question of meaning) and the cognitive level (the process involved in metaphor decoding).

For the first, if metaphor is the transfer of a property or concept (*vehicle*) to another, not conventional context (*topic*), then vehicle has an other meaning from the usual one, or rather an nonliteral meaning.

Secondly, metaphor doesn't seem to be only a “figure of speech”, but even a *modus operandi* of our mind, where some specific processes are involved, as conceptualization, semantic memory activation, the use of iconic representation and semantic attribution, language construction and inference processes (Grady, 2005).

Thus, the linguistic and cognitive aspects are both important to explore metaphor comprehension, where the second aspect is a main issue of recent studies. Previous contributions have focused two dichotomic axes of analysis, even though in many cases such dichotomy has not been opportunely conceptualized:

1) A first question is the opposition between literal vs non literal meaning: is metaphor a “different” or “other” meaning in comparison to the literal, conventional one? (Glucksberg, 2003).

For the pragmatic approach metaphor is usually conceptualized as a shifting from “standard” understanding: some models investigated the semantic status of the metaphor, considering it as an example of linguistic anomaly (Grice, 1975). More specifically, the attribution of metaphoric meaning is possible only after the failure of the literal, standard interpretation and the consequent recognition of semantic anomaly (Bonnaud et al., 2002; Gibbs & Gerring, 1989). A second approach treats the question from a communicative point of view, with the distinction among *direct* and *indirect* elaboration: for some authors the metaphoric meaning decoding required an “indirect” process of analysis (Searle, 1979). In this perspective the inhibition of literal meaning was conceptualized as the key for the process of comprehension of metaphor (Glucksberg, 2003; McGlone & Manfredi, 2001). Bonnaud and coll. (2002) point out as central questions a preliminary lexical control process, a mechanism to elaborate sentences, for which metaphors gains a special status in the semantic memory.

Some behavioural indexes confirm the hypothesis of standard pragmatic model (as the increasing of the response time in reading metaphoric sentences in relation to literal ones), underlying that a literal decoding is a first, necessary step in sentence elaboration and so metaphor comprehension is realized only after it.

Nevertheless, not all results confirm the predominance of the literal on metaphoric meaning (Wolff & Gentner, 2000; Gibbs, 1994). A second set of research, in fact, lean towards the immediacy in decoding metaphor: the metaphorical meaning is automatic and direct (Kazmerski, Blasko & Dessalegn, 2003; Pynte et al., 1996). Some behavioural studies found evidences agree to this theory, showing similar RT (response time) for metaphoric and literal decoding, where the figurative meaning is considered immediate and direct, the main meaning to be elaborated, able to interfere with literal interpretation (Glucksberg, 2003; Iakimova et al., 2005; McElree & Nordlie, 1999; Ortony, 1979; Pynte et al., 1996; Tartter et al., 2002).

2) The second issue concerns the usual definition of metaphor as figurative language, for its specific ability to activate a pictorial representation format.

In fact, some models postulate that exist two different representational format for the elaboration of the word: an iconic elaboration, typical of metaphoric meaning, and a linguistic elaboration (Paivio, 1991; West & Holcomb, 2002): the dichotomy here is set along the literal vs iconic representation. Kazmerski and coll. (2003) correlated the ability in decoding metaphor and the subjects' skill to produce images: they found that the activation of a pictorial code or of a subsystem of the semantic memory is responsible of different subjects' performances. This subsystem would process iconic information in a qualitatively different way from the subsystem involved for linguistic information processing (Gentner & Wolff, 1997; Kintsch, 1988; Hamm et al., 2002; Paivio, 1991).

The second issue regards therefore the representational format of the figurative meaning (Kazmerski, Blasko & Dessalegn, 2003).

1.1. The neuropsychological approach: ERPs (event-related potentials) research

The contribute of neuropsychology was important to explore the neuropsychological structures, the linguistic and cognitive mechanisms involved in metaphor comprehension; in particular the electroencephalographic indexes of the event-related potential (ERPs) gave important information to investigate the relation between literal and figurative meaning decoding.

In fact, giving a good level of control of the cognitive phenomena, with a high temporal resolution, the ERPs allow to monitor the cognitive process sequentially, being the EEG modifications related to the qualitative changes of the processes implicated (Handy & Khoe, 2005; Rugg & Coles, 1995).

N400 is a recent ERP marker of sentence elaboration, a peak around 400 ms after the onset of the stimulus that is correlated with the presence of a detected anomaly, or a violation of a an attended information, in meaning comprehension. In general, N400 was an index that regards the cognitive level of analysis: when the cognitive system needs for the integration and the updating of the meaning of a stimulus within an anomalous or incongruent semantic context (Balconi & Lucchiari, 2005; Balconi & Pozzoli, 2003; 2004; Kutas & Hillyard, 1980; Rugg & Coles, 1995). It was widely used in metaphor research, showing contrasting results, even as consequence of different interpretative approaches adopted. From one side, Coulson and Van Petten (2002) found a N400 of greater intensity for the metaphoric sentences in comparison with the literal ones, but a meaningful differentiation was found even between metaphorical sentences and literal sentences that were semantically false. The authors suggested a broad similarity between metaphorical and literal processing: they would implicate the same mechanisms and the same timing elaboration. The increased peak amplitude for N400 was explained as the request of greater cognitive complexity for metaphoric meaning. The metaphoric and literal meaning would be therefore similar for the processes involved, but they would have only a difference for the cognitive gradient of difficulty, with a progressive increase in understanding metaphors.

Pynte et al. (1996) found a variation of gradual intensity of N4 in three conditions: at first literal, then conventional metaphoric and finally non conventional metaphoric sentences. They argued that other elements play a fundamental role in sentences comprehension: context and familiarity are relevant in the figurative language decoding, able to make the metaphoric meaning similar to literal meaning in the process of comprehension.

Kazmerski et al. (2003) compared metaphor, literal and scrambled sentences with the aim to explore the question of semantic anomaly. They found that is more difficult to evaluate as literally false a metaphor in comparison to a scrambled sentence: this would suggest that figurative language doesn't ask for a higher semantic integration, as it happens for scrambled utterances.

Moreover, Tartter and coll. (2002) didn't find differences for the N400 effect among literal and metaphoric meaning, but rather they showed differences in the early phase of elaboration (N200 effect), that could indicate the existence of different syntactic processes among the two conditions.

Finally, Iakimova et al. (2005) submitted literal and metaphorical sentences in a clinical domain, to normal and pathological subjects (schizophrenic), founding more difficult for all sentences in the comprehension of schizophrenic subjects, but not in relation to the metaphoric vs literal utterances. The authors suggested that these results are in line with the model of the "direct access" of the metaphoric meaning.

Besides, it is possible to compare the two conditions of decoding considering a second ERP variation, the N300 effect, that was found in case of an iconic representation of the meaning (Eddy et al., 2006; Federmeier & Kutas, 2001; Hamm et al., 2002; Laeng et al., 2003; Large et al., 2004). Holcomb et al. (1999) found this negative deflection for pictorial stimuli or linguistic stimuli with a high iconic value, as for images or lexical stimuli with an increased degree of pictorial feature. West and Holcomb (2002) stated that this variation was correlated to the process of transposition of the iconic format in a linguistic representation.

In synthesis, both the ERPs components, one related to the semantic elaboration of the stimulus (N400), the other related to the pictorial representational format (N300), can inform about the nature of the metaphoric decoding.

2. Objectives and hypotheses

The aim of this research is the comparison of the elaboration of the two conditions of linguistic and metaphoric decoding, considering both the semantic elaboration level and the representational format of the meaning. We will analyzed two distinct ERP deflections (N300 and N400 peaks) and behavioural ones (variations in the response time, RT) to the sentences. Specifically:

1. We will compare the literal and metaphor meaning comprehension to analyze the semantic attribution process of the meaning, paying attention to a potential detection of semantic anomaly in metaphorical meaning comprehension. In case of a direct access of the metaphoric meaning, in fact, the N4 deflection should have a similar profile for the two conditions. On the contrary, we expect to find a clear distinction between not anomalous (congruous) vs anomalous (incongruous) sentences in N4 amplitude. In other terms, the presence of semantically anomalous stimuli (incongruous sentences) should be marked by qualitatively different processes from those activated by semantically congruous (as metaphoric as literal) sentences (congruous sentences).
2. Also, peak latency can inform about the nature of the cognitive processes involved in the literal/metaphoric conditions and congruence/incongru-

ence dichotomy. Meaningful differences in the temporal onset of the N400 effect could suggest quantitatively different processes in sentence comprehension, indicating variances in cognitive complexity. A greater latency could be index of an increase in the cognitive complexity, mirror of longer times of elaboration.

3. Behavioral data give further information about the question of greater complexity in metaphor elaboration: an increase for figurative meaning decoding could suggest the necessity of semantic integration in comparison to literal elaboration. Contrarily, a substantial homogeneity of RTs would indicate similar degrees and levels of elaboration, confirming the model of the direct access of metaphorical sentences.
4. Moreover, figurative language could show a typical and different representational format of the meaning: an iconic format marked by specific ERP indexes. In line with this hypothesis, the presence of the negative component N3 will be observed, that was previously found in relation to stimuli with an iconic representational format.
5. Finally we will consider a possible ERP localization effect and in particular for literal vs metaphorical meaning. Localization effect could indicate a cortical specialization for the elaboration of the metaphorical vs. literal meaning, with a different contribution of the one or the another hemisphere. Some studies noticed that the right hemisphere, in general, is more involved then the left for the pragmatic components of the meaning (Beeman & Chiarello, 1998; Newman et al., 2003) as for metaphoric, ironic or sarcastic sentences (Bottini et al., 1994; Giora, 2003; Papagno, Oliveri & Romero, 2002). On the contrary, some studies didn't find these ampler activation of right hemisphere (Stringaris et al., 2006; Kacinik & Chiarello, 2007), leaving open the debate about the contribution of the two hemispheres in figurative language elaboration (Papagno & Carporali, 2007).

3. Method

3.1. Participants

36 subjects (twelve male M = 24.36; SD = 2.36), students of Psychology at the Catholic University of Milan, participated in the study. All subjects were Italians and they gave their agreement to participate at the research.

3.2. Materials

A set of sentences with literal or metaphoric meaning was used. Metaphors have to satisfy the followings characteristics:

- Each sentence was composed by 4 words, with a metaphor expressed in a nominal form (Pynte et al., 1996).
- The metaphoric content was obtained by a unique noun-term (metaphorical target), placed at the end of sentence (metaphorical ending) (Tartter et al., 2002).
- The context of each sentence was enough to activate a metaphoric decoding, without necessity of additional information.
- We tested the familiarity of metaphors (frozen metaphors), considered as salient and contextually relevant. As underlined by previous research, the degree of familiarity seems play an important role in the decoding process (Ahrens et al., 2007; Giora, 2007; Giora & Fein, 1999 [1]; Mashal et al., 2007).

We started form the metaphorical sentence to create the literal one, replacing the final metaphoric target with a literal target (a noun). So, we obtained pairs of analogous sentences in the two experimental conditions, where only the ending word was different (Tartter et al., 2002), as in the following example:
a) "the lawyers are sharks";
b) "the lawyers are professional".

The target word was balanced with respect of the mean length (metaphorical range = 2-5 syllables; literal range = 3-5 syllables). A pre-experimental phase (by 25 subjects on a 7-points Likert scale), tested familiarity (metaphor M = 6.13, SD = 0.69; literal M = 5.96, SD = 0.86) and abstractness/concreteness (metaphorical concrete M = 5.70, SD = 0.54; literal concrete M = 6.01, SD = 0.40; metaphorical abstract M = 5.89, SD = 0.67; literal abstract M = 5.81, SD = 0.47) Regarding the latter parameter, we choose the

[1] The degree of metaphor conventionality plays an important role and is a property placed along a continuum, from a minimum level (innovative and unfamiliar metaphors) to a maximum level (conventional and familiar metaphors). The idioms are set to the extreme of this potential continuum (Katz & Ferretti, 2001; Papagno, Oliveri & Romero, 2002). With conventionality, they means *stability* in our *language*, that refers to a categorial and of pre-existing conceptual system (Lakoff & Johnson, 1980; Pynte et al., 1996). For example, "love is a trip" is a conventional metaphor that belong to our conceptual system, sharing in common knowledge, that it is understood before than a new metaphor (Blank, 1988; Gentner & Wolff, 1997; Lakoff, 1993).

same number of concrete and abstract words (both literal and metaphoric), with a 50% for each category.

Moreover, we balanced the sentences in relation to the content variable: congruence (coherence of content) vs incongruence (incoherence of content) (Balconi & Pozzoli, 2004; 2005). Subsequently we created two sequences of new sentences, one with a congruent content, the other with an incongruous content, as in the following example: for literal "the soldiers are fighters", for metaphorical "the soldiers are lions". Altogether, we have created four different batteries, each containing only one version of sentence of the four possible.

Every subject was submitted to one of the four sequences, composed by 160 sentences, 80 metaphoric (equally subdivided in congruent and incongruent) and 80 literal (the same as previous). Each sequence was opportunely randomized, taking into account to not set similar sentences (for metaphorical meaning or for content) one after the other.

To control the relevance of the metaphoric/literal conditions, 25 subjects evaluated each sentence in a pre-experimental test (7-points Likert scale). For the composition of the final sequences we considered:

- as metaphorical the sentences with an evaluation of metaphoricity of M = 5 or upper (M = 6.43, SD = .38);
- as literal the sentences with an opposite evaluation, that is for metaphoricity M = 2 or lower (M = 1.90, SD = .41).

3.2. Procedure

The experiment took place in a room opportunely darkened and soundproofed. Thanks to the apparatus of stimulation (STIM 2.2) the sentences were presented at the centre of the screen, one word at a time (3 cm of height, white on black background), for a mean duration of 300 ms (SOA 600 ms) and an inter-sentence interval of 1200 ms.

Subjects were seated in front of a monitor to 100 cm of distance (visual horizontal angle of 4° and vertical of 6°), and they were asked only to read and understand the sentence, pressing the right button of the mouse when they have finished to comprehend it. A fixation point was present at the center of the screen, before that each stimulus appeared. With the aim to enable a correct familiarization with the experiment, the subjects were submitted to a pre-experimental phase (20 trials –10 metaphoric and 10 literal).

4. Data analysis and results

4.1. ERPS data

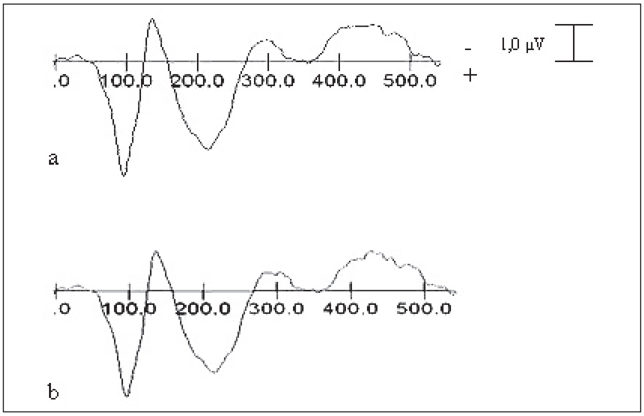
a) Recording parameters
The EEG was recorded with a 64-channel DC amplifer *(SYNAMPS* system) and acquisition software (NEUROSCAN 4.2) at 32 electrodes (International 10-20 system, Jasper, 1958) with reference electrodes at the mastoids, and mounted in a stretch-lycra electro-cup (high density registration). Electroculograms (EOG) were recorded from electrodes lateral and superior to the left eye. The signal (sampled at 256 Hz) was amplified and processed with a passband from .01 to 50 (off-line) Hz and was recorded in continuous mode. Impedance was controlled and maintained below 5 KΩ. Fourteen of the registered sites were considered for the statistical analysis (four central, Fz, Cz, Pz, Oz; ten lateral, F3, F4, C3, C4, T3, T4, P3, P4, O1, O2). An averaged waveform (off-line) was obtained (trials exceeding 50 μV in amplitude were excluded from the averaging process) for each type of condition (literal vs metaphoric) and content (congruent/incongruent). The EEG signals were visually scored on a high-resolution computer monitor and portions of the data that contained eye movements, muscle movements, or other source of artifact were removed. The percentage of the rejected epochs was low (6%). Peak amplitude measurement was quantified relative to 100 ms pre-stimulus (epoch duration: -100/900 ms).

b) Morphological analysis of wave profile
In order to individuate the main variations in the wave profile, we applied a qualitative, morphological analysis to the ERPs for both the literal and metaphoric conditions. As showed by the following figure (Fig. 1), in both cases it was possible to observe a previous positive peak of high amplitude around 200 ms post-stimulus (P2), and a later complex of two negative deflections, peaked at about 300 and 400 ms post-stimulus.

Then, for the statistical analysis (quantitative analysis), we considered only the two negative deflections, N300 and N400 (within the time interval of 200-400 ms and 400-600 ms).

c) Quantitative analysis of ERPs
We considered two dependent measures: the amplitude and the latency of the peaks for each deflection. An ANOVA for repeated measures was applied with three within-subjects factors: condition (2, metaphorical/literal), content (2, congruent/incongruent), electrodes (14). A Greenhouse-Geiser cor-

rection was applied in case of more than one degree of freedom. Besides the correspondent value of η^2 was calculated. In order to simply the data presentation, we reported only what was significant to the statistical analysis. With the aim to better study the localization effect, two new independent factors were calculated: one related to the four electrodes of the median line (Fz, Cz, Pz, Oz, from now the median) and the second one related to the two hemispheres (for the right one, a mean value was calculated on the electrodes F3, C3, T3, P3, O1; for the left one on the F4, C4, T4, P4, O2, from now lateralization). The variability of electrode profile was monitored in such way (Luck, 2005).

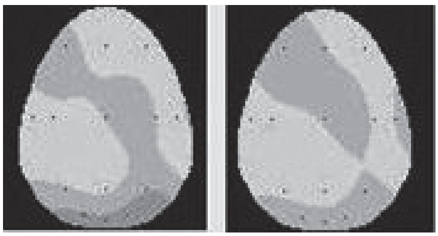


Fiure 1. Grandaverage (all the electrodes) for metaphoric (a) and literal (b) sentences

4.1.1. N3 Effect: Intensity and latency of the peak

The ANOVA for repeated measures (2 × 2 × 14) showed a significant effect for condition ($F(1,35) = 6.46$, $p < .01$, $\eta^2 = .34$) and electrode ($F(13,35) = 6.70$, $p < .01$, $\eta^2 = .37$). As suggests by mean values of peak (Table 1a), the negative deflection for metaphoric condition had greater intensity in comparison to literal sentences. Besides, the significance of the interaction effect "condition x electrode" ($F(13,35) = 4.60$, $p = .01$, $\eta^2 = .28$) allows to point out that the N3 distribution is not homogeneous on the scalp. Contrarily, no relevant differences in peak amplitude were found as a function of the content: the two conditions of congruence/incongruence showed similar profiles.

The following ANOVA better defines the cortical areas involved in the elaboration: we found an interaction effect condition x median ($F(3,35) = 6.28$, $p = .01$, $\eta^2 = .33$). Particularly, the planned comparisons (analysis of the contrasts) showed a greater peak intensity for the metaphoric stimuli in the occipital area of the scalp (Oz) in comparison to the parietal (Pz) ($F(1,35) = 7.13$, $p < .01$, $\eta^2 = .38$), the central (Cz) ($F(1,35) = 6.98$, $p < .01$, $\eta^2 = .31$) and the frontal ones (Fz) ($F(1,35) = 6.61$, $p = .01$, $\eta^2 = .29$), while literal condition doesn't show significant results. On the contrary, the lateralization effect doesn't show statistically significant differences. In the following map, we present the variations of the N3 effect on the scalp.



a b

Figure 2. Cortical maps of N3 (338 msec. latency) for metaphoric (a) and literal (b) sentences

The analysis of N3 latency doesn't show meaningful differences for condition, content and electrode effects, as well as for their interactions. The peak has a mean latency of 338 ms post-stimulus.

4.1.2. N4 Effect: Intensity and latency of peak

We applied an ANOVA for repeated measures to the N400 too, that show the effect of content ($F(1,35) = 4.54$, $p = .03$, $\eta^2 = .26$), and electrode ($F(13,35) = 7.84$, $< .01$, $\eta^2 = .40$), but not of condition. The following table (Table 2a and 2b) shows the presence of a higher peak amplitude of N4 for incongruous in comparison to congruous condition. The N4 effect is not sensitive to the condition: metaphorical and literal sentences aren't significantly differentiated for the intensity of the peak. Besides, the posterior areas of the scalp (Pz particularly) seems to be more activated in comparison to the anterior and central ones.

The successive ANOVA with the median and lateralization factors underlined more specifically the anterior-central-posterior differences (median effect $F(3,35) = 6.89$, $p < .01$, $\eta^2 = .38$), additionally to the content effect.

Table 1a. Mean value of peak amplitude of N3

	Peak amplitude[a]											
	Fz		Cz		Pz		Oz		Right		Left	
N3	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*
congruous metaphors	-0.80	0.40	-0.74	0.15	-0.53	0.11	-0.89	0.10	-0.51	0.09	-0.71	0.07
uncongruous metaphors	-0.90	0.50	-0.95	0.15	-0.76	0.12	-1.01	0.11	-0.78	0.11	-0.87	0.09
congruous literals	-0.40	0.10	-0.48	0.13	-0.32	0.11	-0.82	0.13	-0.36	0.11	-0.63	0.09
uncongruous literals	-0.50	1.20	-0.70	0.12	-0.48	0.13	-0.95	0.12	-0.58	0.10	-0.73	0.07

[a] in μvolt.

Table 1b. Mean value of peak latency for N3

	Peak latency[b]											
	Fz		Cz		Pz		Oz		Right		Left	
N3	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*
congruous metaphors	346.12	3.70	340.19	4.10	342.58	3.86	337.86	3.72	341.38	2.70	336.94	3.19
uncongruous metaphors	340.92	2.34	338.47	4.43	338.58	5.13	343.58	3.58	342.17	3.04	335.89	3.43
congruous literals	336.53	2.89	338.89	4.97	343.06	4.28	341.69	2.93	339.97	2.83	334.06	2.85
uncongruous literals	341.23	3.21	331.72	5.17	338.36	4.79	342.58	3.66	339.61	3.23	335.96	3.09

[b] in msec.

Table 2a. Mean value of peak amplitude of N4

Peak amplitude												
	Fz		Cz		Pz		Oz		Right		Left	
N4	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*
congruous metaphors	-1.30	0.13	-1.24	0.13	-1.24	0.13	-1.22	0.09	-0.98	0.70	-1.11	0.08
uncongruous metaphors	-1.20	0.20	-1.21	0.12	-1.11	0.11	-1.26	0.09	-1.11	0.10	-1.13	0.10
congruous literals	-1.10	0.13	-1.03	0.13	-1.30	0.10	-1.13	0.08	-0.86	0.80	-1.01	0.08
uncongruous literals	-1.40	0.13	-1.13	0.13	-2.00	0.12	-1.31	0.10	-1.50	0.10	-1.11	0.08

Table 2b. Mean value of peak latency for N4

Peak latency												
	Fz		Cz		Pz		Oz		Right		Left	
N4	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*	*M*	*Sd*
congruous metaphors	432.43	4.32	425.42	5.35	425.47	4.89	426.92	4.60	427.69	3.44	430.25	3.19
uncongruous metaphors	439.32	4.89	426.83	5.63	430.50	5.36	428.78	4.32	429.62	3.82	427.78	3.28
congruous literals	431.21	3.23	429.78	6.01	431.06	5.97	423.94	5.42	431.58	3.93	431.03	4.56
uncongruous literals	430.28	5.04	428.81	6.23	439.67	6.18	429.92	4.91	433.76	4.13	433.68	4.29

The contrast analysis showed a greater contribution of Pz in comparison with the other locations (Fz ($F(1,35) = 6.41$, $p < .01$, $\eta^2 = .34$); Cz ($F(1,35) = 5.39$, $p < .01$, $\eta^2 = .28$); Oz ($F(1,35) = 4.48$, $p < .01$, $\eta^2 = .26$). The significance of the interaction effect content x lateralization ($F(1,35) = 7.09$, $p < .01$, $\eta^2 = .42$) and of content x median ($F(3,35) = 6.80$, $p < .01$, $\eta^2 = .35$) revealed the presence of a greater peak amplitude of N4 for Pz in the condition of incongruence in comparison to all the other electrodes (respectively Fz ($F(1,35) = 8.04$, $p < .01$, $\eta^2 = .44$); Cz ($F(1,35) = 6.12$, $p < .01$, $\eta^2 = .32$); Oz ($F(1,35) = 6.78$, $p < .01$, $\eta^2 = .40$). Then, it was shown a greater intensity of peak for incongruous sentences in the right areas in comparison to left ones ($F(1,35) = 8.54$, $p < .01$, .2), while significant differences were not observed for congruent condition.

Significant results were not found for the latency dependent measure.

4.1.3. Behavioural index (RT)

Behavioral data of 32 subjects were used for the statistical analysis, since 4 subjects were eliminated for their too many missing responses (more than 10%). The ANOVA for repeated measures, applied to condition (2) and content (2) independent factor, didn't reveal significant differences. A particular data, even without a significant inferential statistic, is to underline: metaphoric sentences registered anticipated RT values in comparison to literal condition (specifically for metaphoric sentences $M = 224.64$ ms; $SD = 2.45$; for literal sentences $M = 237.75$ ms; $SD = 3.45$).

5. Discussion

The data we found allowed us to investigate the cognitive correlates in understanding metaphors. We synthesize the main results into the following main points.

1. First of all, N4 effect didn't appear as a marker of the elaboration of metaphoric meaning, but it is mostly sensitive to the content variations (congruence/incongruence) of the sentences.
2. The absence of interaction effect between condition and content suggests that the incidence of the content on modulation of N4 appears entirely independent from the presence of metaphoric or literal meaning decoding process. It seems to be localizated in the parietal areas of the scalp (PZ) for the condition of incongruence.

3. The second ERP effect considered, the N3 deflection, appears sensitive only to the condition effect: it was mostly present for the elaboration of metaphoric meanings. The absence of significance in relation to factor content, suggests that it hasn't a direct relationship with the presence of semantic anomalies in the stimuli. Additionally, its cortical distribution involves mainly the posterior areas of the scalp (Oz), above all for metaphoric condition.
4. Lateralization effect (right vs left hemisphere) doesn't show statistical significance in N3 peak amplitude, while the N4 index appears to mostly activate the cortical right areas in condition of content incongruity.
5. Behavioral data show the absence of meaningful differences, and in particular in relationship to the dichotomy metaphorical/literal.

At first, the results about the N4 ERP effect are relevant in the debate about the relationship between metaphoric and literal decoding process. The absence of significant differences in the two conditions doesn't allow to consider the figurative language comprehension after the inhibition of the standard, literal process. These results are in line with the direct access model, for which metaphor appears cognitively and semantically not anomalous at the semantic level.

The approach of some cognitive models (Coulson & Van Petten, 2002), for which metaphor requires a more complex process of elaboration, doesn't find confirm here, and response times too show that there is not a deceleration in understanding metaphor, but it is automatically and immediately activated as literal decoding. Behavioural data about literal/metaphorical condition give even more interesting information: metaphorical comprehension produces an observable reduction of RT in comparison with literal comprehension. Such data could be explained considering the high value of familiarity of our metaphoric sentences: the metaphors we used are conventional, cognitively salient for the subject. As suggested by Giora's model (Giora & Fein, 1999), the salience and the familiarity are reasonable factors for the metaphoric decoding: high-salient metaphors represent the automatic option activated.

The latency of the N4 effect doesn't show differences in relationship to the experimental variables: this tendency is important especially for the condition factor, confirming the homogeneity of metaphorical and literal decoding.

Besides, we confirmed results of other studies, detecting a negative deflection of N4 sensible to the semantic congruence of the stimulus: the significant effect produced by the congruence/incongruence of sentence (and not by the metaphorical/literal condition) would confirm that metaphoric comprehension does not require a decoding process qualitatively different from the literal one. On the whole, we can suppose the existence of a kind of continuum between literal, metaphoric conventional and metaphoric unconventional context. This intermediate position of metaphoric conventional would be due to the membership of familiar metaphorical meaning to a pre-existing semantic system, which makes them "conventional".

A second main issue here examined is referred to the different wave profiles of N3 effect for metaphoric sentences in comparison to literal condition, while the first registered a meaningful higher than the second one. This result, associated to the absence of N4 modifications, would rather suggest an access to a different *representation store* for the metaphor meanings, whose nature might be iconic (Balconi & Tutino, 2006).

Iconic elaboration process could be therefore involved in a significant measure, even though not exclusive. Previous researches found N3 effect for image-based representations, or representative of a pictorial code, in response to iconic stimuli (such as script compared to lexical stimuli) (Holcomb et al., 1999; Paivio, 1991; Shallice, 1993; West & Holcomb, 2002). The N3 localization, that is significantly more present in occipital area of the scalp, would confirm the pictorial nature of the negative deflection. Neuropsychological studies have postulated, in fact, that such areas are extensively responsible for the elaboration of visual stimuli (primary visual areas) and they are mainly involved in processes that implicate an elaboration mediated by the images (Ladavas & Berti, 1995).

On the contrary, we didn't found the expected lateralization effect in metaphor decoding.

The researches about hemispheric asymmetry in language elaboration, in fact, postulated the right hemisphere as mostly responsible of the pragmatic components of language (Beeman & Chiarello, 1998) and particularly of metaphoric decoding (Gineste et al., 2000; Mashal, Faust & Hendler, 2005; Mashal et al., 2007). Contrarily, the left hemisphere was considered more implicated in the lexical processes and, in general, for the elaboration of the standard or literal meaning. Nevertheless, the high degree of familiarity of our metaphoric stimuli could have effect in the similar contribution of both the hemispheres, with a joined action of the right and left areas of the scalp (Schmidt et al., 2007; Stringaris et al., 2007).

Moreover, the hemispheric differentiation appeared to be sensitive to sentence congruousness, with a greater right activation for semantically anomalous stimuli and a substantial homogeneity of two hemispheres for congruent utterances.

This particular finding could be explained with the hypothesis that the right hemisphere in general would clear the ambiguous meaning, or it would operate to choose an alternative meaning to that anomalous. Coney and

Evans (2000) proposed the paradigm of the lexical ambiguity to explain the different contribution of the two hemispheres in language decoding, where the relationship between context and sentence meaning plays a fundamental role. For the authors, the left hemisphere would be preferably activated when exist a concordance between the contextual domain and the dominant meaning, while the right hemisphere give a greater contribution for not-dominant or anomalous meaning. According with this point of view, the left hemisphere would be more selective, choosing an unique semantic option between those possible (Faust & Lavidor, 2003), and the right hemisphere has the function to support it in order to make accessible a greater ensemble of alternative and less probable meanings (Jung-Beeman, 2005).

In synthesis, we found the presence of a negative ERPs complex composed by two different ERP indexes: the first (N300) is presumably a marker of the "iconic" format of representation, and the second (N400) is involved in the semantic elaboration of the stimuli (congruousness effect), testing the consonance between sentence-meaning and sentence-context. Nevertheless, our results show a substantial difference in the processes involved in metaphorical and literal elaboration, based on the contribution of different mechanisms that make specific and unique metaphoric meaning representation compared with literal meaning: the iconic format of representation is the main point that must be considered in order to explain the main differences with the literal format of representation.

Moreover, these results are opposite with theory of linguistic anomaly or indirect access, indicating that the difference is not for the presence of differences in terms of degree of complexity in sentence elaboration or of anomalous/not anomalous meaning comprehension.

In general, our results would suggest a direct resemblance between the semantic comprehension of metaphors and literal sentences decoding, even if it involves different representational format. Nevertheless, the high level of conventionalization of metaphor may have facilitate the comprehension of the sentence meaning, making more easier to compare metaphoric with literal decoding process. Moreover, the balanced contribution of concrete/abstract target in the sentences construction is a fact to be evaluated, since this feature was shown to be directly related to the level of imaginability (West & Holcomb, 2002). An explicit comparison between these two categories of target stimuli may produce some interesting effect on the ERP modulation, specifically on the N3 negative deflection.

References

Ahrens, K., Liu, H.-L., Lee, C.-Y., Gong, S.-P., Fang, S.-Y., & Hsu, Y.-Y. (2007). Functional MRI of conventional and anomalous metaphors in Mandarin Chinese. *Brain and Language*, 100, 163-171.

Balconi, M., & Lucchiari, C. (2005). Consciousness, emotion and face: An event-related potential study. In: Ellis, R., Newton, R.N. (eds.), *Consciousness and Emotion. Agency, Conscious Choice, and Selective Perception*. Philadelphia: Benjamins, pp. 121-135.

Balconi, M., & Pozzoli, U. (2003). Face-selective processing and the effect of pleasant and unpleasant emotional expression on ERP correlate. *International Journal of Psychophysiology*, 49, 67-74.

Balconi, M., & Pozzoli, U. (2004). Elaborazione di anomalie semantiche e sintattiche con stimolazione visiva e uditiva. Un'analisi mediante correlati ERPs. *Giornale Italiano di Psicologia*, 3, 585-612.

Balconi, M., & Pozzoli, U. (2005). Comprehending semantic and grammatical violations in Italian. N400 and P600 comparison with visual and auditory stimuli. *Journal of Psycholinguistic Research*, 34, 71-98.

Balconi, M. & Tutino, S. (2006). A fighter is a lion. Neuropsychological and cognitive processes in decoding a metaphor. An analysis through ERPs. *Journal of the International Neuropsychological Society, Supplement*, 12, 88.

Beeman, M., & Chiarello, C. (1998). Concluding remarks: Getting the whole story right. In: Beeman, M., Chiarello, C. (eds.), *Right Hemisphere Language Comprehension: Perspectives from Cognitive Neuroscience*. Mahwah, NJ: Lawrence Erlbaum Associates, pp. 377-389.

Blank, G.D. (1988). Metaphors in the lexicon. *Metaphor and Symbolic Activity*, 3, 21-36.

Bonnaud, V., Gil, R., & Ingrand, P. (2002). Metaphorical and non-metaphorical links: A behavioral and ERP study in young and elderly adults. *Clinical Neurophysiology*, 32, 258-268.

Bottini, G., Corcoran, R., Sterzi, R., Paulesu, E., Schenone, P., Scarpa, P., Frackowiak, R.S.J., & Frith, C.D. (1994). The role of the right hemisphere in the interpretation of figurative aspects of language. A positron emission tomography activation study. *Brain*, 117, 1241-1253.

Coney, J., & Evans, K.D. (2000). Hemispheric asymmetries in the resolution of lexical ambiguity. *Neuropsychologia*, 38, 272-282.

Coulson, S., & Van Petten, C. (2002). Conceptual integration and metaphor: An event-related potential study. *Memory and Cogntion*, 30, 958-968.

Eddy, M., Schmid, A., & Holcomb, P.J. (2006). Masked repetition priming and event-related brain potentials: A new approach for tracking the time-course of object perception. *Psychophysiology*, 43, 564-568.

Faust, M., & Lavidor, M. (2003). Semantically convergent and semantically divergent priming in the cerebral hemispheres: Lexical decision and semantic judgment. *Cognitive Brain Research*, 17, 585-597.

Federmeier, K.D., & Kutas, M. (2001). Meaning and modality: Influences of context, semantic memory organization, and perceptual predictability on picture processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 202-224.

Gentner, D., & Wolff, P. (1997). Alignment in the processing of metaphor. *Journal of Memory and Language*, 37, 331-355.

Gibbs, R. (1994). *Poetics of Mind: Figurative Thought, Language, and Understanding.* Cambridge, MA: Cambridge University Press.

Gibbs, R.W., & Gerring, R.J. (1989). How context makes metaphor comprehension seem "special". *Metaphor and Symbolic Activity*, 4, 145-158.

Gineste, M., Indurkhya, B., & Scart, V. (2000). Emergence of Features in Metaphor Comprehension. *Metaphor and Symbol*, 15, 117-135.

Giora, R. (2003). *On our Mind: Salience, Context, and Figurative Language*. New York: Oxford University Press.

Giora, R. (2007). Is metaphor special? *Brain and Language*, 100, 111-114.

Giora, R., & Fein, O. (1999). On understanding familiar and less-familiar figurative language. *Journal of Pragmatics*, 31, 1601-1618.

Glucksberg, S. (2003). The psycholinguistics of metaphor. *Trends in Cognitive Science*, 7, 92-96.

Grady, J. (2005). Primary metaphors as inputs to conceptual integration. *Journal of Pragmatics. Special Issue: Conceptual Blending Theory*, 37, 1595-1614.

Grice, H.P. (1975). Logic and Conversation. In: Cole, P., Morgan, J. (eds.), *Syntax and Semantics*, vol. 3. New York: Academic Press, pp. 41-58.

Hamm, J.P., Johnson, B.W., & Kirk, I.J. (2002). Comparison of the N300 and N400 ERPs to picture stimuli in congruent and incongruent contexts. *Clinical Neurophysiology*, 113, 1339-1350.

Handy, T.C., & Khoe, W. (2005). Attention and sensory gain control: A peripheral visual process? *Journal of Cognitive Neuroscience*, 17, 1936-1949.

Holcomb, P.J., Kounios, J., Anderson, J.E., & West, W.C. (1999). Dual-coding, context-availability, and concreteness effects in sentence comprehension: An electrophysiological investigation. *Journal of Experimental Psychology. Learning Memory and Cognition*, 25, 721-742.

Iakimova, G., Passerieux, C., Laurent, J., & Hardy-Bayle, M. (2005). ERPs of metaphoric, literal, and incongruous semantic processing in schizophrenia. *Psychophysiology*, 42, 380-390.

Jasper, H.H. (1958). The ten-twenty electrode system of International Federation EEG. *Clinical Neurophysiology*, 10, 371-375.

Jung-Beeman, M. (2005). Bilateral brain processes for comprehending natural language. *Trends in Cognitive Science*, 9, 512-518.

Kacinik, N.A., & Chiarello, C. (2007). Understanding metaphors: Is the right hemisphere uniquely involved? *Brain and Language*, 100, 188-207.

Katz, A.N., & Ferretti, T.R. (2001). Moment-by-moment readings of proverbs in literal and nonliteral contexts. *Metaphor and Symbol*, 16, 193-221.

Kazmerski, V.A., Blasko, D.G., & Dessalegn, B.G. (2003). ERP and behavioral evidence of individual differences in metaphor comprehension. *Memory and Cognition*, 31, 673-689.

Kintsch, W. (1988). The role of knowledge in discourse comprehension construction-integration model. *Psychological Review*, 95, 163-182.

Kutas, M., & Hillyard, S.A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, 207, 203-205.

Ladavas, E., & Berti, A. (1995). *Neuropsicologia*. Bologna: Il Mulino.

Laeng, B., Zarrinpar, A., & Kosslyn, S.M. (2003). Do separate processes identify objects as exemplars versus members of basic-level categories? Evidence from hemispheric specialization. *Brain and Cognition*, 53, 15-27.

Lakoff, G. (1993). The contemporary theory of metaphor. In: Ortony, A. (ed.), *Metaphor and Thought*, 2nd. ed. Cambridge, MA: Cambridge University Press, pp. 202-251.

Lakoff, G., & Johnson, M. (1980). *Metaphors We Live by.* Chicago: University of Chicago Press.

Large, M.E., Kiss, I., & McMullen, P.A. (2004). Electrophysiological correlates of object categorization: back to basics. *Cognitive Brain Research*, 20, 415-426.

Luck, S.J. (2005). Ten simple rules for designing ERP experiments. In: Handy, T.C. (ed.), *Event-related Potentials. A Method Handbook*. Cambridge, MA: The MIT Press, pp. 17-33.

Mashal, N., Faust, M., & Hendler, T. (2005). The role of the right hemisphere in processing nonsalient metaphorical meanings: Application of Principal Components Analysis to fMRI data. *Neuropsychologia*, 43, 2084-2100.

Mashal, N., Faust, M., Hendler, T., & Jung-Beeman, M. (2007). An fMRI investigation of the neural correlates underlying the processing of novel metaphoric expressions. *Brain and Language*, 100, 115-126.

McElree, B., & Nordlie, J. (1999). Literal and figurative interpretations are computed in equal time. *Psychonomic Bulletin & Review*, 6, 486-494.

McGlone, M.S., & Manfredi, D.A. (2001). Topic-vehicle interaction in metaphor comprehension. *Memory & Cognition*, 29, 1209-1219.

Newman, S.D., Just, M.A., & Mason, R.A. (2003). Understanding text with the right side of the brain: What functional neuroimaging has to say. In: Tomitch, L.M.B., Rodrigues, C. (eds.), *Ensaios Sobre a Linguagem e o Cérebro Humano: Contribuições Multidisciplinares*, pp. 71-84.

Ortony, A. (1979). *Metaphor and Thought*. Cambridge, MA: Cambridge University Press.

Paivio, A. (1991). *Images in Mind: The Evolution of a Theory.* New York: Harvester Wheatsheaf.

Papagno, C., & Caporali, A. (2007) submitted. Testing idiom comprehension in aphasic patients: The modality and the type of idiom effects. *Brain and Language*.

Papagno, C., Oliveri, M., & Romero, L. (2002). Neural correlates of idiom comprehension. *Cortex*, 38, 895-898.

Pynte, J., Besson, M., Robichon., F.H., & Poli, J. (1996). The time-course of metaphor comprehension: An event-related potential study. *Brain and Language*, 55, 293-316.

Rugg, M.D., & Coles, M.G.H. (1995). The ERP and cognitive psychology: Conceptual issues. In: Rugg, M., Coles, M. (eds.), *Electrophysiology of Mind*. Oxford: Oxford University Press.

Schmidt, G., DeBuse, C., & Seger, C. (2007). Right hemisphere metaphor processing? Characterizing the lateralization of semantic processes. *Brain and Language*, 100, 127-141.

Searle, J.R. (1979). *Speech Acts.* Cambridge: Cambridge University Press.

Shallice, T. (1993). Multiple semantics: Whose confusions? *Cognitive Neuropsychology*, 10, 251-261.

Stringaris, A., Medford, N., Giora, R., Giampietro, C.V., Brammer, J.M., & David, S.A. (2006). How metaphors influence semantic relatedness judgments: The role of the right frontal cortex. *Neuro Image*, 33, 784-793.

Tartter, V.C., Gomes, H., Dubrovsky, B., Molholm, S., & Stewart, R.V. (2002). Novel metaphors appear anomalous at least momentarily: Evidence from N400. *Brain and Language*, 80, 488-509.

West, W.C., & Holcomb, P.J. (2002). Event-related potentials during discourse-level semantic integration of complex pictures. *Cognitive Brain Research*, 13, 363-375.

Wolff, P., & Gentner, D. (2000). Evidence for role-neutral initial processing of metaphors. *Journal of Experimental Psychology. Learning Memory and Cognition*, 26, 529-554.