



# Neuropsychological *Trends*

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# Understanding irony: an ERP analysis on the elaboration of acoustic ironic statements

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## ABSTRACT

*Irony is part of our daily experience, that is probably the reason why a lot of studies have been trying to define its nature and the way we are able to understand the pragmatic intentions lying behind ironic communication. This study addresses the issue of pragmatic comprehension of language by analysing the differences or similarities in processing ironical and non-ironical language. The aim of the study is specifically to explore neuropsychological correlates (ERPs) of irony decoding. 10 subjects listened to 240 sentences presenting a counterfactual vs. non-counterfactual content (counterfactual modality) and spoken with ironical vs. neutral prosody (prosody modality). ERPs analysis showed a negative deflection peaking at about 460ms post stimulus onset (N400) for all the conditions. Statistical analyses (repeated measures ANOVA) applied to peak amplitudes showed no statistically significant differences between the conditions as a functions of the type of sentence (ironical vs. non ironical) and the content of ironical sentences (counterfactual vs. non counterfactual). An increase of N400 related to ironical sentences was observed although no statistical significant differences between ironical and non ironical sentences were found. The absence of an N400 effect may indicate that irony is not treated as a semantic anomaly, thus rejecting the standard pragmatic hypothesis. The observed differences in amplitude could be probably attributed to a higher requirement for the cognitive resources in order to integrate contrasting and complex lexical, prosodic and contextual cues.*

*Keywords:* ERPs; Irony; Neuropragmatics

## 1. INTRODUCTION

What is irony and how is irony understood. In this paper we'll try to give directly an answer to this second question, anyway some reflections on the first one ought to be done. Gibbs (1994) argues that irony is a common form of thought through which humans are able to juxtapose ones' expectations with reality. Following this perspective ironic language is the representation of an *ironic way* to think, that permeates many aspects of life and that can express itself in many different forms. So irony's boundaries are not easy to draw in everyday communication, and that is why, even if common, irony can be considered a complex pragmatic and communicative phenomenon. Some examples could help to delineate this complexity.

1. George has just red his results in the math test: he got an F. In that moment his classmate Fred passes by and seeing the results says:
  - a) "You know George, you should study harder!".
  - b) "You know George, you shouldn't study *this* hard!".
  - c) "You didn't *so* bad, *did* you?".
  - d) "Congratulations George, you're just a *genius*!".
2. Annie asks his son to tide up his really messy room. After a while, she goes back to her son's room finding it still messy and exclaims:
  - a) "Your room is still messy!".
  - b) "Your room seems still a little messy, doesn't it?!".
  - c) "I *just* love dutiful guys who keep their room clean!".
  - d) "I see you did a great job in tiding up your room!".

Most people reading this examples would agree that (1a) and (2a) represent "literal" (non-ironic) statements since both are negative affirmation in negative contexts, in other words both affirmations are congruent with what one would expect in that context.

Some problems arise with (1b), that appears to be clearly false: George did not study hard otherwise he would have got an "A", not an "F". So, what allows us to interpret Fred's statement in an ironic way? Probably some meta-representational reasoning. Since (1b) is clearly false, three interpretative options are then possible: (1) Fred is obviously mistaking: he has misread George's result and he is congratulating; (2) Fred is lying, but this option has a low probability since context can easily disconfirm it; (3) Fred is uttering an ironic comment, in the specific case he is criticising by praising. A different case is represented by (1c) and (2b), since these statements are not completely false and not completely incongruent. It is not denied that George did bad or the room is still messy, but the situation is described in a mitigated way. This case is described as understatement and it is recognized, together with its counterpart hyperbole – see examples (1d) and (2d) – as a form

of irony (Colston & O'Brien, 2000). In addition to the hyperbolic construction, (1d) and (2d) also present a form of opposition to reality: the state-of-things presented in the statements is opposite to the actual state-of-things; this could be the most easily recognizable kind of irony (Colston & O'Brien, 2000). The last case presented here (but not the last possible) is the one of example (2c). Annie's statement is definitely true: she really loves dutiful kids who keep their room clean, so why is this statement ironic? Her affirmation can be interpreted ironically because it is context-inconsistent, so we can infer she does not want to express her thought about dutiful kids, but wants to remark how her son is not of that kind (implicit critic).

The examples above show how defining irony as a pragmatic phenomenon, where what is said is the contrary of what is intended, is way too simple and, secondly, how it is not always so easy to cleanly distinguish ironic and non ironic statements. Kreuz demonstrated (1996) that saying something patently false is only one cue of irony, but not a sufficient one. In fact, it is not always possible to detect a clear cut between the truthfulness of the literal content of an ironic statement and its incompatibility with reality. We saw how, in order to better understand this issue, we should think in terms of speech acts theory (Austin, 1962). If a statement is literally true, it can't be ironic. On the contrary, if a statement is incongruent with a true state of affairs it could have some other kind of illocutionary force: it could be ironic or false or a mistake (Kreuz, 2000). In addition there is the case of understatements and hyperboles, those particular forms of language where a situation is described in intermediate terms between its opposite and its reality (Colston & O'Brien, 2000); finally the case of true statements that can be appropriate but not fully relevant in the situation (Utsumi, 2000; Attardo, 2000). In addition, some comments such as questions, offerings, overpolite requests or expressives, could be ironic even if they cannot be evaluated in terms of truth conditions. In order to explain the ironicity conveyed by these expressions, Kumon-Nakamura and colleagues (1995) appealed to the concept of pragmatic insincerity that is an expression that violates felicity conditions more than truth conditions (Austin, 1962; Searle, 1969; 1976). Again, pragmatic insincerity cannot be considered a sufficient cues for irony: other cues have been identified in the call-backs to expectations, whether explicit or implicit (Sperber & Wilson, 1984; Kreuz & Glucksberg, 1989; Clark & Gerrig, 1984), norms or shared beliefs (Utsumi, 2000; Kihara, 2005). Finally extralinguistic cues, such as, vocal and prosodic profile or facial mimics, have been considered important on a communicative level (Kreuz, 1996; Anolli et al., 2000; Attardo et al., 2003).

Thence the complexity of irony is apparent and it is not surprising that different theories have been elaborated to explain what irony is and how it is

understood by decoders. It has been considered as a form of semantic anomaly (Grice, 1975; Searle, 1969) or as a pragmatic construct involving forms of pragmatic insincerity (Kumon-Nakamura, 1995), pretense (Clark & Gerrig, 1984), echoic elements (Sperber & Wilson, 1986) or a context-inappropriateness (Attardo, 2000) or again it has been considered as a form of indirect negation (Giora, 1995; Giora et al., 1998). On a cognitive level it has been conceptualized as a form of thought (Gibbs, 1994; Kihara, 2005; Ritchie, 2005) involving different grades of contrast between linguistic representation and the reality domain it refers to (Colston, 2002). Finally, with a communicative approach, we can consider irony not as a semantic or pragmatic anomaly, but as a form of communication involving different levels of representation and complex communicative intentions (Anolli et al., 2002; Gibbs & Colston, 2007b, for analytic review of principal theories on irony).

The complexity of irony as a pragmatic phenomenon is well mirrored in the debate, still open, on how is irony understood. Pragmatics studies, using behavioural measures, still haven't provided sufficient evidence to explain which processes and in which times are involved in the decoding and comprehension of ironic comments. In the following paragraphs we'll examine principal pragmatic models of irony comprehension and we'll see how the experimental findings still leave the question open.

## 2. PRAGMATIC MODELS OF IRONY COMPREHENSION

Psycholinguistics discusses the interaction between verbal (lexical-semantic) and contextual information in terms of "local" and "global" factors. Understanding a message, literal or non-literal, is therefore a matter of integration of local and global factors. The question about when and how these two kinds of information interact is still an important object of debate (see Nieuwland & Van Berkum, 2006; Hagoort et al., 2004).

Some models of language elaboration affirm that hearers process local information first, independently from utterance context, and, only in a second phase, they relate that meaning to the wider context. This is a two step model where initial semantic/local information is not influenced by pragmatic/global information. More recently, this functional and temporal distinction between local and global factors has been questioned by some interactive models (Jackendoff, 2002; MacDonald et al., 1994). These models generally postulate the existence of a single phase of message elaboration where semantic information has not functional or temporal precedence over global/contextual factors. Both kinds of information could, in general, ei-

ther simultaneously define the message interpretation or have an influence one over the other or, finally, one could prevail over the other depending on its relevance (Sperber & Wilson, 1986), salience (Giora, 2003) or contextual strength (Gibbs, 1994).

This general debate on pragmatic language comprehension applies to irony comprehension as well. Three main models of language processing tried to explain irony comprehension processes formulating three different hypothesis on the basis of the relation between literal and ironic meaning of ironic statements.

According to the Standard Pragmatic View (Grice, 1975; Searle, 1969), irony can be considered a violation of conversational maxims, in particular of the quality (truthfulness) one. In other words, an ironic utterance is a literal statement falsified by the reality context. It is thus necessary, in order to understand irony, to recognise that the speaker is meaning something different from what he/she is saying and to reconstruct the real meaning of the utterance, that is usually the opposite of what is said. In order to understand an ironic meaning a decoder should at first process the literal meaning of a statement, then test this meaning against the context and, whether the violation of conversational maxims is detected, he/she should look for an alternative – nonliteral – meaning since the first literal interpretation makes no sense. The process to retrieve the intended meaning involves extra-inferential processes named “conversational implicatures”; only at the end of this process the incoherence is solved and the intended meaning reconstructed (Clark & Lucy, 1975; Searle, 1976). This process is supposed to require an extra-effort, therefore extra-time, to reach the right interpretation. This standard model has been actually disconfirmed by different empirical studies which found that, in particular cases, response time (RT) to figurative language in general and to ironies in particular are not slower than RT to literal statements (Gibbs, 1994; 1999; 2002; Giora, 1999; Giora & Fein, 1999a; 1999b).

Other pragmatics models propose a different hypothesis of elaboration: a Parallel Access Model. This approach suggests that both the literal and the nonliteral interpretation of an utterance are always processed but generally makes no assumption about the order in which that happens. Two main models can be brought back to this general model: the Parallel Race Model (Long & Graesser, 1988) and the Graded Salience Hypothesis (Giora, 2003).

Long and Graesser proposed a multiple meaning model based on Suls (1977) incongruity-resolution theory of humour. According to that theory, the essential condition for humour is the perception of a discrepancy between what is expected and what actually occurs. Adapting this model to verbal iron-

ny, Long and Graesser proposed that what is expected is the intended ironic meaning while what occurs is the literal meaning. In this hypothesis, context (background, linguistic, conversational and social) plays a crucial role in irony comprehension processes either allowing comprehension to occur after some discrepancy is recognized or biasing the interpretation early on. In this last case, the intended meaning is accessed before the incongruity of literal meaning is recognized. Eitherway both literal and ironic meaning are always activated even if there is no hierarchical order in meaning activation: both literal and non literal meaning are simultaneously accessed and concurrently processed, and they both participate in ironic meaning construction. Dews and Winner (1999; Schwoebel, Dews, Winner et al., 2000) tested this model showing that deriving an ironic interpretation involves some recognition (conscious or unconscious) of the discrepancy between literal and ironic meaning. If one only recognizes the intended meaning of an ironic utterance without noticing at some level what was literally said, one has not fully understood irony. Anyway Dews and Winner concludes that the entire literal meaning need not be processed before the intended meaning, as was the case of standard pragmatics, since multiple meanings can be processed simultaneously.

On the other side, Giora (1999; 2003) suggests the initial elaboration of literal or nonliteral meanings is linked to meaning salience. To be salient a meaning should be coded in the mental lexicon and that happens when it is familiar, frequent, conventional and prototypical. When two or more meanings are salient, they should be accessed in parallel. According to this model, irony elaboration is a matter of salience more than of context (Giora et al., 2007). Giora distinguishes between familiar and non familiar ironies. This two kinds of irony have been studied in literally biased versus ironically biased contexts. In both literally and ironically biased context, non familiar ironies have one salient meaning (literal) and deriving the intended but not salient ironic meaning involves a sequential process where the ironic meaning is derived after the salient literal meaning is rejected. Instead familiar ironies have two salient meanings (literal and ironic) and they are both activated regardless of contextual fit. In other words, according to the Graded Salience Hypothesis, non lexical contextual information should not affect initial meaning activation: salient lexical meaning (literal) of non familiar ironies is the only one instantly activated also in ironically biased context, *even though* it is incompatible with contextual information. On the contrary, the salient literal meaning of familiar ironies is available in ironically biased contexts in spite of a mismatch with contextual information. In sum, irony comprehension seems to be function of meaning salience and not of context (Giora et al., 2007).



A third approach to verbal irony comprehension proposes that, under some particular circumstances, ironic meaning is directly accessed (Gibbs et al., 1995; Gibbs, 2002). Gibbs proposes that in a context offering enough ironic cues, non literal interpretation of a statement is direct and automatic with no need to compute the literal inconsistent interpretation. That could happen because in a high constraining context, a nonliteral interpretation is conventional, so the elaboration of nonconventional literal meaning is optional and the listener does not have to fully elaborate the literal meaning and its incongruity. This hypothesis has been tested through reading time paradigms, whose basic assumption is that reading times of sentences could be suggestive of the initial comprehension processes. Longer reading time indicates an utterance involves more effortful processes, while shorter reading time indicates the process requires less cognitive effort. Reading time of ironic non conventional utterances showed they require extra effort to elaborate than their literal conventional interpretation, whereas this is not the case of conventional ironies (Giora et al., 1999; Ivanko & Pexman, 2003; Schwoebel et al., 2000).

As we have seen, empirical findings supporting or opposing these models are controversial, therefore the question about how irony is processed remains open.

### 3. APPLYING ERPs TO IRONY INVESTIGATION

Early studies on irony processing looked at the products of comprehension rather than at the online processing of ironical utterances. Further studies introduced behavioural measures (reading time) in order to investigate the online mostly unconscious process (see for examples Giora, 1999; Giora et al., 2005; 2007; Gibbs, 1999; 2002) of irony elaboration, delineating a crucial role for the context. In fact, context incompatibility and rich pragmatic cues have been proved to ease ironic interpretation.

In our study we propose to apply electrophysiological paradigm to an irony comprehension study. In particular we propose to use event-related potentials (ERPs) to measure irony elaboration processes. ERPs have been successfully used in psycholinguistic studies on literal and figurative language (Kutas & Van Petten, 1994; Coulson, 2004 for a review) with interesting results that, together with reading time and lexical decision paradigms, helped to understand complex pragmatic phenomenon such as metaphor (Coulson & Van Petten, 2002; Pynte et al., 1996; Balconi & Tutino, 2006; 2007) or humour (Coulson & Wu, 2005), and only recently have been applied to irony studies (Cornejo et al., 2007; Balconi & Amenta, 2007; 2008).

ERPs are a measure characterized by high temporal definition and provide intrinsic indexes of cognitive processes (Rugg & Coles, 1995). The most known index of semantic integration is N400, a negative, central-parietal deflection, that peaks around 400 ms from stimulus onset (Kutas & Hillyard, 1980). N400 is an amodal index elicited by any content of words or sentences which amplitude is directly proportional to the effort requested by the integration process. N400 is sensitive to ambiguous words in context, semantic and pragmatics anomalies and unexpected words or sentence finals (Kutas & Hillyard, 1984; Coulson et al., 1998; Balconi & Pozzoli, 2004; 2005; Kuperberg et al., 2003; Nieuwland et al., 2006). Therefore it could be a valid index to explore the process of irony comprehension and to test the pragmatic models of irony processing.

A recent study (Cornejo et al., 2007) used event-related potentials to assess the effects of cognitive elaboration strategies (analytic versus holistic) on irony comprehension. The results of the study show that in the holistic condition, where subjects were asked to look for the global sense of the proposed sentence, each category tested (literal vs. ironical vs. nonsensical) generate a negativity, analogue to the N400 component, mainly in the left frontal-central zone. Significant differences were observed in the literal condition when compared to both the ironical category and the nonsensical category. Authors concluded that the differences observed in the N400 time window for both the nonsensical and the ironical condition compared to the literal condition could be due, in the first case to the semantic incongruity of the nonsensical stimulus, instead, in the second case, the increase of the N400 could be attributed to the lack of contextual information favouring the ironical comprehension. The authors found also a positivity in a later time window (600-700 ms) for ironical stimuli in comparison to nonsensical and literal sentences. Other studies (Juottonen et al., 1996; Tartter et al., 2002) have associated this component with higher requirements needed to select the appropriate meaning associated to the linguistic expression, once the ironic intention has been recognized. Taken together these results seem to indicate that ironical sentences demand more of the cognitive resources involved in closure task since the meaning of ironical sentences remains inconclusive. The greater usage of cognitive closure resources would explain the larger later positive amplitude in response to irony.

Another study (Regel et al., 2006) tried to assess the influence of prosody on ironic comprehension by manipulating both the context and the paralinguistic components of ironic expressions. Results of this study showed no difference in the N400 amplitude due to prosody, instead found a sustained posterior positivity in a 500-900 time window evoked by ironic biasing context. These findings seem to confirm that, when sufficient contextual infor-

mation is present, ironical elaboration is easier at least in the first phases (no N400 effect appeared in a prosodically enriched context).

#### 4. OBJECTIVES AND HYPOTHESES

Main aim of the present study is to explain how ironic sentences are processed, testing pragmatic models of irony comprehension through the ERP's methodology.

We will consider irony as a complex form of *indirect communication* where multiple communicative intentions and goals are intertwined and pursued and where multiple discourse and representational levels are involved. Speaker and hearer have an active role in irony production and comprehension: they both should play meta-representational and meta-linguistic abilities to produce and decode an ironic comment.

From pragmatics' point of view, irony comprehension is not only a matter of linguistic decoding, but also of nonverbal decoding: extra-linguistic and paralinguistic cues are important since they contribute to define the ironic meaning of a message. Nonverbal cues such as mimics but also (and foremost) prosody are crucial elements in irony production and comprehension, since, ironic communication is mainly characterized by a contrastive synergy between linguistic (verbal) aspects and mimic and prosodic patterns (nonverbal). Therefore, recognizing and decoding irony typically consists in noticing nonverbal cues that contradict the verbal expression. On the other side, a failure in the identification of nonverbal cues which mark ironic communication could result in a failure in the identification of the ironic intention, hence in the comprehension of the speaker's meaning. In fact, ironic meaning arises in the synthesis of the lexical meaning of the sentence and the prosodic profile that commonly conveys an opposite sense (Anolli et al., 2000; 2002). In other words, ironic meaning is build through the interaction between verbal and nonverbal information in a given context (background knowledge, world knowledge, pragmatic context).

In the present study we intend to explore the influence of the prosodic cues on the initial phases of irony comprehension process where little contextual information is given. In particular, we are interested in better understand the cognitive and neuropsychological mechanisms involved in early phases of the comprehension process of ironic statements, therefore our analyses will focus on early ERP components such as N400.

We will manipulate the content of sentences and their prosodic profile in order to construct and compare literal (congruent content) statements

conveyed with neutral prosody to ironic (congruent and incongruent content) sentences conveyed with an ironical prosody.

We hypothesize that if irony is perceived and categorized as a semantic incongruity, therefore we should observe an ampler N400 (from now hence: *N400 effect*). On the contrary, if ironical prosody would interact with contextual information easing the recognition of the ironical intention, no N400 effect should be present.

Tracking it down to classical pragmatic hypothesis we can say that if, as standard pragmatics asserts, ironical meaning is derived after the literal meaning is processed and rejected, therefore an N400 effect should be present. On the contrary, if the ironical meaning is concurrently processed together with literal meaning or directly accessed, as Parallel Model and Direct Access view argue, no N400 effect should be present.

## 5. METHODS

### 5.1. Participants

12 right-handed university students (9 women, 3 men; mean age = 23 years, SD = 0,56) all enrolled in the Psychology Faculty of the Catholic University of Milan participated to the study. All the participants presented a regular neurological profile and normal hearing. They gave informed consent for participating in the study, and they were not paid for their participation.

### 5.2. Materials and Procedure

#### 5.2.1. Stimuli

Stimuli consisted in a set of literal and ironic sentences presented in auditory modality. All the statements were of the type “X is Y”, where the first part was the same concrete noun in each condition, while the ending could be literal (congruent with neutral prosody) or ironic (congruent with ironic prosody or incongruent with ironic prosody). So the three experimental conditions can be exemplified as follows:

- a) An insult is an affront (neutral tone of voice). Literal.
- b) An insult is a pleasantry (ironic tone of voice). Counterfactual irony.
- c) An insult is an abuse (ironic tone of voice). Non counterfactual irony.

There were a hundred sentences of each type. The stimuli were tested in a pre-experimental phase (12 participants) on a 5-points Likert-type scale for familiarity, truthfulness and concreteness. Items not reaching 3 on each scale were rejected.

Finally, we ask a professional actor to read all the sentences while we were recording his voice. He was asked to perform the literal sentences with a plain tone of voice and the ironic sentences with an ironic prosody (Anolli, Ciceri & Infantino, 2000; Kreuz & Roberts, 1995; Attardo et al., 2003). A new pre-experimental test (12 participants) was conducted to assess on a 5-points Likert-type scale the ironic level of the auditory stimuli. Ironic stimuli not reaching 3 on the scale were rejected. At the end of the pre-experimental phase, 240 stimuli were considered for the research.

The stimuli were then randomized and organized in four batteries containing 20 literal statements, 20 counterfactual ironic statements and 20 non counterfactual ironic statements each (STIM 2.2). Every statement was followed by an interval (ISI) of 3 seconds of silence. Sequences were also split in two sub-batteries of 30 stimuli each, so not to overload subjects' cognitive system. Subjects were randomly divided in groups of four, then assigned to one battery.

### *5.2.2. Procedure*

The experiment took place at the Laboratory of Cognitive Psychology of Catholic University of Milan. Subjects were invited to take a seat on a comfortable chair in a darkened and tested for electromagnetic interference room. They were informed on the scope of the experiment, that is language comprehension processes, and about the experimental procedure. After we placed the electrodes (see below) on the participants' scalp, they were asked to keep still, in front of a computer monitor, to stare at a fixation point (a green dot) presented in the centre of the screen and to listen carefully to the stimuli.

First the participants were familiarized with the procedure with a sequence consisting in 12 stimuli, three for every type of sentence. After a short pause, subjects were presented with the experimental battery. We explicitly ask the subjects to listen to the stimuli and to try to understand what the speaker meant by what he was saying.

After the experiment, participants were asked to express some evaluations on the stimuli previously heard. Stimuli were tested on a 5-points Likert-type scale for literality and irony.

### 5.2.3. EEG and ERPs recording techniques

The participants wore an electrocap which measured a continuous EEG while they performed the task. We recorded the EEG from 14 Ag/AgCl electrodes that were all referenced to the earlobes. We recorded the vertical electro-oculogram (EOG) from bipolar electrodes above and at the outer canthus of the right eye. The 14 scalp sites used according to the international 10-20 system (Jaspers, 1958) were: (a) four midline, Fz, Cz, Pz and Oz; (b) right or left frontal, F4 and F3; (c) central, C4 and C3; (d) temporal, T4 and T3; (e) parietal, P4 and P3; and (f) occipital, O2 and O1. A ground electrode was placed on the forehead. Electrode impedance was kept below 5  $\Omega$ . The EEG data were sampled by an amplifier (NeuroScan SYNAMP 4.2) for 2.000 ms (100-ms baseline) at 500 Hz.

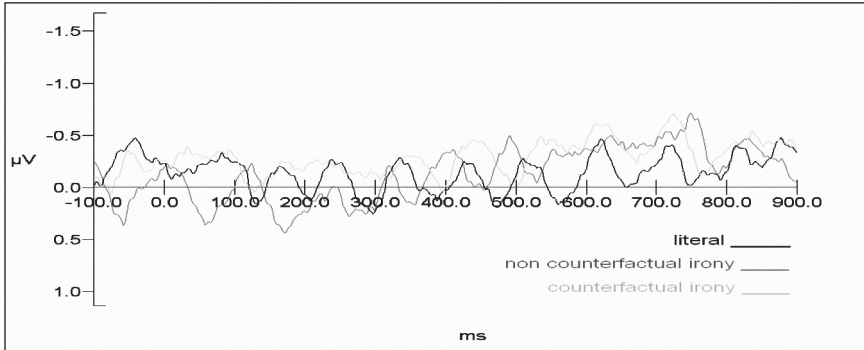
## 6. DATA ANALYSES

### 6.1. Morphological analysis

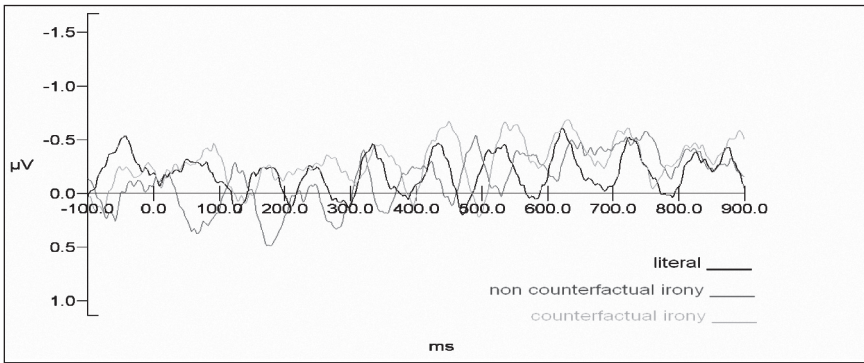
We used an artefact rejection procedure (each epoch filtered using a digital 1-40 Hz band pass filter). Among the remaining trials we used a visual detection procedure to discharge possibly artifacted EEG segments (i.e. trials invalidated by interferences such as blinks). We rejected 13% epochs for EOG or muscular artifacts. For the same reason, 2 subjects' EEG were eliminated. We computed the averaged evoked responses (offline) for each participant. Then we computed three waves elicited by (a) literal sentences, (b) counterfactual ironic sentences and (c) non counterfactual ironic sentences. We then proceeded with morphological analysis.

First step of our analysis consisted in a qualitative exploration of the wave profiles in search of significant variations relative to stimulus presentation in the three conditions. We combined a visual exploration of the profiles with a computerized peak detection (Edit Software NeuroScan 4.2) in order to find minimum and maximum values of peak intensity.

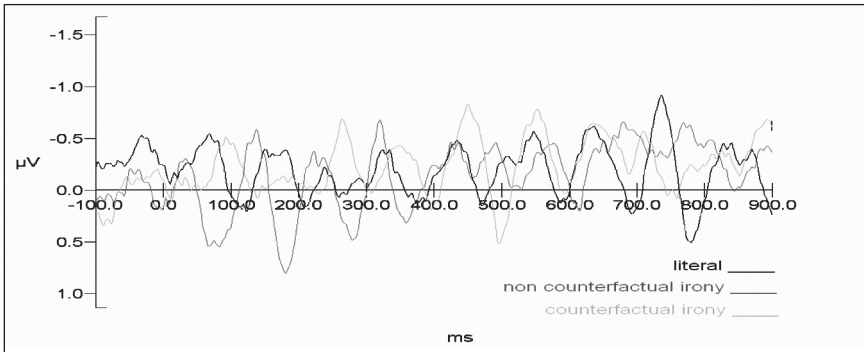
The analyses showed in each condition a first negative deflection peaking around 350 ms followed by a second negative deflection peaking about 460 ms from stimulus onset (N400). In a later time window it appeared a sustained negative deflection. We then obtained a grand mean average across participants for two temporal windows, 300-400 ms and 400-500 ms. Peak amplitude measurement was quantified relative to 100 ms pre-stimulus. For statistical analyses we focused only on the N400 time window.



(a)



(b)



(c)

Figure 1. Grandaverage for counterfactual irony, non counterfactual irony and literality on Fz (a), Cz (b) and Pz (c)

6.2. Amplitudes analysis

A repeated measure ANOVA was applied to our data with three within-subjects factors (2 x 3 x 5 design): hemisphere (right vs. left), type of sentence (literal vs. counterfactual irony vs. non counterfactual irony), cerebral area (frontal vs. central vs. temporal vs. parietal vs. occipital). A Greenhouse-Geisser correction was applied. Results show no statistically significant effects of type ( $F = 2,704, p = .125$ ), hemisphere ( $F = .438, p = .524$ ) or area ( $F = 1,831, p = .197$ ). Besides no significant interaction effect was found.

From descriptive analyses emerged an interesting trend relative to the difference in mean amplitude for the three conditions. In particular we observed that counterfactual and simple ironic statements showed a mean amplitude of  $-0.188\mu V$  and  $-0.187$  respectively while literal statements elicited a less intense N400 component with maximum peak around  $-0.143$ . Left hemisphere seemed to be the more involved in counterfactual irony processing (mean amplitudes: left =  $-0.195$ ; right =  $0.180$ ) while no substantial differences were observed between the hemispheres in the other conditions. Finally, the N400 component reached maximum amplitudes in the frontal (mean amplitude  $F = -0.192$ ) and central (mean amplitude  $C = -0.189$ ) areas and in parietal regions (mean amplitude  $P = 0.171$ ).

Figure 2 and 3 summarize our results.

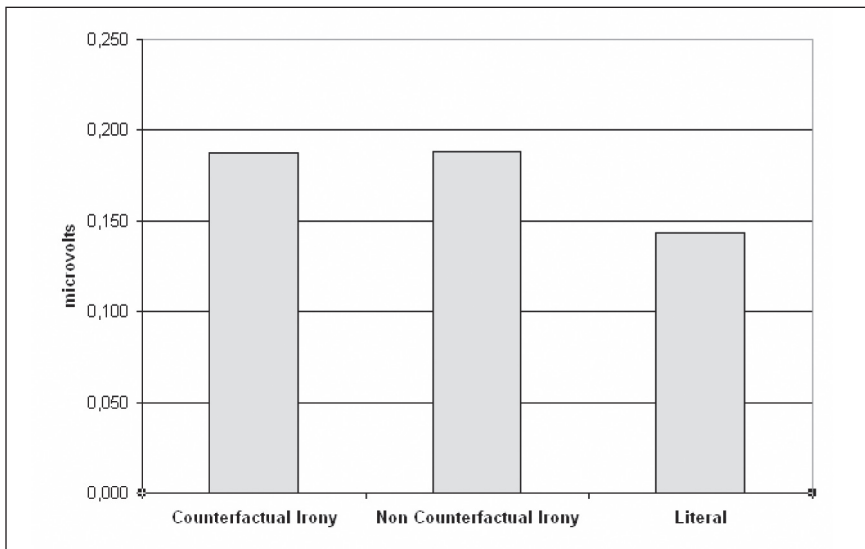


Figure 2. N400 peak amplitude as a function of the type of sentence



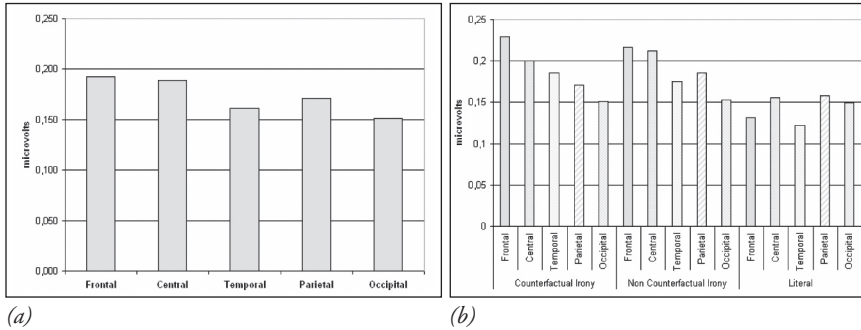


Figure 3. N400 peak amplitude in different cortical areas across the conditions (a) and as a function of the type of sentence and of localization (b)

## 7. DISCUSSION AND CONCLUSIONS

Classical pragmatics models discussed whether irony should be considered as a semantic anomaly or as a complex phenomenon whose meanings originates in the early integration of linguistic and contextual information. In the first case, as standard pragmatics argues, ironic meaning is the result of three distinct operation: linguistic meaning processing, semantic incongruity detection and conversational implicatures generation. An ERP of this incongruity resolution process should be an increased N400, since this component has been associated to the detection of a semantic incongruity likely due to the individuation of violations of conversational rules. In the second case, instead, linguistic and contextual information interact early on in ironic meaning construction, therefore no incongruity is relieved and no N400 effect should be apparent.

Our analysis showed no statistically relevant N400 effect relative to irony elaboration with respect of literal utterances. This result, in line with previous studies (Regel et al., 2006), which found no N400 effect relative to ironic processing when sufficient contextual information relative to extralinguistic components is given, seems to rule out standard pragmatic model as a valid elaboration hypothesis. Besides, the results seem to confirm the hypothesis that the N400 modulations is a function of contextual and especially nonverbal information (Giora, 2005; 2007; Cornejo et al., 2007). In this sense we are allowed to accept that irony is not a semantic anomaly and that ironic meaning is not interpreted after an incongruity detection and resolution process has taken place. On the contrary, we can suppose that, when

enough contextual information is given – such vocal clues – ironic meaning elaboration starts early on in sentence processing.

Interesting it seems to be also the lack of a statistically significant difference between the two kinds of irony involved, that is counterfactual vs. non-counterfactual. This result, together with the previous one, confirms that irony is not treated as a semantic anomaly, as false (hence counterfactual sentences are) and suggests that ironic meaning is derived in a global meaning retrieval process where counterfactual content could serve as an index of an ironic intention (Kreuz, 2000; Colston, 2000; 2002).

The absence of a statistically relevant effect due to ironical stimulation leaves two hypotheses open: the Parallel Access and the Direct Access. This last approach assumes that ironical meaning should be as easy to elaborate as nonironical meaning, since local and global information interact early on in the meaning selection process. Nevertheless, our data showed a tendency toward an increase in the N400 amplitude in ironic statements elaboration in comparison to literal statements processing that seems not to confirm at all this hypothesis. Furthermore we found a substantial modification of the N400 component relative to ironic stimuli, with an increasing in the frontal-central areas. We will discuss the two tendencies separately.

First, the increase of the N400 amplitude for ironic stimuli (both conditions) suggests that ironic elaboration required more of the cognitive resources. Following a Parallel Access model, this requirement can be attributed to a higher complexity of ironic processing due to an effort to select the ironic meaning against other meanings concurrently activated. In alternative, the increase of the N400 component in our data set could be attributed to the low aptness of our ironic stimuli, since prosody was the only relevant contextual information subjects were given. In other words, we could interpret the tendency relieved in ironic processing as an extra-effort required by the subjects to reconstruct the ironic meaning. In fact, other studies (Cornejo, 2007) have associated this increase with a higher requirement for the cognitive system in order to elaborate ironic stimuli and this could be due to the nature of ironic meaning that is somehow inconclusive or manifold and therefore makes the closure process more difficult. As Gibbs and Colston (2007a) remarks, ironical statements express more than the contrary of what is patently said. In other words, telling a bad friend “You are *really a fine* friend”, conveys more meaning than simply saying “You are *a bad* friend!”. That is why understanding irony could be more complex than understanding non ironical statements.

In this study, we did not dispose of reading times that could help to clarify this point about the actual complexity of ironical decoding, giving more information about the actual complexity of irony elaboration. So we

prefer to let it as an hypothesis that will need further investigations to be endorsed. Furthermore, to assess this point, analyses should be performed on later time windows (see Regel et al., 2006).

Second, the larger increase on frontal-central areas is congruent with neuropsychological data that show the importance of frontal areas in irony comprehension (Gallagher et al., 2000; Stuss et al., 2001; Ting Wang et al., 2006; Shamay-Tsoory et al., 2005). Frontal areas have been associated with intentions decoding, therefore higher activation of this area in the early stages of irony processing seems to indicate that the decoding of the ironic intention occurs early on and is involved in semantic processes. In fact, neuropsychological studies (Ting Wang et al., 2006; Uchyama et al., 2006; Wakusawa et al., 2007) affirm that irony elaboration is a complex process where the decoding of *ironic intention indexes* (mainly nonverbal) occurs in the first phases of sentence interpretation, as the early activation of frontal areas suggests, and functions as an heuristic for meaning construction.

## REFERENCES

- Anolli, L., Ciceri, R., & Infantino, M.G. (2000). Irony as a game of implicitness: Acoustic profiles of ironic communication. *Journal of Psycholinguistic Research*, 29, 275-311.
- Anolli, L., Ciceri, R., & Infantino, M.G. (2002a). Behind dark glasses: Irony as a strategy for indirect communication. *Genetic, Social and General Psychology*, 128, 76-95.
- Attardo, S. (2000). Irony as relevant inappropriateness. *Journal of Pragmatics*, 32, 793-826.
- Attardo, S., Eisterhold, J., Hay, J., & Poggi, I. (2003). Multimodal markers of irony and sarcasm. *Humor*, 16, 243-260.
- Austin, J.L. (1962). *How to do Things with Words: The William James Lectures Delivered in Harvard University in 1955*. Oxford: Clarendon.
- Balconi, M. & Amenta, S. (2007). Neuropsychological processes in verbal irony comprehension: An event-related potentials (ERPs) investigation. *Journal of the International Neuropsychological Society*, 13 (Suppl. 2), 77.
- Balconi, M. & Amenta, S. (2008). Dalla pragmatica alla prospettiva neuropragmatica. In: Balconi, M. (ed.). *Neuropsicologia della comunicazione*. Milan: Springer-Verlag, pp. 163-181.
- Balconi, M., & Pozzoli, U. (2004). N400 and P600 or the role of the ERP correlates in sentence comprehension: Some applications to the Italian language. *Journal of General Psychology*, 131, 268-303.

- 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*, 12 (Suppl.), 88.
- Balconi, M., & Tutino, S. (2007). The iconic representation of metaphor: An event-related potentials (ERPs) analysis of figurative language. *Neuropsychological Trends*, 2, 41-61.
- Clark, H., & Gerrig, R. (1984). On the pretense theory of irony. *Journal of Experimental Psychology: General*, 113, 121-126.
- Clark, H.H., & Lucy, P. (1975). Understanding what is meant from what is said: A study in conversationally conveyed requests. *Journal of Verbal Learning and Verbal Behavior*, 14, 56-72.
- Colston, H.L. (2000). On necessary conditions for verbal irony comprehension. *Pragmatics & Cognition*, 8, 277-324.
- Colston, H.L. (2002). Contrast and assimilation in verbal irony. *Journal of Pragmatics*, 34, 111-142.
- Colston, H.L., & O'Brien, J. (2000). Contrast and pragmatics in figurative language: Anything understatement can do, irony can do better. *Journal of Pragmatics*, 32, 1557-1583.
- Cornejol, C., Simonetti, F., Aldunate, N., Ibanez, A., Lopez, V., & Melloni, L. (2007). Electrophysiological evidence of different interpretative strategies in irony comprehension. *Journal of Psycholinguistic Research*, 36, 411-430.
- Coulson, S. (2004). Electrophysiology and pragmatic language comprehension. In: Sperber, D., Noveck, I.A. (eds.). *Experimental Pragmatics*. Palgrave: Dan Diego, pp. 187-206.
- Coulson, S., King, J.W., & Kutas, M. (1998). Expect the unexpected: Event-related brain responses to morphosyntactic violations. *Language and Cognitive Processes*, 13, 21-58.
- Coulson, S., & Van Petten, C. (2002). Conceptual integration and metaphor: An event-related potential study. *Memory and Cognition*, 30, 958-968.
- Coulson, S., & Wu, Y.C. (2005). Right hemisphere activation of joke-related information: An event-related brain potential study. *Journal of Cognitive Neuroscience*, 17, 494-506.
- Dews, S., & Winner, E. (1999). Obligatory processing of literal and nonliteral meanings in verbal irony. *Journal of Pragmatics*, 31, 1579-1599.
- Gallagher, H.L., Happé, F., Brunswick, N., Fletcher, P.C., Frith, U., & Frith, C.D. (2000). Reading the mind in cartoons and stories: An fMRI study of "theory of mind" in verbal and nonverbal tasks. *Neuropsychologia*, 38, 11-21.

- Gibbs, R.W. (1994). *The Poetics of Mind: Figurative thought and Figurative Language*. San Diego: Academic Press.
- Gibbs, R.W. (1999). Interpreting what speakers say and implicate. *Brain and Language*, 68, 466-485.
- Gibbs, R.W. (2002). A new look at literal meaning in understanding what is said and implicated. *Journal of Pragmatics*, 34, 457-486.
- Gibbs, R.W., & Colston, H.L. (2007a). The future of irony studies. In: Gibbs, R.W., Colston H.L. (eds.). *Irony and Language and Thought. A Cognitive Science Reader*. New York: Erlbaum, pp. 581-593.
- Gibbs, R.W., & Colston, H.L. (eds.) (2007b). *Irony and Language and Thought. A Cognitive Science Reader*. New York: Erlbaum.
- Gibbs, R.W., O'Brien, J.E., & Doolittle, S. (1995). Inferring meanings that are not intended: Speakers' intentions and irony comprehension. *Discourse Processes*, 20, 187-203.
- Giora, R. (1995). On irony and negation. *Discourse Processes*, 19, 239-264.
- Giora, R. (1999). On the priority of salient meanings: Studies of literal and figurative language. *Journal of Pragmatics*, 31, 919-929.
- Giora, R. (2003). *On our Mind: Context, Salience and Figurative Language*. New York: Oxford University Press.
- Giora, R., Federman, S., Kehat, A., Fein, O., & Sabah, H. (2005). Irony aptness. *Humor*, 18, 23-39.
- Giora, R., & Fein, O. (1999a). Irony comprehension: The graded salience hypothesis. *Humor: International Journal of Humor Research*, 12, 425-436.
- Giora, R., & Fein, O. (1999b). Irony: Context and salience. *Metaphor and Symbol*, 14, 241-257.
- Giora, R., Fein, O., Laadan, D., Wolfson, J., Zeituny, M., Kidron, R., Kaufman, R. & Shaham, R. (2007). Expecting irony: Context versus salience-based effects. *Metaphor and Symbol*, 22, 119-146.
- Giora, R., Fein, O., & Schwartz, T. (1998). Irony: Graded salience and indirect negation. *Metaphor and Symbol*, 13, 83-101.
- Grice, P. (1975). Logic and conversation. In: Cole, P., Morgan, J.L. (eds.). *Syntax and Semantics 3: Speech Acts*. New York: Academic Press, pp. 41-58.
- Hagoort, P., Halal, L., Bastiaansen, M., & Petersson, K.M. (2004). Integration of word meaning and world knowledge in language comprehension. *Science*, 304, 438-441.
- Ivanko, S.L., & Pexman, P.M. (2003). Context incongruity and irony processing. *Discourse Process*, 35, 241-279.
- Jackendoff, R. (2002). *Foundations of Language: Brain, Meaning, Grammar, Evolution*. Oxford: Oxford University Press.

- Jaspers, H.H. (1958). The ten-twenty electrode system of International Federation EEG. *Clinical Neurophysiology*, 10, 371-375.
- Juottonen, K., Revonsuo, A., & Lang, H. (1996). Dissimilar age influences on two ERP waveforms (LPC and N400) reflecting semantic context effect. *Cognitive Brain Research*, 4, 99-107.
- Kihara, Y. (2005). The mental space structure of verbal irony. *Cognitive Linguistics*, 16, 513-530.
- Kreuz, R.J. (1996). The use of verbal irony: Cues and constraints. In: Mio, J.S., Katz, A.N. (eds). *Metaphor: Implications and Applications*. Hillsdale: Lawrence Erlbaum.
- Kreuz, R.J. (2000). The production and processing of verbal irony. *Metaphor and Symbol*, 15, 99-107.
- Kreuz, R.J., & Glucksberg, S. (1989). How to be sarcastic: The echoic reminder theory of verbal irony. *Journal of Experimental Psychology: General*, 118, 374-386.
- Kreuz, R.J., & Roberts, R.M. (1995). Two cues for verbal irony: Hyperbole and the ironic tone of voice. *Metaphor and Symbolic Activity*, 10, 21-30.
- Kumon-Nakamura, S., Glucksberg, S., & Brown, M. (1995). How about another piece of pie: The allusional pretense theory of discourse irony. *Journal of Experimental Psychology: General*, 124, 3-21.
- Kuperberg, G.R., Holcomb, P.J., Sitnikova, T., Greve, D., Dale, A., & Caplan, D. (2003). Distinct patterns of neural modulation during the processing of conceptual and syntactic anomalies. *Journal of Cognitive Neuroscience*, 15, 272-293.
- Kutas, M., & Hillyard, S.A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, 207, 203-205.
- Kutas, M., & Hillyard, S. (1984). Brain potential during reading reflect word expectancies and semantic association. *Nature*, 307, 161-163.
- Kutas, M., & Van Petten, C.K. (1994). Psycholinguistics electrified: Event-related brain potential investigations. In: Gernsbacher, M.A. (ed.). *Handbook of Psycholinguistic*. New York: Academic Press, pp. 83-143.
- Long, D.L., & Graesser, A.C. (1988). Wit and humour in discourse processes. *Discourse Process*, 11, 35-60.
- MacDonald, M.C., Pearlmutter, N.J., & Seidenberg, M.S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, 101, 676-703.
- Nieuwland, M.S., & Van Berkum, J.J.A. (2006). When peanuts fall in love: N400 evidence for the power of discourse. *Journal of Cognitive Neuroscience*, 18, 1098-1111.
- 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.

- Regel, S., Gunter, T.C., & Friederici, A.D. (2006). Processing of ironic and non-ironic sentences examined with ERPs. *Proceedings of the 19th Annual CUNY Conference on Human Sentence Processing*, 193.
- Ritchie, D. (2005). Frame-shifting in humor and irony. *Metaphor and Symbol*, 20, 275-294.
- 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, pp. 27-38.
- Schwoebel, J., Dews, S., Winner, E., & Srinivas, K. (2000). Obligatory processing of the literal meaning of ironic utterances: Further evidence. *Metaphor and Symbol*, 15, 47-61.
- Searle, J.R. (1969). *Speech Acts: An Essay in the Philosophy of Language*. Cambridge: Cambridge University Press.
- Searle, J.R. (1976). A classification of illocutionary acts. *Language in Society*, 5, 1-23.
- Sperber, D., & Wilson, D. (1984). Verbal irony: Pretense or echoic mention? *Journal of Experimental Psychology: General*, 113, 130-136.
- Sperber, D., & Wilson, D. (1986). *Relevance: Communication and Cognition*. Oxford: Blackwell.
- Stuss, D.T., Gallup, G.G.Jr., & Alexander, M.P. (2001). The frontal lobes are necessary for theory of mind. *Brain*, 124, 279-286.
- Suls, J.M. (1977). Cognitive and disparagement theories of humor: A theoretical and empirical synthesis. In: Chapman, A.J., Foot, H.C. (eds). *It's a Funny Thing, Humor*. Oxford: Pergamon, pp. 41-46.
- 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.
- Ting Wang, A., Lee, S.S., Sigman, M., & Dapretto, M. (2006). Developmental changes in the neural basis of interpreting communicative intent. *Scan*, 1, 107-121.
- Uchiyama, H., Seki, A., Kageyama, H., Saito, D.N., Koeda, T., Ohno, K., & Sadaoto, N. (2006). Neural substrates of sarcasm: A functional magnetic-resonance imaging study. *Brain Research*, 1124, 100-110.
- Utsumi, A. (2000). Verbal irony as implicit display of ironic environment: Distinguishing ironic utterances from nonirony. *Journal of Pragmatics*, 32, 1777-1806.
- Wakusawa, K., Sugiura, M., Sassa, Y., Jeong, H., Horie, K., Sato, S., Yokoyama, H., Tsuchiya, S., Inuma, K., & Kawashima, R. (2007). Comprehension of implicit meanings in social situations involving irony: A functional MRI study. *NeuroImage*, 37, 1417-1426.

