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The processing of N-words in Italian.

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In this paper I investigate the processing of N(egative)-words such as *mai* (ever) in Italian, by means of the Event-Related Potentials methodology. N-words pose some questions about their syntactic and semantic behavior, such as: a) what principles underlie their distribution; b) which is the role of syntactic and semantic factors in determining their meaning; c) how the brain processes these linguistic items in grammatical and ungrammatical sentences. In the present work I will provide some theoretical and psychological argumentations to address these questions.

1. Introduction

The syntactic and semantic behavior of Negative Polarity Items (NPIs) and N(egative)-words (N-words) is currently under debate in the linguistic community (cf. Zeijlstra, 2008; Zanuttini, 1997; Chierchia, 2006). Roughly, NPIs are a class of words (quantifiers like *anyone*, adverbs like *ever* and predicates like *lift a finger*) that are licensed under the scope of negative operators. N-words, on the other hand, share a similar behavior with NPIs when they occur in negative contexts, but they behave like negative quantifiers, adverbs or predicates when they occur in positive contexts. The nature of the debate regards the mechanism underlying the licensing and the interpretation of these two types of linguistic items. In this work we will discuss some linguistic and experimental evidence in favor of the existence of common mechanisms at play during the processing of both N-words and NPIs. Further, we will argue for the hypothesis that N-words are in fact NPIs, with some additional properties such as the capacity of inserting a covert negation in the structure, which is responsible of their self-licensing. Finally, we will claim that this property is driven by a semantic mechanism geared to check the polarity of the local environment in which the N-word occurs, and we will provide some speculations about what sort of process it might look like.

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2. NPIs and N-words in the linguistic theory

2.1 Distributional properties of N-words

N-words are negative markers that do not always carry a negative meaning. In Italian, for instance, words such as *nessuno*, *niente* and *mai* - which mean *anyone/no-one, anything/nothing, ever/never* - are generally interpreted with a negative meaning when they occur in preverbal position (1a), where the auxiliary *ha* 'has' counts as the main verb in analytic tenses. If they occur postverbally, on the other hand, they require a negative context (e.g. an overt negative particle *non* that applies to the verb, such as in 1b) to be licensed (for an overview on this phenomenon see Zanuttini, 1997).

(1) a. Maria *mai* ha bevuto una birra
'Maria never drank a beer'
b. Maria non ha *mai* bevuto una birra
'Maria did not ever drink a beer'

Although the distribution of N-words is not completely uniform across the languages displaying this phenomenology (cf. Zeijlstra, 2008, for cross-linguistic comparisons), their main characteristic is that exemplified in the contrast between (1a) and (1b). Namely, in (1a) *mai* occurs in preverbal position, in a positive context (i.e. it is not in the scope of any negative operators), and it means *never*. In (1b), on the other hand, *mai* occurs in postverbal position, under the scope of a negative particle (*non*, which means *not* in Italian), and it means *ever*. To explain this complex behavior, some theories (cf. Zeijlstra, 2008) state that N-word licensing and interpretation is a case of negative concord, akin to gender or number agreement. Along this view N-words are an instance of morphosyntactic agreement with a negative operator. This explains why multiple morpho-syntactic occurences of negation yield only one semantic negation. Under the minimalist framework, N-words would carry an uninterpretable formal feature [uNEG], whereas negative operators carry an interpretable one [iNEG]. Before discussing the implications of this proposal we will briefly review some accounts on NPI licensing, in which some issues will be raised that are relevant to the distributional properties of the N-words themselves.

2.2 The meaning and distribution of NPIs.

The behavior of NPIs has been argued to be regulated by syntactic principles. Klima (1964) proposed that NPIs are licensed by an "affective" trigger that has to c-command the NPI. Progovac (1993) provided a binding-theoretic account for NPI licensing, where NPIs are licensed by a negation or a formal operator (Op) in the specifier position of the same clause. More recent theories, on the other hand, maintain that the NPIs licensing is determined by their meaning and their function (Ladusaw, 1979; Kadmon and Landman, 1993). Krifka (1995), for instance, proposed an account to explain why words such as *any* are licensed in Downward Entailing[2] environments, which do not have to be associated to a negative meaning. Along this view, an NPI like *any* activates alternatives and its meaning corresponds to an existential predication plus an obligatory scalar implicature. Providing a sketch of the details, the meaning of (2a) and (3a) is laid out in (2b) and (3b).

[2] A Downward Entailing context is characterized by its property of licensing inferences from a set to a proper subset. The scope of clausal negation, the antecedent of conditionals, the restriction of universal quantifier, questions, negative predicates, *before*-sentences etc. are claimed to be Downward Entailing, and NPIs are licensed in all these contexts (cf. Chierchia, 2004).

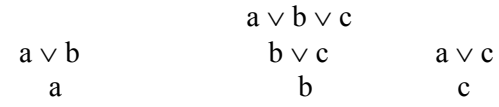
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(2) a. John did not eat any potatoes
b. $\neg\exists$x (potato(x) $\wedge$ ate (J,x), potato, P | P $\subseteq$ potato)

(3) a. * John ate any potatoes
b. $\exists$x (potato(x) $\wedge$ ate (J,x), potato, P | P $\subseteq$ potato)

The meaning of (2a), as formalized in (2b), can be paraphrased as follows. There is not a set of things *x*, such that *x* are potatoes and they were eaten by John. Then, the scalar implicature (potato, P | P $\subseteq$ potato) tells that this holds for any property *P* that is entailed by "potato" (i.e. whatever more specific kinds of potato). In a Downward Entailing context, such as the scope of the negation in (2), the implicature yields a true meaning (e.g. if John did not eat any potato, there's no more specific kind of potato that he could have eaten), whereas in (3) it yields a contradiction[3]. Therefore (3a) is ruled out, not because it violates some syntactic requirment, but rather it produces a contradiction at the level of Logical Form. Chierchia (2004, 2006) made a similar proposal under which NPIs like *ever* activate domain alternatives (i.e. intervals of times). Then, an operator resembling that introduced by focus (cf. Rooth, 1985) is responsible for interpreting the NPI through an exhaustification of the alternatives. This *exhausitivity* operator, thus, requires that all the alternatives are entailed by the assertion, otherwise they must be false. In a concrete example, (4a) is a sentence where *ever* occurs in a non-Downward Entailing context.
Its meaning is exemplified in the formula in (4b), which can be spelled out as follows: there exists at least an interval of time in the Domain ({a, b, c}) such that I drank a beer at that time. The relevant alternatives are listed in (4c), and they may be ordered in a semi-lattice (as in 4d) where the more restricted (hence stronger) alternatives lay at the bottom, and the broader one, which is equivalent to the meaning of the sentence, is on top of the diagram. In an affirmative sentence such as (4a), which is upward entailing, all the alternatives entail the meaning of the propositions. According to the meaning of the exhaustivity operator, thus, they must be negated. This operation yields a contradiction, spelled out in (4e.iii).

(4) a. * I ever drank a beer.
b. Assertion: $\exists$t$\in${a, b, c} [drink(beer, me,t)]
c. (Proper) Alternatives :
i. $\exists$t$\in${a, b} [drink(beer, me, t)] ii. $\exists$t$\in${b, c} [drink (beer, me, t)]
iii. $\exists$t$\in${a, c} [drink (beer, me, t)] iv. $\exists$t$\in${a} [drink (beer, me, t)]
v. $\exists$t$\in${b} [drink (beer, me, t)] vi. $\exists$t$\in${c} [drink (beer, me, t)]
d.



e. *Exhaustification*
i. $O_{ALT}(p) = p \wedge \forall q \in ALT[\, q \rightarrow p \subseteq q]$
ii. $O(\exists t \in D\ [drink(beer, me,t)]) =$
$\exists t \in D[drink(beer, me,t)] \wedge \forall q \in ALT\ [\, q \not\subset \exists t \in D\ [drink(beer, me,t)] \rightarrow \neg\, q]$
iii. $(a \vee b \vee c) \wedge\neg\, a \wedge\neg\, b \wedge\neg\, c$

[3] The contradictory meaning can be paraphrased as follows. There exist some instances of potato that John ate, and for any kind of more specific potatos (e.g. fried potatoes, baked potatoes, rotten potates etc.) he did not eat it.

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It may be showed that if *ever* occurs in a downward entailing context, the entailment relation among the alternatives is reversed. That is, all the alternatives are weaker - and entailed - by the proposition, therefore the meaning of the exhaustification winds up being consistent. Krifka (1995) and Chierchia's (2004, 2006) approaches share many features, such as the idea that the meaning of an NPI depends on the entailing pattern of the local environment where it occurs and that NPIs have an existential force plus an obligatory scalar-like implicature computed on the proper alternatives. If the context is Downward Entailing, the NPI yields a consistent meaning, otherwise it's contradictory. With this respect Gajewski (2002) elaborated on the idea of L-analytic sentences, which are propositions that are either tautologies or contradictions at the level of the Logic Form. He noted that exceptive sentences induce ungrammaticality when they modify existential quantifiers (as in "some students but John left the room") because they lead to an analytic contradiction, and the same reasoning may account for the ungrammaticality of NPIs in sentences such as (3a) or (4a).

2.3 Parallels in the interpretation of NPIs and N-words

As we mentioned, NPIs are licensed in several kinds of Downward Entailing contexts, not only in those introduced by negation operators, such as wh-questions and *if*-clauses. A key observation, here, is that N-words may occur in the same contexts as well, without carrying a negative meaning, in pre-verbal or post-verbal position either.

(5) *Wh*-Questions:
a. Chi *mai* ha mangiato la torta sacher a Siena? (Preverbal *mai*)
b. Chi ha *mai* mangiato la torta sacher a Siena? (Postverbal *mai*)
'Who ever ate the sacher-pie in Siena?'

(6) *If*-clauses:
a. Se *mai* vincerò la lotteria, ti regalerò un diamante. (Preverbal *mai*)
b. Se vincerò *mai* la lotteria, ti regalerò un diamante. (Postverbal *mai*)
'If I ever win the lottery, I'll give you a diamond as a gift.'

In other terms, *mai* in (5a,b) and (6a,b) has a semantics identical to a "pure" NPI like *ever* even though there is no negation present in the sentence (cf. Chierchia, 2004, for a deeper analysis of NPIs across different languages). To account for this fact we may posit that N-words are just like "pure" NPIs, with an additional feature. That is, if they occur in a non-Downward Entailing context, they insert a covert negation in the phrase structure, which is itself responsible for their licensing. This account challenges the idea that the meaning of N-words is driven by negative concord, in that it relies on the semantic property of the context (i.e. Downward Entailingness), which, e.g. in *if*-clauses and questions, prevents N-words from carrying a negative meaning. The generalization embraced by the exponents of semantic/pragmatic accounts for NPIs licensing and their distribution then straightfowardly extends to N-words.

(7) In those contexts where NPIs are licensed (i.e. Downward Entailing), N-words do not carry a negative meaning and are interpreted as NPIs.

From a psycholinguistic point of view, the claim in (7) suggests that similar processes might be at play during the interpretation of both NPIs and N-words. Critically, while processing these items the parser has to ensure that the local context possesses the right semantic requirements for NPIs to be interpretable, and for N-words to select the

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right meaning (i.e. do not add a covert negation in Logical form in certain contexts). Note that linguistic accounts of NPIs licensing (Krifka, 1995; Chierchia, 2004, 2006; Ladusaw, 1979) do not make any assumption with respect to processing concerns. Their generalization is just about the distribution of NPIs in natural languages[4]. To investigate whether semantic processes are exploited on-line by the parser while processing N-words, we designed an experimental study described in the following paragraphs.

3. The processing of NPIs

3.1 Syntactic and semantic processing in the brain.

The Event Related Potentials (ERPs) methodology is a powerful instrument to investigate brain processes associated with different kinds of linguistic mechanisms in real time. In the psycholinguistics literature two differential waves are often associated with syntactic and semantic processes and violations. The N400 is a well-studied electrophysiological component (Kutas & Hillyard, 1983) that is elicited by semantic anomalies, such as in (8b), compared to control sentences such as (8a). It is a negative ongoing wave arising at 250-300ms on central electrodes after the presentation of the critical stimulus (i.e. *radios* in 8b), raising to its maximum at 400ms and decaying after roughly 500ms.

(8) a. Turtles eat *leaves* and various plant parts.
b. Turtles eat *radios* and various plant parts.

The P600, on the other hand, is an ERP component associated with syntactic processing load and structural repair strategies induced by syntactic or semantic anomalies. It is a positive ongoing wave arising on centro-posterior sites at roughly 500-600ms after the presentation of the critical word (i.e. *hopes* in 9b, cf. Osterhout et al., 1995; Friederici et al., 2002).

(9) a. The elected officials *hope* to succeed
b. The elected officials *hopes* to succeed

3.2 Electrophysiology of NPIs

There are some studies that explored the processing of NPIs by means of ERPs methodology. Shao and Neville (1998) compared the processing of *ever* with that of *never* in an affirmative proposition (as in 10), with the former being un-licensed and yielding an ungrammatical sentence. They found an anterior negativity between 300-500ms for *ever*, followed by a centro-posterior positivity after 600ms (P600).

(10) Max says that he has *ever/never* been to a birthday party.

[4] In principle, for example, it might be conceivable that the semantic generalization on the distribution of NPIs (i.e. they occur in Downward Entailing contexts) became crystallized in the syntax. Along this hypothesis each Downward Entailing head should have a syntactic feature [DE] that is checked by the NPI when it's interpreted. Though this idea is less parimonious than relying on a single, unitary semantic principle, it could well be, as a matter of fact, how things go on in the brain. Hence, our experimental inquiry is headed to disentangle syntactic and semantic factors associated to NPIs and N-words interpretation.

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This study, while potentially revealing, was criticized (Xiang, 2008) because the authors compared the elctrophysiological activity elicited by two different words.
Drenhaus et al. (2006) conducted an ERP study in German on the processing of licensed vs. unlicensed NPIs. They employed the same word *jemals* (similar to *ever* in English) in two conditions. In (10a) the NPI is grammatical in that it occurs under the scope of a negative quantifier (*Kein*, that is *no* in English). In (10b) it is embedded in the same sentence, except for the substitution of *Kein* with the existential quantifier *ein* (*a* in English).

(10) a. Kein Mann war jemals glücklich.
'no man was ever happy'
b. *Ein Mann war jemals glücklich.
'a man was ever happy'

They found that the unlicensed *jemals* (as in 10b) yielded both the N400 and P600 wave. Their interpretation of the results is that NPI violations are due to a semantic/pragmatic integration problem. Such problem is reflected in the N400 wave, which is often found in semantic anomalies having different sources (i.e. contextual integration problems, implausible continuations etc.), and this problem induces a structural repair of the ill-formed sentence, resulting in a P600.
Xiang et al. (2008) conducted an ERP study in English, presenting subjects sentences containing licensed vs. unlicensed occurrences of *ever*.

(11) a. *No/Very few* restaurants that the local newspapers have recommended in their dining reviews have *ever* gone out of business.
b. *Most restaurants that the local newspapers have recommended in their dining reviews have *ever* gone out of business.

In (11a) *ever* is grammatical as it is c-commanded by *no* or *very few*, which generate a Downward Entailing environment. (11b), on the other hand, is ungrammatical as *ever* is not licensed by any Downward Entailing operator. The authors found a P600 that was not preceded by any significant wave (i.e. no N400 was found). They interpreted this result by proposing that NPI violations, though they generate a semantic mismatch, elicit a structural/syntactic repair of the sentence that is reflected in the P600. However, they argued that the N400 found by Drenhaus et al. was not associated to a semantic processing but rather to attentional and task-related strategies adopted by subjects to individuate an ill-formed sentence (acceptability judgments were requested by Drehanus et al. whereas comprehension questions were posed to subjects by Xiang et al.).
The results of these studies leave open some questions. First, it is not clear whether the N400 is systematically elicited by NPI violations, and if so, why it would be the case since N400s are usually a result of difficult contextual integration and unexpected words. Strictly speaking, "turtles eating radios" should be processed rather differently from "men ever having a beard", because one involves syntactic and semantic licensing while the other involves only world knowledge. Secondly, if NPI violations do not elicit a pattern different from other syntactic violations, it would be plausible that NPI licensing is a syntactic driven phenomenon, handled by a feature checking mechanism rather than any process associated with semantic operations sensitive to polarity and entailing patterns. To address these questions we design an experimental paradigm to study N-words (i.e. *mai*) in Italian. Through this experiment we aim to

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figure out a) whether N-words are processed as NPIs in postverbal position, as in English and German, b) whether they elicit semantic-associated components (e.g. N400), c) whether the same brain processes are at play while interpreting N-words in preverbal position, either in grammatical or ungrammatical sentences, and d) what, if any, effect of the ungrammaticality surfaces in the ERP measures.

4. An ERP study on the processing of N-words

4.1 Experimental design and predictions

24 subjects were presented with 160 sentences such as (12a-d), word by word, while their EEG was recorded. At the end of each sentence subjects had to judge the acceptability of the sentence they just read, grounding on their intuition about the well-formedness of the sentence.

(12) a. Sul giornale si legge che il presidente non ha *mai* avuto un'amante.
'The newspaper reports that the president has not ever had a lover.'
b. *Sul giornale si legge che il presidente ha *mai* avuto un'amante.
'The newspaper reports that the president has ever had a lover.'
c. Sul giornale si legge che il presidente *mai* ha avuto un'amante.
'The newspaper reports that the president has never had a lover.'
d. *Sul giornale si legge che il presidente non *mai* ha avuto un'amante.
'The newspaper reports that the president has not never had a lover.'

Each of these sentences was composed by a proposition containing *mai*, which was embedded in another proposition to discourage subjects from reading it as an interrogative sentence, which would render, e.g., (12b) well-formed as a question.
In (12a) *mai* occurs postverbally within a grammatical sentence, as it is licensed by a negative marker (*non*), whereas in (12b) it raises ungrammaticality as the negative marker is absent. Thus (12b) is the counterpart of an NPI violation with N-words, provided that N-words are interpreted just as NPIs when occurring in postverbal position. In (12c) *mai* occurs preverbally and in a positive context (i.e. embedded in a relative clause and following a noun, that is, "il presidente"), hence it is normally interpreted with a negative meaning (i.e. *never*). In fact, as we noted above, in Italian N-words such as *mai*, when occurring in preverbal position and in a non-Downward Entailing context, are interpreted with a negative meaning. In (12d) *mai* yet occurs preverbally as in (12c), but there is a negative particle placed right before it (i.e. "...non mai..."). So, (12d) induces a strong sense of ungrammaticality as no N-words may occur after a negative particle in Italian[5]. We might speculate on the reason why (12d) is ungrammatical. For instance, it's possible that the overt negative particle inserts a negation in the structure, which crashes against the covert negation automatically promped in by *mai*, when used preverbally. Be it as it may, this condition is useful to check whether the syntactic mismatch blocks the interpretation of *mai* in preverbal position, or if its interpretation results in a ERP wave that is similar to those elicited by NPI or N-word violations in postverbal position.

[5] Actually, *non* can modify a predicate ("Un cane non tranquillo" A dog not calm), as can *mai* ("un cane mai tranquillo" A dog never calm) but they cannot co-occur next to each other ("*un cane non mai tranquillo"). The only case where *mai* can occur after *non* is in a common Italian idiom ("come non mai"). In ancient Italian, however, *mai* could occur before *non* at least in infinitive sentences ("secreto sicurissimo per non mai morire"). This informs us that there is no structural reason, in principle, why this form (corresponding to (12d)) is ruled out, but it's likely to be a specific rule of Italian.

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There is another important difference between our study and the other ones conducted on German and English NPI violations, and it is about the rescue strategies employed by speakers while coping with NPIs vs. N-words violations. Namely, while in German and English, sentences such as (10b) and (11b) hardly convey any meaning at all, an Italian sentence like (12b) is generally interpreted as - rescued towards the meaning of - (12a). This, in fact, is consistent with what all the subjects reported after the experiment, and derives from the fact that *mai* in Italian is often associated with a negative meaning. Further, also a sentence such as (12d) gets a uniform interpretation, which is that of (12c). Hence it's plausible to assume that some repair strategies come in play while readers are processing (12d), in deleting one of the two negations from the phrase structure. Otherwise (12c) would have got a double negation reading, which was not reported by almost any subject at all. We do believe, thus, that this facts can play a crucial role in the processing of ungrammatical sentences such as (12b) and (12d), and offer a great advantage with respect to studies on NPI violations in Germanic languages. Namely, it should favor a deeper processing and more successful reanalysis (i.e. 12b interpreted as 12a, and 12d interpreted as 12c, respectively) towards a meaninfgul informational content.
Taking stock, (12a) serves as a control sentence, where *mai* normally occurs in a proper negative context, against which all the other conditions may be compared. (12b) is expected to elicit an N400 (index of semantic incongruency) and a P600, or a P600 alone, as reported by Xiang et al. (12d) is predicted to elicit a structural repair (P600), but we don't know in advance if *mai* in preverbal position, placed immediately after *non*, causes any problem in its interpretation (perhaps an N400). Finally, what can we expect with respect to (12c), where *mai* occurs preverbally, and it is given a negative meaning? If we maintain that these ERP components are correlates of neurophysiological processes which are called in to solve some heavy semantic or syntactic incongruencies, it might be plausible that (12c) does not present any difference with respect to (12a) whatsoever. If, on the other hand, these components also reflect an additional processing load caused by complex syntactic and semantic structures, (12c), although grammatical, might elicit either a N400 or a P600. In fact, the preverbal use of *mai* is associated with a syntactic topicalization operation, whereby the Negative Phrase containing *mai* moves higher in the structure (Rizzi, 2004).
Further, it might turn out that the parser exploits the semantic/pragmatic operations associated to the meaning of an NPI (i.e. exhaustification or scalar implicature) in order to figure out whether the N-word has to be interpreted with a negative or existential (i.e. NPI-like) meaning. Along this hypothesis, the processing of (12c) could be reflected in the same processing components that are elicited by (12b), despite the former sentence is grammatical whereas the latter is not.
Finally, recall that preceding studies employed pure NPIs (*ever* and *jemals* in English and German, respectively). Such items were not associated to a negative meaning. Shao and Neville (1998), on the other hand, compared the processing of *ever* to that of *never*, finding an anterior negativity followed by a P600 for *ever*. It could be that N-words, with respect to pure NPIs, elicit an ERP pattern similar to that study, in that in both cases the processing of negative meaning is involved.

4.2 Results

The acceptability judgment for the four experimental conditions showed an overall good accuracy (around 85%) for (12a), (12b) and (12d), whereas (12c) was judged

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grammatical in 68% of time. This confirms our expectations that (12c) is harder to process, at least when read in word by word visual presentation.
The N-word violation with *mai* occurring postverbally (12b), compared to the grammatical control (12a), elicited a centro-parietal negativity between 250 and 400ms. This component has the same scalp distribution of the classic N400, but an earlier onset (by about 50-100ms). This wave was followed by an anterior positive deflection (FP600) arising after 400ms, followed by a centro-posterior positive wave around 600ms (P600).
The N-word violation with *mai* occurring preverbally (12d), compared to (12a), elicited the same ERP components: early N400, followed by FP600 at 400ms, followed by P600 at 600ms.
The grammatical sentence with the N-word *mai* occurring preverbally and carrying a negative meaning (12c), compared to the other grammatical condition with *mai* occurring postverbally under the scope of negation (12a), elicited an early N400 (even more pronounced than in the other contrasts) followed by a FP600, but not by a significant P600.
The statistical analysis (ANOVA) in the N400 time-window (250-400) showed a significant interaction of the factors *grammaticality* (12a,c vs. 12b,d) and *type* (12a,b vs. 12c,d), which confirms that the N400 was higher for (12c) with respect to the ungrammatical conditions (12b and 12d). In the FP600 time window (400-550ms) the *grammatical* factor was significant. Also a significant interaction between the *electrode* and *grammaticality* factors was found, attesting that the grammatical conditions were more positive in frontal electrodes, whereas the ungrammatical ones were more positive in posterior sites. Finally, in the P600 time windows both *type* and *grammaticality* factors were significant, in absence of significant interactions between them.

4.3 Discussion

This experiment was conducted to investigate how the brain processes in real time a particular class of linguistic items called N-words. We started by noticing that N-words behave as NPIs when they occur in postverbal position, while they introduce a negative meaning when they occur in preverbal position and in a non-Downward Entailing context. Otherwise, if they occur preverbally but in a Downward Entailing context, they are still interpreted as NPIs, namely with an existential meaning. Thus, the parser has to check, in some way, the surrounding context in order to figure out whether an N-word occurring preverbally is to be interpreted with a negative meaning or not. The question of how this might happen shares some features with a similar question raised by studies on the meaning of NPIs and on their processing. That is, how is an NPI is licensed in Downward Entailing contexts, how the parser can become aware of this property in real time, and how does it handle an NPI violation - namely an unlicensed occurrence of an NPI.
The results stemming from this experiment provide some new evidence in favor of the fact that N-words violations have much in common with NPIs violations. Sentences such as (12b) compared to grammatical sentences such as (12a) elicit the same biphasic pattern (N400 plus P600) found by Drenhaus et al. (2006), together with a new component (the FP600) whose interpretation in the literature is still under debate (Friederici et al., 2002; Kaan and Swaab, 2003). Leaving the FP600 aside for a moment, we will focus now on the N400 and the P600 effects. The N400 was argued to be associated to a semantic mismatch induced by the NPI violation by Drenhaus et al., whereas Xiang et al. attributed it to attentional processes geared to individuate a

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deviant sentence. Our results strongly support the first interpretation. First because the N400 was elicited by (12b) vs. (12a), which resembles the NPI violation pattern employed in previous studies, and suggests that N-words are really NPIs when occurring postverbally. Second, an N400 was elicited by grammatical sentences, and this discourages the idea that it is due to some task dependent control strategies. On the contrary, in this experiment the higher N400 for (12c) attests that this component may be found in association to a deeper and succesful processing of a *well-formed* structure, as the preverbal occurrence of *mai*. Finally, the N400 was also found in (12d), where an overt negative particle generated a strong syntactic mismatch with the N-word. To account for this result, it's plausible to hypothesize that the interpretation of *mai* continued successfully, regardless of the structural mismatch, up to the point where the covert negation inserted by the preverbal *mai* clashed against the overt negation introduced by *non* in (12d).

Summing up, these results suggest that the N400 is, indeed, a neurophysiological component that may be associated with NPI processing. Recall, however, that we found N400 for (12b), (12c) and (12d), which were anticipated by 50-100ms[6]. It might be conceivable - and it's fodder for further research - that the early N400 can be distinguished from the classic one, and it might reflect different causes (i.e. world knowledge mismatch vs. logic contradiction) as well as different sources.

For what concerns the P600, on the other hand, this study is in line with the classic interpretation given to this component. That is, a P600 was elicited by ungrammatical sentences, such as (12b) and (12d), whereas it was attenuated if not absent in (12c). Therefore, it is likely to be associated to structural repair of an ill-formed phrase structure. In the case of N-words or NPI violations, thus, the need of a repair could be induced by a semantic problem, such as a contradiction at the level of logical form, as discussed above.

Finally, we found a FP600 for (12b), (12c) and (12d). This result is somehow surprising as it was never found in these kind of studies. In the psycholinguistics literature the FP600 has been interpreted as a sign of syntactic complexity (Frederici et al., 2002) or discourse complexity (Kaan and Swaab, 2003). Both these ideas would fit with the contrasts displayed by the conditions in our study. In (12b) a novel negation should be added to the phrase structure, to rescue the interpretation of *mai*. In (12c) the Negative Phrase, whose *mai* is the specifier, is argued to be moved towards the left periphery of the sentence through a mechanism of topicalization. Finally, in (12d) it is possible that the covert negation introduced by *mai* is added to the structure, and then removed through a repairing process. All these mechanisms do involve a repair of the sentence, and impose additional syntactic or semantic operations for the parser, which could be reflected in the FP600.

A similar, but perhaps deceptively simple explanation, is that the FP600 is really a neurophysiological correlate of negation. This idea traces back to Shao and Neville (1998), who found an anterior negativity in almost the same time-window for *ever* versus *never*, with the former being unlicensed. In ERPs, the polarity of a component is just matter of interpretation. Shao and Neville attributed this effect to a processing difficulty imposed by the unlicensed *ever* vs. the grammatical *never*. However, it might be the case that the anterior negativity for *ever* is, indeed, an anterior positivity

[6] It's worth notinghere, that through visual inspection of the graphs reported by Saddy et al., 2004, the N400 they found started at about 250ms like that discussed in our study. Also, they adopted a 300-400ms time-window in the statistical analysis, which is remarkably earlier than the usual time-windows utilized to look for an N400 effect (i.e. 350-450). This is tatamount to saying that N400 they found could be exactly as early as the one we found in this study.

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associated to the processing of *never*, which was succesfully interpreted with a negative meaning. Though this interpretation is purely speculative, it would find support in our results. In (12b) the negation was added to rescue the meaning of *mai*, in (12c) it was the meaning of the preverbal N-word, and in (12d) it could be added, and then removed a second time when crashing against another negation in the structure.

5. Final conclusions

The results of this experiment bring converging evidence that NPI processing - not only NPI distribution - is a phenomenon governed by semantics. This holds if we assume that N-words are just NPIs with an additional property, namely, that of carrying a negative meaning if they occur in a context that is syntactically and semantically constrained (i.e. in preverbal position and in a non-downward entailing environment). In addition we have brought in some linguistic evidence that this is a reasonable assumption (see (7)).

One issue that is left open is why a preverbal occurrence of an N-word requires more semantic processing, as attested by the greater N400 found in this study. The idea we put forward is that the parser, upon encountering an N-word like *mai* in preverbal position, in order to check whether the context is Downward Entailing interprets the N-word as if it were an NPI. This means, with respect to (12c), that the result of this interpretation is exactly as contradictory as that of an unlicensed NPI (as in 12b). At this point, however, the parser knows that it has to introduce in the phrase structure - and possibly interpret - a negation that will create a suitable semantic environment for the meaning of the N-word, which is still identical to that of a pure NPI. The evidence we provide in favor of this hypothesis is that (12c), which is a grammatical sentence, elicited an N400 and a FP600 like (12b) and (12d), which are ungrammatical, but it does not show a consistent P600. In other words, the process whereby a preverbal *mai* is interpreted is incredibly similar, from a neurophysiological perspective, to that of the N-word violations we constructed, with the exception of the index of structural repair (P600), which for (12c) is not needed, as this sentence is allowed by the grammar.

In conclusion, our findings support a view along which the parser, unpon encountering an N-word, exploits both the information about its syntactic position with respect to the verb (i.e. pre- vs. post-verbal) and that about the semantic context in which it occurs. Furthermore, we brought linguistic and psycholinguistic evidence favoring the idea that the meaning of N-words is strictly associated with that of NPIs. When they occur in a Downward Entailing environment N-words are, in fact, interpreted as NPIs, in that their violation elicit a neurophysiological component typical of semantic mismatches and NPI violations. This can be accounted for by positing that NPI violations are contradictory at the Logical Form, and this causes their ungrammaticality. When they occur in a non-Downward Entailing context, on the other hand, they introduce a negation in the structure, which is taken to be responsible for their self-licensing. Strikingly, however, this mechanism requires a certain amount of semantic processing that is arguably geared to check the local semantic environment, perhaps through the interpretation of a semantic operator (e.g. Exhaustivity operator or Scalar Implicature). Nevertheless, only when N-words violate the rules of the language - e.g. when occurring postverbally in a non-Downward Entailing environment, or when occurring preverbally after a negative particle - prompt a reanalysis of the phrase structure indexed by a P600 effect.

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