

Backward licensing of Negative Polarity Items in Dutch: An ERP investigation



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ABSTRACT

This Event-related Potential (ERP) study examines the licensing of NPIs in Dutch in a grammatical configuration where the NPI linearly precedes its licensor. It investigates how the addition of modifiers at two different structural positions in the sentence affects differently the process of actively searching for an upcoming licensor. We measured the ERPs elicited at the licensor position by comparing conditions with modifiers at two different structural positions, with a control condition where no modifier was added, where all the tested conditions were grammatical. In addition, we examined whether adding different number of modifiers at the two structural positions affects the processing of the licensor differently. Our results show that there is a central anterior negativity elicited at the licensor in conditions with modifiers at the structural position where a licensor could occur in comparison to the control condition without modifiers. Further, there is an amplitude difference shown for the central anterior negativity when these conditions differ in the number of modifiers. In comparison, an ERP component with a reduced amplitude was elicited at the licensor for conditions with modifiers at a structural position where the licensor cannot occur, when compared with the control condition. We suggest that our results show evidence that the parser is sensitive to structural relations in the on-line licensing of NPIs.

1. Introduction

The process of language comprehension and parsing in real-time invokes mechanisms to establish relationships between words in order to construct sentences. These relationships or dependencies between words in a sentence are not always local and have to be established long-distance, which requires the interaction of several different cognitive processes, including memory access for retrieval of previous input and for incremental structure building, and the on-line application of grammatical constraints.

The effects of different kinds of grammatical constraints on the resolution of linguistic dependencies in language comprehension have been experimentally studied at length and results show a mixture of evidence. On the one hand, typically grammatical constraints are clearly applied in the on-line processing of sentences as in the cases involving island constraints on filler-gap dependencies (see Stowe, 1986; Traxler & Pickering, 1996; Yoshida, Kazanina, Pablos, & Sturt, 2014, among others) or backward anaphora resolution cases (e.g. Aoshima, Yoshida, & Phillips, 2009; Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007; Pablos, Doetjes, Ruijgrok, & Cheng, 2015; Sturt, 2003). On the other hand, there are recent observations of interference effects and grammatical illusions in certain syntactic/semantic NPI licensing contexts (e.g. Drenhaus, Saddy, & Frisch, 2005; Parker & Phillips, 2016; Vasishth, Bruessow, Lewis, & Drenhaus, 2008; Xiang, Dillon, & Phillips, 2009; Xiang, Grove, & Giannakidou, 2016). These effects

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point to a delayed application of constraints and a temporary acceptance of ungrammatical linguistic dependencies.

Phillips, Wagers, and Lau (2011) provide an initial attempt to identify properties that can account for the observed difference in the effectiveness of the application of the constraints by the parser. Among the properties they consider, we highlight the concept of *directionality* that classifies the dependencies between: a) those, like filler-gap, or backward anaphora dependencies, with “a left-hand element” that identifies the start of the dependency (e.g., *wh*-word, pronoun) and triggers a *prospective search* for the linking element (e.g., *wh*-gap, antecedent), and b) those, like forward anaphora, or forward (licensor-)NPI dependencies, which are only identifiable once “the right-hand element” (i.e., anaphora, NPI) is processed and the linking of this element to the adequate antecedent or licensor is required to complete the interpretation of the dependency. There are several data supporting the claim of an *active*, or *prospective search* that only considers grammatically licit positions in processing long-distance dependencies. For example, in *wh*-question dependencies, the *wh*-word has been shown to trigger the search for a gap position (Clifton & Frazier, 1989; Crain & Fodor, 1985; Stowe, 1986) and in backward anaphora dependencies, pronouns have been shown to trigger the search for an antecedent in the upcoming sentence (Kazanina et al., 2007; Pablos et al., 2015). There is also data supporting the claim of there being a *retrospective search* for an antecedent or licensor at an anaphor or an NPI. Relevantly, for this data it has been shown that the parser only considers the retrieval of antecedents or licensors in grammatically licit positions (e.g., Dillon, Clifton, & Frazier, 2014; Kush, Lidz, & Phillips, 2017; Parker & Phillips, 2016, 2017).

These processes of search and dependency building require a consideration of the memory systems that support them and significant work in the last decade has focused on the encoding and access of structural relationships in memory (see Felser, Phillips, & Wagers, 2017 for recent examples). Among available memory models, two broad classes could be defined in the context of long distance dependency formation: those considering memory as a flat buffer and for which difficulty of retrieval is related to distance between the dependency constituents and memory decay (e.g. *Dependency Locality Theory*; Gibson, 1998, 2000; Just and Carpenter, 1992), and those models that assume a limited working memory and a content-addressable memory that use *retrieval-cues* (e.g., McElree, 2000; Van Dyke & Lewis, 2003). Cue-based retrieval (henceforth, CBR) models and their computational implementation (Lewis & Vasishth, 2005), which is based on concepts from the cognitive architecture *Adaptive Control of Thought Rational (ACT-R)* by Anderson et al., 2004), have succeeded in explaining and modelling experimental observations such as the independence of retrieval time on dependency length (e.g. Martin & McElree, 2008, 2009; McElree, Foraker, & Dyer, 2003) on the one hand, and interference effects and grammatical illusions on the other (e.g., Parker, Lago, & Phillips, 2015; Wagers, Lau, & Phillips, 2009). However, a few elements key to the current study are still debated (see discussion in Parker, Shvartsman, & Van Dyke, 2017). These are questions such as how grammatical constraints are adequately encoded as retrieval cues (see Kush, 2013) and the integration of *prediction* or *prospective search* accounts in the CBR model (see Martin & McElree, 2008).

The present study examines the incremental on-line processing of sentences such as (1a) in Dutch in which the Negative Polarity Item (henceforth NPI) *ook maar iets* ‘anything’, occurs linearly before its licensor, the negative expression (i.e., negation *niet* ‘not’). NPIs are lexical items that need to be licensed by a licensor such as negation that c-commands them (Ladusaw, 1980; see section 1.1 for further details). There is a wide range of licensors that can license NPIs: asserted negations such as *no*, *few*, and *only*; negative licensors such as *rarely* and *hardly*; and non-veridical contexts such as emotive predicates, conditionals or yes/no questions (see Giannakidou, 2011). Consider first a situation where the licensor precedes the licensee as in (1a), and compare it with a context where the NPI appears linearly before the licensor in a sentential subject, as in (1b).

- (1) a. Het is **niet** waarschijnlijk dat de man **ook maar iets** gezegd heeft.
 it is not probable that the man anything said has
 ‘It is not probable that the man said anything.’
- b. [Dat de man **ook maar iets** gezegd heeft] is **niet** waarschijnlijk.
 that the man anything said has is not probable.
 ‘It is not probable that the man said anything’
- c. *[Dat de man **ook maar iets niet** gezegd heeft] is waarschijnlijk.
 that the man anything not said has is probable.
 ‘It is probable that the man not said anything’

As discussed by Hoekstra (1991) and Hoeksema (2000), the complement-clause *Dat de man ook maar iets gezegd heeft* ‘that the man anything said’ in (1b) is within the scope of the matrix negation *niet* ‘not’, meaning that structurally it is in a position where the indefinite NPI can be licensed by negation.¹ This is not the case with the negation in the complement-clause in (1c), where the NPI cannot be licensed by the embedded negation in the structural position where it sits.

We hypothesize that, just as in *wh*-question and backward anaphora dependencies, during the on-line processing of NPI constructions in (1b), the parser will identify the dependency as soon as the NPI is encountered and this will in turn trigger an active search for an upcoming licensor (e.g. a negation). Further, based on the cue provided by *dat* ‘that’, the parser knows that the NPI is contained within an embedded clause and that in order to be able to license the NPI, its licensor can only occur in the main clause. Therefore, and in line with previous work on backward dependencies (see Kush et al., 2017 and Phillips et al., 2011 for a discussion),

¹ According to Hoekstra (1991) and Hoeksema (2000, p. 25), the fronted clause containing the NPI in (1b) originates in a lower position which is within the scope of the negation *niet* ‘not’. The grammaticality of the sentence is due to reconstruction at Logical Form, which places the clause *Dat de man ook maar iets gezegd heeft* back in its original position. As a result of this reconstruction, the clause containing the NPI is interpreted within the scope of the matrix negation *niet* ‘not’.

we expect the parser to respect grammatical constraints and to only perform a search for a licensor in structurally licit positions: at the main clause where the licensor can take scope over the NPI. We examine these predictions in an Event Related Potential (ERP) study, by manipulating the delay (both in time and in structure, see [Parker & Phillips, 2016](#)) in the appearance of a licensor for the NPI. We aim to investigate first, how this delay interferes with the *prospective search* for a licensor; second, whether this interference is only apparent when additional information increasing the length of the dependency is introduced at structural positions where the licensor is expected (i.e., meets structural constraints) and third, whether the length of this dependency at different structural positions modulates the ERP effect at the licensor position. If the parser actively looks for a licensor only at structural positions where it is likely to license the NPI (e.g., negation in the complement clause in (1b)), then we expect that we should see ERP effects at the licensor when modifiers are introduced at structural positions where it could license the NPI; conversely, we should not see significant ERP effects when modifiers intervene in positions that are not potential licensing positions (e.g., negation in the embedded clause in (1c)). In addition, we examine how an active search mechanism and the observed ERP effects could be mapped to current cue-based retrieval (CBR) theory ([Lewis & Vasishth, 2005](#)).

In the following subsections, we expand on the characteristics of NPI licensing, we first introduce the concept of the active search mechanism in long-distance dependencies and second, we describe the main characteristics of the CBR model. In section 2, we discuss the specific design for this study. In sections 3 and 4 we present the experimental materials and results. Finally, we conclude in sections 5 and 6 first, with a discussion of the implications of our results in light of the existing parsing theories on memory constraints and on incremental NPI licensing and second, by putting our results in context with respect to previous ERP findings.

1.1. NPI licensing in the ERP processing literature

Negative Polarity Items are expressions that must be licensed in order to be grammatical. Generally, they need to be in the scope of a licensor such as negation or other non-veridical contexts (e.g., emotive predicates, conditionals, yes/no questions, among others, see [Giannakidou, 2011](#) for further discussion) and this licensor must take scope over the NPI ([Ladusaw, 1980](#)). In the sentence in (2), the negative expression *no tourist* takes scope over the NPI *ever*, resulting in a grammatical sentence. As further illustrated in (3), the NPI *ever* cannot be used in the absence of a licensor. And even if there is a potential licensor (i.e., the negative noun phrase *no glasses*) within an embedded relative clause as in (4), the NPI *ever* in the matrix clause is not licensed. The negative expression *no glasses* is too deeply embedded in the structure to take scope over the NPI.

- (2) *No tourist ever* eats raw herring.
- (3) *A tourist *ever* eats raw herring.
- (4) *A tourist [that wears *no glasses*] *ever* eats raw herring.

Despite the fact that our description of the basic properties of NPI licensing focuses on a one-to-one relation between the NPI and its licensor, current linguistic theories of negative polarity licensing establish that NPI licensing follows a semantic/pragmatic mechanism in which, instead of individual words or phrases, the complete semantic/syntactic context where the NPI is positioned acts as a licensor (see [Giannakidou, 2011](#) for a review and summary; [Chierchia, 2006](#); [Kadmon & Landman, 1993](#)). Our discussion regarding the existing processing mechanisms during NPI licensing, is compatible with both the point of view in the current semantics literature and the more item-to-item relation in which it has been investigated to-date in the processing literature (e.g. [Vasishth et al., 2008](#)) since the proposed test case can be captured under both NPI licensing accounts (for further discussion on this issue, see [Parker & Phillips, 2016](#)).

The processing of NPIs has been extensively studied using the EEG technique. A number of studies have examined over the last two decades the ERP components generated in the processing of unlicensed NPIs, either in contexts where an appropriate (negative) licensor was absent, as in (3), or contexts where the licensor is in a structurally inaccessible position where it cannot take scope over the NPI, as in (4). Studies that included mostly negation (*no*, *not*) as licensors for cases like (3) or (4), found an N400 effect, followed by a P600 in most cases,² across different languages: German ([Drenhaus et al., 2005](#); [Saddy, Drenhaus, & Frisch, 2004](#)), Italian ([Vespignani, Panizza, Zandomenighi, & Job, 2009](#)), Turkish ([Yanilmaz & Drury, 2013, 2018](#)), Dutch ([Yurchenko et al., 2013](#)) and Basque ([Pablos et al., 2011](#)). However, not all the ERP studies found the same ERP signature for failure of NPI licensing. For example, the ERP studies on English by [Steinhauer, Drury, Portner, Walenski, and Ullman \(2010\)](#) and [Xiang et al. \(2009\)](#), did not consistently identify an N400 effect between licensed and unlicensed NPIs. This was hypothesized to be due to the effect of including a wider range of licensors in their experimental design (e.g. non-veridical contexts, other negative licensors such as ‘rarely/hardly’), to the complexity of the stored representations of the NPIs that have been tested to date and to the linear and hierarchical distance between the licensor and the NPI. Recent work by [Xiang et al. \(2016\)](#) tested sentences containing different licensors such as asserted or explicit negations (i.e., *No*, *few*, *only*) and non-asserted or implicit negations (e.g. emotive predicates such as *surprised*, *amazed*, *glad*, *shocked*, etc.). Xiang and colleagues consistently found a qualitatively similar N400 reduction elicited for conditions containing all types of licensors, regardless of whether negation was explicit or implicit, relative to the unlicensed condition. In turn, non-asserted or implicit negations elicited a larger P600 than asserted negations. As [Giannakidou and Etxeberria \(2018\)](#) further discussed in a recent review, the reduced N400 may be the physical correlate of semantic licensing, and the P600 may show an integration effect ([Giannakidou & Etxeberria, 2018](#), p. 16).

² Studies such as [Saddy et al. \(2004\)](#), [Yurchenko et al. \(2013\)](#) and [Pablos et al. \(2011\)](#) did not find a P600 in the unlicensed NPI conditions that had an absent or an inaccessible licensor.

Most of the previous ERP studies on NPI licensing focused on the measurement of the ERP effect at the NPI position (cf. Yanilmaz & Drury, 2018 on Turkish, which measured the ERP effects at the licensor position) compared to unlicensed (i.e., ungrammatical) instances of NPIs. In contrast, in the current study we examine *grammatical* instances of NPIs in a licensed environment where the licensor (i.e., negation) occurs linearly after the NPI, as in (1b). This configuration, with NPIs in a backward dependency relation, makes it possible to test the dynamic effects of the time-course of the online resolution of the dependency started by the NPI (we will refer to this licensing contexts as *NPI-licensor dependencies*). A recent research contemporary to our work by Yanilmaz and Drury (2018) investigated a similar backward NPI dependency configuration in Turkish, with the NPI preceding its licensor. Nevertheless, this was done with a slightly different research question in mind, where backward NPI licensing scenarios were examined in licensed and unlicensed contexts. The comparisons made by Yanilmaz and Drury (2018) included local and distant NPI licensing violations and found a different ERP effect for each case: a P600 for the licensing violation local to the NPI, and a biphasic N400/P600 for the matrix NPIs (or NPIs that were at a distance). Of relevance to our study, is the comparison of the ERP components generated by the two licensed NPI conditions, where the contrast of the two conditions lays in the licensing occurring at the embedded or at the matrix verb ([Subj [NPI^E V + NEG^E] V + Ø] vs. [Subj [NPI^E V + Ø] V + NEG^M]). This contrast between the *grammatical* (or licensed) conditions shows a P600 for the dependency that is completed locally (i.e., at the embedded verb) and a LAN for the dependency that is completed at a distance (i.e., at the matrix verb). As identified in previous work (discussed in section 1.2), the authors relate the LAN to the need to maintain the dependency open in working memory.

The current experimental manipulation (which will be extensively described in section 3.2) modifies the amount of material intervening between the NPI and the licensor by the addition of adverbial modifiers. We expect the observed ERP component at the licensor to reflect the increased difficulty of integration of this licensor and possibly the reactivation of the NPI. We could therefore expect both ERP components related to the process of integrating the licensor (e.g., P600, as discussed in Giannakidou & Etzberria, 2018; or LAN as in Yanilmaz & Drury, 2018), and ERP components related to delaying licensor occurrence (e.g., sustained (anterior) negativities, see section 1.2.). We expect this delay to have an effect mainly if intervening material occurs at structural positions from which the licensor can take scope over the NPI. We discuss these predictions in the next section.

1.2. Active Filler Hypothesis and the effect of distance in the resolution of dependencies

As we briefly discussed in section 1, the backward NPI-licensor dependency examined in this study may be parsed similarly to *wh*-question dependencies or cataphoric pronoun dependencies in that an *active search* process might be initiated when an NPI (which requires a licensor) is encountered. In describing what an active search is, the *Active Filler Hypothesis* (AFH) claims that in a dependency that involve *wh*-questions such as (5), for example, the identification of ‘a filler’ (i.e., the *wh*-phrase *what fish*) that needs to be interpreted induces a special mechanism in the parser of searching for a gap to interpret the *wh*-filler *what fish* at its thematic position (Clifton & Frazier, 1989; Frazier & Clifton, 1989).

(5) **What fish** did Giulia eat <gap> at the market?

One crucial assumption of the AFH is that the parser posits a gap in the first position where a gap could occur, before confirming evidence for the presence of this gap becomes available. In other words, the AFH assumes that the parser predicts the presence of a gap before this gap can be totally confirmed at its thematic position, while the sentence is incrementally interpreted. This assumption is made based on results from different behavioral reading time studies (e.g., Crain & Fodor, 1985; Stowe, 1986; Tanenhaus, Carlson, & Seidenberg, 1985; Tanenhaus & Lucas, 1987; Frazier and Flores D'Arcais, 1989) that support the existence of this active strategy in the parser. As illustrated in (6), the first position where a gap could be expected when performing the incremental parse of the sentence is banned once the complementizer of the complement clause is encountered. Thus, in (6), the only grammatically licit gap is the second one, the gap's thematic position.

(6) **What fish** did Giulia say <gap> that she ate <gap> at the market?

As the sentence in (6) suggests, filler-gap dependencies are unbounded and can be made arbitrarily long, which implies that the filler has to be maintained in memory and retrieved only when it is necessary, while unrelated elements are being processed.

A number of behavioral and ERP studies have manipulated the length of *wh*-dependencies in order to examine the effects of holding a *filler* in memory over different lengths (linearly or structurally). On the behavioral side, different studies have introduced extra information to lengthen the dependency either by adding parentheticals (Dillon et al., 2014; Parker & Phillips, 2016) or adverbial modifiers (Wagers & Phillips, 2014) in different types of dependencies (e.g., *wh*-dependencies in Wagers & Phillips, 2014; Antecedent-reflexive dependencies in Dillon et al., 2014 and NPI-licensor dependencies in Parker & Phillips, 2016). On the ERP research side, in a seminal study, King and Kutas (1995) investigated the processing of subject and object relative clauses and its interaction with on-line working memory processes. In multiword ERPs, they found a sustained anterior negativity in object relative clauses from the filler (the relativizer *who*) to the relative clause verb (which occurred at different linear positions in each condition), as compared to subject relative clauses, and in single ERPs,

at the main verb they found a more prolonged negativity over left anterior regions of the scalp in object relatives in comparison to subject relatives.

Later on, Fiebach, Schlesewsky, and Friederici (2002) examined the processing of object vs. subject *wh*-questions in short and long-distance contexts in German. In their study, the distance between the filler (*wh*-word) and the gap was increased via the insertion of additional adverbial modifiers. In multi-word ERPs, object long-distance *wh*-dependencies generated a long-sustained negativity starting from the *wh*-word and lasting to its gap position, while subject *wh*-dependencies did not generate any long-sustained negativity. Subsequently, Phillips, Kazanina, and Abada (2005) examined the processing of both long and short-distance *wh*-dependencies in English. They found (in multi-word ERPs) at the *wh*-word that started the dependency a long-sustained negativity that remained significant throughout the dependency. This was found for both dependency lengths with a greater amplitude in long-distance cases. At the verb which marked the end of the *wh*-dependency where the *wh*-word had to be integrated, they found a P600 for both dependency lengths, without any amplitude difference between dependency lengths. Similarly, Kaan, Harris, Gibson, and Holcomb (2000) examined the processing of *wh*-dependencies and compared them with non-extraction cases (such as indirect questions with *whether*) in English. They found a P600 at the verb position where the *wh*-word should be interpreted in *wh*-dependencies, which they interpreted as an integration cost.

The previous ERP research on different dependencies of different lengths seems to point to the following two ERP effects: 1) length effects (which are usually best captured by multi-word ERPs) result in sustained negativities that are associated with the process of maintaining an unresolved dependency in working memory and whose amplitude is modulated depending on the length of this dependency (where longer dependencies show bigger amplitude) and 2) integration of the dependency effects result in P600 effects.

However, and in contrast to the previous ERP effects, in an ERP experiment on dependencies of slightly different nature, i.e., subject-verb dependencies, Kaan (2002) examined the effect of linear distance and interfering material (i.e., three-word-phrases) in the completion of the dependency and found no effect due to distance on the ease of reactivation and integration of subject and verb features at the position of the verb.

Except for Yanilmaz and Drury (2018), none of the previously discussed ERP studies that manipulated distance ever examined NPI-negation dependencies (i.e., with the NPI appearing first).³ The main characteristic that the NPI-negation dependency in our study has in common with other types of dependencies in the previously mentioned ERP studies (e.g., *wh*-dependencies, relative clause dependencies, subject-verb agreement dependencies) is the fact that the parser needs to hold the NPI in memory until it encounters its licenser (i.e., negation). Assessment of the integration difficulty at the position of the licenser in our study allows us to capture both the effect of dependency length and whether the prospective search started at the NPI has an impact on integration.

For our study, we could expect the elicitation of (anterior) sustained negativities visible for the length manipulation due to maintaining the dependency open in memory over time, or a P600 for the integration of the dependency.

1.3. Cue-based retrieval models for predictive search

Current sentence processing models postulate the presence in the human parser of a *content-addressable memory architecture* (McElree, 2000; Van Dyke & Lewis, 2003). This memory architecture is able to access *directly* elements encoded in memory by a *search* that is mediated by *retrieval cues*. This architecture entails two key concepts: 1) *direct* access, which implies that the search is conducted in parallel based on the content, in contrast to a serial search that would navigate a linear buffer in memory until the adequate element is found (see McElree, 2001, 2006; McElree & Doshier, 1993); and 2) a *cue-based retrieval model* (henceforth CBR, Lewis, Vasishth, & Van Dyke, 2006) where items stored in memory are tagged with a set of features that allow their subsequent retrieval. This architecture further allows a general mechanism in the case of long-distance dependencies to retrieve the related elements in a dependency once the key element that triggers a search for the other is encountered. The CBR model adequately predicts the observed independence of retrieval time on dependency length (Martin & McElree, 2008; McElree et al., 2003) and interference effects of distractors with fully or partially match retrieval cues (e.g., Drenhaus et al., 2005; Parker & Phillips, 2016; Van Dyke, 2007; Van Dyke & McElree, 2006; Xiang et al., 2009).

In what follows, we describe a number of elements in the CBR model that are key to the discussion of this study.

1.3.1. Nature and encoding of retrieval cues

Some retrieval cues directly match the morphological features of the dependent elements (e.g. number and person in subject-verb dependencies). However, dependency completion in other instances requires relational syntactic constraints to be used as retrieval cues. In the NPI licensing example in (2), repeated here as (2'), under a CBR account, when the NPI *ever* is reached, a backward search is triggered for an element with {[+Negation], [+c-command]} features, where [+c-command] is a syntactic constraint that requires careful consideration of the structure of the sentence and [+Negation] is a semantic constraint (which could be alternatively coded as [+Non-veridical context]).

(2') **No** tourist **ever** eats raw herring

³ As we discussed earlier, only the study by Yanilmaz and Drury (2018) examined this though not only in purely grammatical contexts. Further, the behavioral study by Parker and Phillips (2016) examined forward NPI dependencies by manipulating distance in various speeded acceptability judgements and self-paced reading experiments, but they did not test ERP effects.

The specific process of the encoding in memory of constraints like c-command (or the more generic downward entailing scope relationship in NPis, see Giannakidou, 2011) or the precise general encoding of syntactic and semantic information as cues is still under discussion (see Alcocer & Phillips, 2012; Dillon, Mishler, Sloggett, & Phillips, 2013; Kush, Lidz, & Phillips, 2015, 2017; Parker et al., 2017).

1.3.2. CBR model's account of prospective search

The CBR model is based on the search for a particular set of cues once the foot of a dependency is found. The focus in this case is put on the element that completes the dependency and how retrieval of the antecedent proceeds. This is different when the element of the dependency starts a *prospective search* (as discussed in section 1.2). How does CBR account for the search of upcoming information (such negation in our study) is not clear (see discussion in Martin & McElree, 2008, p. 882).

The parser description by Lewis et al. (2006) incorporates the concept of a 'chunk' (in ACT-R vocabulary) with the prediction of upcoming information that is encoded in memory (see, Lewis et al., 2006: Fig. 1). Using this concept, one way to implement the *prospective search* in CBR with the NPI-licensor dependencies in (1b), is to create at the NPI a memory representation with the expected cues ({ [+Negation/Nonveridical context], [+c-command/scope]}) that will be retrieved once negation is encountered in the main clause.

1.3.3. Recency and activation of antecedents in backward relationships

The CBR model has been formalized computationally (Lewis & Vasishth, 2005) by means of a realization of the ACT-R architecture (Anderson et al., 2004). ACT-R representation can provide a closed-form mathematical approximation to calculate the probability of retrieval of an element (or chunk) represented in memory based on the level of *activation* (A_i) at the time a search is conducted. *Activation* (A_i) can be calculated as follows (Lewis & Vasishth, 2005):

$$A_i = B_i + \sum w_j S_{ij} + PM + \varepsilon_i$$

The different components of the *activation* (A_i) are: B_i , which represents the baseline activation, which accounts for the decay in memory of the element, and the time since its last retrieval. It incorporates the concept of re-activation to reflect the number of times the element is accessed or searched during processing. The second term in the equation is the associative strength (S_{ij}) of an item in memory with the current searched cues and includes a penalty introduced by inhibitory interference (w_j) caused by other matching elements in memory. PM reflects the penalization on activation due to chunks with partial matching cues, and finally, ε_i encodes the noise in the retrieval process. The element that has the highest activation value has a higher probability of recall and the lowest retrieval time. This expression can be used to make simulations for processing predictions by CBR.

For the case of a *prospective search* in the current study, we need to consider which will be the expected points in the sentence that would lead to a reactivation, as this has implications for our predictions. We will come back to this point during the discussion of the results.

2. The current study

The present study manipulates distance in order to establish if and how eagerly the licensor (i.e., negation) is searched for after processing an NPI in the sentential subject, as in (1b), repeated here as (7). In such sentences, the complementizer *dat* 'that' indicates that the NPI is contained within an embedded clause and therefore its licensor must come in the main clause in order to license it. In order to vary the degree in which a licensor could be expected after the NPI has been introduced, we added extra material (which consisted of different number of adverbial modifiers) between the NPI and its licensor at different structural positions in the sentence (i.e., embedded and main clause), resulting in two different distances between the NPI and its licensor. As discussed in section 1.2, in previous behavioral and ERP studies, researchers have used adverbial modifiers or parentheticals to increase the length of various kinds of long-distance dependencies. We follow these studies and assume that the adverbial modifiers we introduce in our stimuli do not interfere significantly with the interpretation of the sentence (neither alter their structure radically). In (7) we indicate where the extra material is inserted: A, in the embedded clause, which immediately follows the NPI, and B, in the main clause, which immediately follows the main verb *is*.

- (7) [Dat de man ook maar iets [A] gezegd heeft] is [B] niet waarschijnlijk.
 that the man anything [A] said has is [B] not probable
 'It is not probable that the man said anything'

(8) and (9) show examples that include one adverbial modifier in the embedded or main clause respectively, where the linear

distance between the NPI *ook maar iets* ‘anything’ in the complement clause and its licensor *niet* ‘not’ in the main clause is exactly 6 words apart in both cases.

- (8) [Dat de man **ook maar iets** *over zijn problemen* gezegd heeft] is **niet** waarschijnlijk.
that the man anything about his problems said has is not probable
‘It is not probable that the man said anything about his problems’
- (9) [Dat de man **ook maar iets** gezegd heeft] is *in dit geval* **niet** waarschijnlijk.
that the man anything said has is in this case not probable.
‘It is in this case not probable that the man said anything about his problems’

We expect that the modifiers introduced in positions A and B in (7) will differ with respect to their role in delaying the licensing of the NPI. Specifically, we expect that *over zijn problemen* ‘about his problems’ in the embedded clause (i.e., position A) in (8) does not have as much of an intervening (or delaying) effect concerning the NPI-negation dependency as *in dit geval* ‘in this case’ (i.e., position B) in (9). This is first, because a post-NPI element in the same embedded clause cannot license the NPI (i.e., the extra material in position A is c-commanded by the NPI, which means that a licensor is not expected to occur in this position and that material that intervenes at this position should not interfere) and second, because the licensor (i.e., negation *niet* ‘not’) can only license the NPI from the main clause and not from the embedded clause (i.e., the extra material in position B, occurs at a structural position in which the licensor can license the NPI and thus interferes to a greater extent in the completion of the dependency). Following the assumptions of the *active search hypothesis*, the licensor (i.e. negation) in (9) should occur immediately after the verb ‘to be’ in the main clause, but not immediately after the NPI *ook maar iets* ‘anything’ in the embedded clause in (8). Therefore, we predict first, that there will mainly be an ERP effect shown for (9) and not for (8) at the licensor position, and second, that the ERP component expected at negation in (9) will differ in amplitude depending on the number of intervening modifiers (as discussed in section 1.2). Further, there could be ERP effects that emerge resulting from having to hold an unresolved dependency in memory over time in both (8) and (9).

To have a measurable magnitude for the effect, we varied the linear length in both cases (embedded and main clause) by introducing one or two modifiers with the same number of words each. Testing distance effects in this kind of dependencies allows a correlation to be established with memory load and structural complexity. This is, to our knowledge, quite novel in ERP studies that have examined NPI licensing in grammatical sentences.

3. Material and methods

3.1. Participants

Twenty-five students of Leiden University participated in this study, which was conducted at the EEG Laboratory of the Social Sciences Faculty at Leiden University. All participants were native speakers of Dutch and had normal or corrected-to-normal vision. They provided informed consent and were paid 12,50 € for their participation, which lasted around 1.5 h, including set-up time. The experiment followed the Ethics Code for linguistic research in the faculty of Humanities at Leiden University, which approved its implementation.

3.2. Materials

Experimental materials consisted of five conditions. All conditions contained an NPI that appears within a sentential subject. The control condition in (10a) contains no modifiers. The NPI is within a sentential subject, while the licensor (i.e., the sentential negation *niet* ‘not’) appears in the main clause, following the copular verb *is* ‘is’. This means that the NPI linearly precedes the licensor. In the Embedded Single Modifier condition in (10b), a three-word modifier occurs right after the NPI in the embedded clause, and in Embedded Double Modifier condition in (10c) two modifiers with three words each occur right after the NPI. In the Main Single Modifier condition in (10d), a three-word modifier occurs right after the main verb *is* in the main clause, while in the Main Double Modifier condition in (10e), two modifiers occur after the main verb *is* ‘is’. In order to examine first, if introducing different number of modifiers at different structural positions in the sentence and second, if delaying with them the appearance of the licensor would elicit different ERP effects at the licensor position (i.e., negation), we compared the control condition in (10a) with the other four conditions at the position of negation (i.e., *niet*).

(10) **a. Control**

[Dat de man **ook maar iets** gezegd heeft] is **niet** waarschijnlijk.
 That the man anything said has is not probable.
 ‘It is not probable that the man has said anything’

b. Embedded - Single Modifier

[Dat de man **ook maar iets over** zijn problemen gezegd heeft] is **niet**
 That the man anything about his problems said has is not
 waarschijnlijk.
 probable.
 ‘It is not probable that the man has said anything about his problems’

c. Embedded - Double Modifier

[Dat de man **ook maar iets over** zijn problemen tegen zijn moeder
 gezegd
 That the man anything about his problems to his mother said
 heeft] is **niet** waarschijnlijk.
 has is not probable.
 ‘It is not probable that the man has said anything about his problems to his
 mother’

d. Main - Single Modifier

[Dat de man **ook maar iets** gezegd heeft] is *in dit geval* **niet**
 waarschijnlijk.
 That the man anything said has is in this case not probable.
 ‘It is not probable that the man has said anything in this case’

e. Main - Double Modifier

[Dat de man **ook maar iets** gezegd heeft] is *in dit geval om verschillende*
 That the man anything said has is in this case for various
 redenen **niet** waarschijnlijk.
 reasons not probable.
 ‘It is not probable that the man has said anything in this case for different
 reasons’

3.3. Procedure

Participants were comfortably seated in a dimly lit test room around 100 cm in front of a computer monitor. Sentences were presented one word at a time in black letters on a white screen using the presentation software E-prime[®]. Each sentence was preceded by a fixation cross (“+”) which appeared at the center of the screen and remained there for 1000 ms. This fixation point was followed by a blank screen interval of 300 ms, followed by the word-by-word presentation of each experimental sentence.

Each word appeared on the screen for 300 ms, followed by a fixation cross that remained visible for 300 ms. Participants were instructed to read the sentences carefully for comprehension. The last word of each sentence was marked with a period, and 1000 ms later a comprehension question appeared and prompted the participant to press a button to continue. The comprehension questions never targeted the NPI position. Feedback was provided for incorrect responses. Five counterbalanced lists were used for the experiment. Before starting the experimental phase, 4 warm-up practice trials were presented to the participants. The practice trials were not similar to any of the targets or filler items in the experiment. Participants were able to ask clarification questions to the experimenter about the task at the practice time.

The experimental session consisted of 71 sentences out of which 35 were target sentences and 36 were fillers. Items were fully randomized in 5 counterbalanced lists and participants could take a break after every 15 sentences. The 36 filler sentences belonged to a study on gender mismatch effects in cataphoric pronouns in Dutch which had no similarity with the current study (for further details see Pablos et al., 2015). We decided to have a relatively small number of target items per experimental condition, compared with general practices, for two main reasons: (a) to avoid a familiarization effect given the experimental sentences in (10), and (b) to maintain the experiment length within 1.5 h both to limit the reading fatigue of the participants and to keep their attention as much as possible. A required sample size of 20–25 subjects was estimated using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) considering a targeted statistical power of 0.8 for effect sizes achieved in previous NPI related studies. Although this assumption was an approximation, given the fact that no previous work could be referred to which contained a comparison of only grammatical targets

in a NPI-licensor dependency completion, results of the G*Power calculation show a sufficient level of statistical power. For a relevant recent discussion on the required number of trials and subjects in ERP studies, we refer the reader to Boudewyn, Luck, Farrens, and Kappenman (2018).

3.3.1. EEG recording

The EEG signal was continuously acquired at a sampling frequency of 512 Hz using a BioSemi (Active Two) system from 32 Ag/AgCl electrodes distributed in the scalp following the extended 10–20 convention (Fp1/2, AF3/4, F7/8, F3/4, Fz, FC5/6, FC1/2, T7/8, C3/4, Cz, CP5/6, CP1/2, P7/8, P3/4, Pz, PO3/4, O1/2, Oz). EEG data was referenced on-line to Cz, and re-referenced off-line to the mean of the activity at the two mastoid processes and filtered with a high pass filter at 0.1 Hz to eliminate DC drifts. Vertical and horizontal eye movements were monitored with an electrode at the infraorbital and an electrode at the outer canthus of the right eye. Electrode impedances were monitored during installation to ensure a low level of electronic noise.

3.3.2. EEG analysis

EEG recordings were segmented from 200 ms before to 800 ms after the onset of the significant region being analyzed. We subsequently filtered the segments using a low-pass filter with a cut-off frequency of 30 Hz, and we applied a correction algorithm for blinks and horizontal eye movements (Gratton, Coles, & Donchin, 1983). We further applied a semi-automated process for detection of artifacts that resulted in the rejection of < 1% of the segments. Finally, a baseline correction was performed based on the average of the 200 ms prior to the stimulus onset. All data reduction and ERP extraction were performed using the EEGLAB toolbox (Delorme & Makeig, 2004).

To perform statistical analysis of the signal scalp distribution, two topographical factors were considered: *Hemisphere* (Left, Central, Right), and *Position* (Frontal, Medial and Parietal). Data was divided into 200 ms time windows with 100 ms steps (0–200, 100–300, etc.), and for each segment a 3-way repeated-measure ANOVA (with factors: Condition x Position x Hemisphere) was performed considering the mean voltage-amplitude as the dependent variable in the analysis. All statistical analyses were conducted with the statistical software R (R Development Core Team, 2014) and the *lme4* package (Bates, Maechler, Bolker, & Walker, 2014).

4. Results

4.1. Comprehension questions

Overall, the accuracy on the comprehension questions was high ($M = 85.1\%$, $SD = 6.8\%$) and no participants were rejected on the basis of accuracy. The accuracy scores did not significantly differ by condition (a mixed effect logistic regression with the binary response *accuracy* as dependent variable, *condition* as a predictor and random intercept for *Subject* did not yield significant difference when compared with a minimal model with only the random structure $\chi^2(4, N = 6) = 0.85$, $p = .93$). Average accuracy of all subjects for individual conditions were as follows: Control, 83%; Embedded - Single Modifier, 85%; Embedded - Double Modifier, 85%, Main - Single Modifier, 85% and Main - Double Modifier, 87%.

4.2. Event-related potentials

We investigated the Event Related Potentials (ERPs) at the licensor position (i.e., negation), baselined to the 200 ms activity immediately preceding the critical word. Figs. 1 and 2 show the grand averages of the ERPs generated at the position of the licensor (i.e., the negative element *niet*) at the five different conditions for the midline electrodes Fz, Pz and Cz. All conditions elicited a typical visual stimuli early response (i.e., N1 followed by P2 with P1 component on occipital sites). Comparison with the control condition (10a), shows that the conditions where the extra material is introduced in the main clause (i.e., (10d, e)) yield a sustained negative deflection with an onset at around 250–300 ms, which peaks at 400 ms (see Fig. 1). In contrast, the conditions with modifiers in the embedded clause (i.e., (10b, c)) display some visual difference with the control conditions beyond 600 ms (see Fig. 2).

Furthermore, for the Main clause conditions in (10d, e), the ERPs do not appear to differ substantially at the latencies where the negativity peaks (around 400 ms) when the Double Modifier condition in (10e) is compared to the Single Modifier condition in (10d). However, when the ERPs of these Main clause conditions are compared at later latencies (e.g., 600–800 ms), the sustained negativity shows a larger amplitude.

The negativity centered at 400 ms in Fig. 1 is predominantly present at Anterior and Central electrode sites, a topographical distribution consistent with a N400 component (Curran, Tucker, Kutas, & Posner, 1993; Kutas & Hillyard, 1980). Inspection of the scalp map distribution with the purpose of examining the morphology of the ERP confirms the observation from the midline electrodes in Fig. 1. Fig. 3 shows the scalp map distribution at four different time windows for the difference between the ERP at the licensor *niet* 'not' for the Main - Single Modifier condition in (10d), and the Control condition in (10a). This difference average ERP at the licensor *niet* 'not' displays a typical broad central anterior negativity characteristic of the N400.

Moreover, a positive going deflection is observed in Fig. 3 starting at around 500 ms (bottom-left) and extending to 800 ms (bottom-right) most prominently at the Main - Single Modifier condition in (10d). The amplitude of this positive deflection is more significant on the central posterior sites, which is characteristic of a P600 wave.

To confirm the significance of the observed effects and determine the onset of the effect, we performed analysis of variance on the mean ERP voltage amplitudes in a global window of 200–800 ms and with sliding 200 ms windows from 0 to 800 ms that had a 100 ms overlap. We conducted a 3-way ANOVAs correcting for sphericity as required (corrected p -values are indicated, and

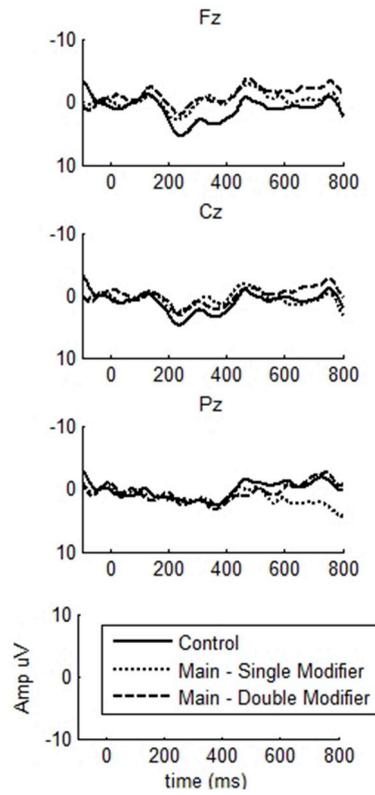


Fig. 1. Midline electrode ERPs for conditions with (single/double) modifiers introduced in the main clause.

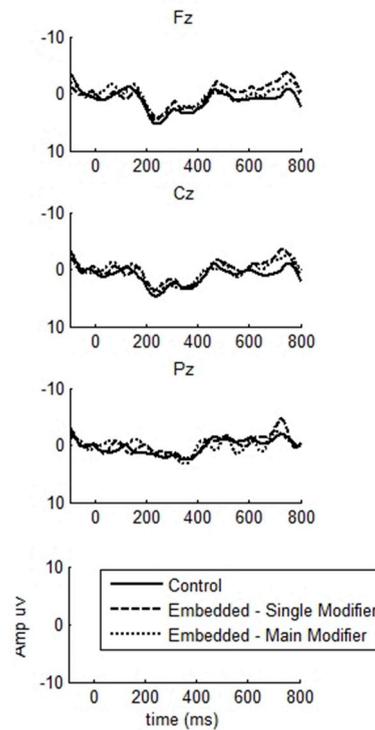


Fig. 2. Midline electrode ERPs for conditions with (single/double) modifiers introduced in the embedded clause.

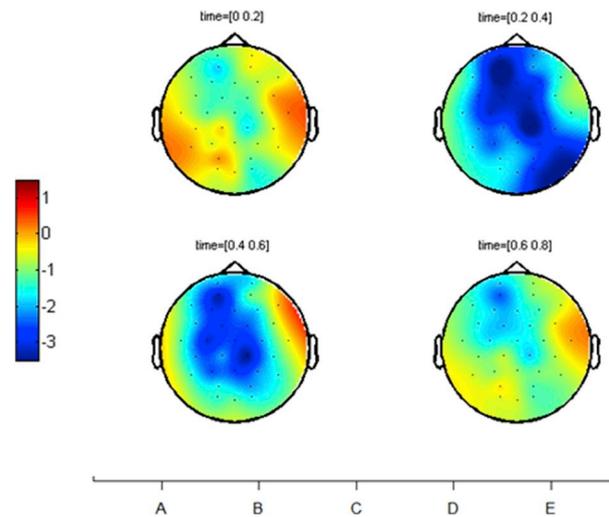


Fig. 3. Topographic maps of the difference average ERP at the licensor *niet* of the Main – Single Modifier condition in (10d) and the Control condition in (10a) at four different time windows (Top-Left: 0–200 ms; Top-right: 200–400 ms; Bottom-left: 400–600 ms; Bottom-right: 600–800 ms).

uncorrected *F*-values and degrees of freedom are reported for interpretation ease), with the following three factors: *Condition* ((10a), (10b), (10c), (10d), (10e)), *Position* (Anterior, Central, Posterior) and *Hemisphere* (Left, Right, Central).

The omnibus ANOVA in the 200–800 ms window revealed a significant 2-way interaction between the factors *Position* x *Condition* ($F(8,192) = 2.604, p = .034$). A breakdown of this interaction for each level of the *Position* factor showed a significant main effect of *Condition* in the Anterior sites ($F(4,96) = 2.90, p = .043$), but not in the Central ($F(4,96) = 1.94, p = .109$) and Posterior ($F(4,96) = 0.30, p = .880$) ones.

To confirm the centering of the ERP component in the 400 ms window, we carried out the same analysis using sliding 200 ms windows. Table 1 summarizes the results for the omnibus ANOVAs, where only significant *Position* × *Condition* interactions were found (for readability, only significant comparisons and effects are shown). Table 2 provides the follow up 1-way ANOVA interaction evaluation for the four significant windows derived from the omnibus ANOVA at the three different topographical sections (i.e., Anterior, Central and Posterior).

As can be seen in Table 2, a reliable effect of *Condition* centered around 400 ms is present in Central and Anterior regions, and in an extended 200–600 ms window, it is predominantly present in anterior sites.

Fig. 4 shows the average amplitude of the electrode Fz in the 200–400 ms time window (which showed significant effects for Anterior and Central sites, see Table 2) for all conditions, together with the standard error in the anterior region.

To determine the nature of the effect we observed, we performed post-hoc comparisons between the five different conditions in the complete 200–500 ms time window.

Main clause conditions (10d) and (10e) present an average ERP amplitude with a stronger negativity ($M_{(1d)} = 1.401, M_{(1e)} = 1.411$) than the Control in (10a) ($M_{(1a)} = 4.166$), as well as the Embedded clause conditions (10b) and (10c) ($M_{(1b)} = 2.709, M_{(1c)} = 2.725$). Table 3 shows the results of the pairwise *t*-test comparison conducted at the anterior position electrodes between the four different conditions where additional material was inserted (10 b, c, d, e) and the control condition in (10a).

Considering the Bonferroni correction to account for multiple comparisons, we test to a critical $\alpha < 0.0125$. Table 3 shows a highly significant difference in Main clause conditions (10d) and (10e) with a strong effect size (see reported Cohen's *d*) with respect to the control. The Embedded – Single Modifier condition (10b) was not significant with respect to the control to the selected α -level. We nevertheless report it, given that the *p*-values reflect a close to relevant difference, although with a smaller effect size. Comparison

Table 1
3-Way ANOVA interaction results (values reported when significant only).

	<i>Time Window (ms)</i>						
	0–200	100–300	200–400	300–500	400–600	500–700	600–800
Position X Hemisphere X Condition	–	–	–	–	–	–	–
Hemisphere X Condition	–	–	–	–	–	–	–
Position X Condition	–	$F(8,192) = 1.99$ $p = .049$	$F(8,192) = 2.37$ $p = .045$	$F(8,192) = 2.65$ $p = .034$	$F(8,192) = 2.40$ $p = .047$	–	–
Condition	–	–	–	–	–	–	–

Table 2
1-Way ANOVA at different electrode position sites (values reported when significant only).

Position	Time Window (ms)			
	100–300	200–400	300–500	400–600
Anterior	–	$F(4,96) = 3.70$ $p = .017$	$F(4,96) = 3.22$ $p = .016$	–
Central	–	$F(4,96) = 2.71$ $p = .035$	–	–
Posterior	–	–	–	–

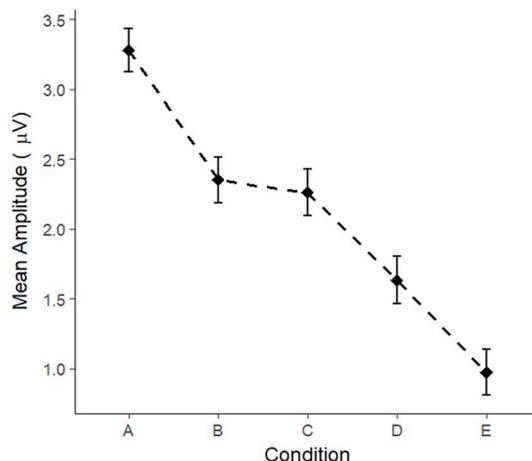


Fig. 4. Mean Amplitude (in μV) of the Fz electrode in the 200–400 ms window for the five different conditions in (10) (A: Control condition; B: Embedded- Single Modifier; C: Embedded- Double Modifier; D: Main- Single Modifier; E: Main- Double Modifier). Error bars correspond to the standard error.

Table 3
Post-hoc simple comparisons in 200–600 ms window.

	Time Window (ms)		
	t-value	P	Cohen's d
Embedded – Single modifier (10b) vs. Control (10a)	$t(174) = 2.31$	$p = .022$	0.175
Embedded – Double modifier (10c) vs. Control (10a)	$t(174) = 2.79$	$p = .006^*$	0.211
Main – Single modifier (10d) vs. Control (10a)	$t(174) = 5.50$	$p < .001^*$	0.426
Main – Double modifier (10e) vs. Control (10a)	$t(174) = 9.61$	$p < .001^*$	0.727
Embedded – Single modifier (10b) vs. Embedded – Double modifier (10c)	–	–	–
Main – Single modifier (10d) vs. Main – Double modifier (10e)	$t(174) = 1.95$	$p = .05$	0.148

between the presence of one or two modifiers (consisting of three words each, therefore three to six-word difference) in the clause did not yield statistically significant differences for embedded clause conditions (10b) and (10c). In contrast, when the modifiers are in the main clause, there is a significant difference: the Main - Double Modifier condition in (10e) shows an increased negative amplitude when compared with the Main - Single Modifier condition in (10d).

To summarize, the statistical analysis confirms the presence of a central anterior negativity in the 200–600 ms time window and corroborates that the amplitude of the negativity shows a correlation with the position and number of modifiers in the sentence with respect to the position of the licenser (i.e., negation). A significant effect was observed when modifiers were introduced in the main clause following the verb *is*. However, even though with a smaller effect size, an effect is still present when material is introduced in the embedded sentence. Consequences and possible explanations for the observations are discussed in section 5.

5. Discussion

We take the results described in the previous section to confirm the two main predictions we initially set for the experiment: a) the on-line processing of NPIs takes into consideration structural constraints in that a licenser is mainly expected in a position from which it can take scope over the NPI. Thus, modifiers that are introduced at structural positions where a licenser cannot appear show smaller interference effects at the process of integrating the licenser; and b) processing an NPI prior to its licenser triggers a search (and thus an expectation) for a licenser (i.e., negation) in the upcoming sentence in a similar fashion to what studies have previously

shown for how gaps are predicted in processing filler-gap *wh*-dependencies.

The observed effects can be related to the difficulty in the completion of a dependency (i.e., an NPI-negation dependency). There are several experimental observations on the increased parsing effort when the distance between two elements within a dependency is manipulated and the dependency is kept *open* for longer time (e.g., Fiebach et al., 2002; Gibson, 2000; King & Kutas, 1995; Phillips et al., 2005). However, the nature of the increase in effort can be attributed to different reasons depending of the theoretical parsing account that is considered. One possibility is to attribute it to a reflection of working memory constraints. Classic models that assume that the incomplete dependency is maintained in working memory (Gibson, 2000; Wanner & Maratsos, 1978) argue that the effects observed can be attributed to the effort to maintain the dependency active over time. This reasoning is purely based on the linear distance of the two elements in the dependency, and the memory decay associated with the time lag to complete the dependency. This would predict that we should not observe any difference in our experimental manipulation since the linear distance between the two elements in the dependency is the same, regardless of whether the interfering material is introduced in the main or embedded clause. This does not appear to be the case. If, on the other hand, we take a cue-based retrieval account without memory decay considerations, the retrieval of the NPI when negation is encountered should be independent of linear distance as the material introduced does not interfere with the cues used for the search ([+Negation], [+c-command]). This does not seem to be the case either.

To explain the clear increase in the effect size when adding one or two modifiers, mainly in the main clause in conditions (10 d, e), we should consider the concept of reactivation in a *prospective search*. If reactivation of the NPI in memory took place at clause boundary, for example, since at that position the NPI is still not licensed, we could expect effects due to distance in the main clause to have a bigger effect than in the embedded clause. Differences between one and two modifiers in the main clause can be attributed to activation decrease mainly due to memory decay (since the modifiers occur at a position posterior to the clause boundary and the verb *is*), whereas differences in the embedded clause can be primarily due to the delay in the reactivation of the NPI in memory. Thus, under the CBR account, the effect in the main clause conditions should be mainly due to memory decay, whereas the effect in the embedded clause conditions should be mainly due to the delay of reactivation.

The present results add up to the large amount of evidence showing that there is a memory encoding of information that includes information regarding sentence structure. As discussed in section 1.3, how this encoding is actually implemented is still unclear. In previous work on the processing of NPIs by Vasishth et al. (2008) using eye-tracking methodology, encountering the polarity item could trigger a parallel search in memory for retrieval of the licenser of the NPI in the preceding context that contained cues such as [+NPI, c-command], which incorporate the structural constraint in the search. However, in our experimental paradigm, the NPI is encountered linearly first, and a *prospective search* has to be started instead. How this prospective search is accounted for in CBR needs further study together with how the structural information is encoded and used in this processing account.

5.1. Relation to previous ERP findings

As discussed in section 1.1., previous ERP studies on processing NPI dependencies examined both grammatical and ungrammatical contexts where NPIs failed to be licensed either by having a missing licenser or a licenser in an inaccessible position. Among the ERP components that these studies found for unlicensed NPIs there were mainly a N400 and a P600 elicited at the position of the NPI, with some differences existing among studies with respect to whether both components were elicited that derive from the experimental design of each study (see Giannakidou & Etxebarria, 2018, for a review). Further, in a recent study by Yanilmaz and Drury (2018) on Turkish NPI licensing, conditions that contained locally *unlicensed* NPIs elicited a N400 and conditions with distantly unlicensed NPIs a biphasic N400/P600, whereas conditions with *licensed* NPIs elicited a P600 for the locally licensed NPI and a LAN for the long-distantly licensed one. In the current study, we investigated the processing of sentences where NPIs always appear in *grammatical* contexts (i.e., the interpretation of the NPI is always eventually resolved by a negation in the main clause) and we measure ERP effects at the position of its licenser, because this is the position at which the dependency is resolved. We therefore do not expect similar ERP components to those found in previous studies to be elicited both because of differences in the grammatical nature of our experimental sentences and because of measuring our effects at the licenser, and not at the NPI. Further, in previous studies, the NPI appears after the potential licenser, which means it is the search for the NPI that is initiated. In contrast, in our study the NPI appears prior to the licenser, which means a *prospective search* for a licenser is started when the NPI is first encountered. All this considered, we relate the central anterior negativity elicited at the position of negation (*niet* ‘not’) to the completion of the dependency and to the interpretation of the NPI, which needs to be retrieved and be finally resolved at negation.

As we discussed in section 1.2., previous studies that manipulated distance in the processing of different kind of dependencies (i.e., *wh*-dependencies, subject/object relative clauses) found on the one hand, long-sustained negativities for the comparison of short and long-distance *wh*-question contexts (Fiebach et al., 2002; Phillips et al., 2005) and on the other hand, a sustained anterior negativity for object relative clauses compared to subject relative clauses (King & Kutas, 1995).

We suggest that the central anterior negativity we obtained at the licenser position is connected to holding an NPI in memory over a distance until it can be finally interpreted at negation. Nonetheless, as our results suggest, holding the NPI in memory seems to be costly mainly when the intervening material that delays the occurrence of negation is in the main clause, but not so much in the embedded clause. This observation, as discussed, could be related to memory decay considerations after reactivation in terms of the CBR model.

6. Conclusions

Our results show that, delaying the resolution of an NPI-licensor dependency using additional modifiers in the main clause yields a processing cost reflected in the elicitation of a central anterior negativity at the position of negation. This cost is less apparent when these modifiers appear in the embedded clause. Furthermore, the amount of intervening material affects the expectation for the licensor, which manifests as an increase in the amplitude of the central anterior negativity correlated with the number of modifiers when the intervening material appears mainly in the main clause.

The more negation is anticipated, the bigger interference there is in introducing intervening modifiers and the bigger the amplitude of the central anterior negativity. Therefore, we can conclude that the location of modifiers in the sentence matters when processing NPI-negation dependencies. The actual implementation of structural constraints in the memory representations used in the processing of this kind of long-distance dependencies calls for further investigation.

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