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NEURAL CORRELATES OF PROSODY AND INFORMATION STRUCTURE

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The research reported in this thesis has been carried out under the auspices of the Center for Language and Cognition Groningen (CLCG) of the Faculty of Arts of the University of Groningen and the School for Behavioral and Cognitive Neurosciences (BCN) of the University Medical Center Groningen.

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To my family

Contents

1
Introduction

1.1 Introduction

Language enables interlocutors to exchange knowledge and beliefs. In the process of information 'packaging', communication partners apply grammar rules as well as universal communication principles to generate the information structure of their message. In West Germanic languages such as Dutch and English, prosody, i.e., the melody and rhythm of speech, serves as an important factor helping speakers to structure their message into more and less informative parts. Prosody guides the listeners' attention towards what is prominent and facilitates the detection of important information that is accented (focus) and less important information that is unaccented (background). The present dissertation applies the event-related brain potentials technique (ERP) to investigate the neural correlates that underlie the processing of prosody and information structure in spoken language.

The neural aspects of speech processing have recently received much attention in the neuroimaging literature. However, there is still no consensus regarding the number and nature of neural mechanisms involved in the processing of prosody, and the timeline of integrating prosody with information from the syntactic, semantic and pragmatic levels. Previous research has mostly focused on the pragmatic use of prosody for highlighting focus elements and on its consequences for the comprehension of short dialogues. Various other functions of prosody, for instance the marking of contrastive and corrective meaning and the syntactic disambiguation of complex sentences, have not been attested systematically in the literature and as a result, the neurobiology of linguistic prosody is still poorly understood. The fact that most previous studies apply tasks involving the meta-linguistic judgment of prosodic well-formedness which is known to modify neural responses to prosody (e.g., Toepel & Alter, 2004; Astesano et al., 2004) is a concern which opens up questions on whether previous findings reflect the naturalistic processing of prosody.

The goal of the present dissertation is to provide a systematic investigation of the neural mechanisms that underlie the processing of pitch accents in naturalistic speech, without the implementation of a meta-linguistic task. The current studies are concerned with the interaction of linguistic prosody and discourse context and investigate how congruity, but also the mere presence of discourse context, may impact the neural processing of speech. In particular, chapter 2 and 3 address the pragmatic use of prosody: is there evidence that the placement of accents in speech is evaluated against the information structure projected by the preceding context (chapter 2) or by a focus particle in isolated sentences (chapter 3), such that more effortful processing is the result of incongruous accent placement? Chapter 4 focuses on the neural correlates of accent types with distinct semantic interpretations that signal corrective and neutral focus, to answer the question whether accents carry a semantic meaning themselves or whether their interpretation arises on the basis of the meaning projected by the discourse context. Chapter 5 investigates the neural processing of accents that disambiguate conjoined clauses with verb ellipsis that are ambiguous between a gapping reading (clause coordination) and a nongapping reading (verb phrase coordination). The following sections provide a brief sketch of the theoretical and empirical evidence on information structure, prosody, and the neural processing of spoken language.

1.2 Information structure

Information structure refers to the organization of a message into more and less informative parts which can be achieved by grammar rules and universal principles of communication that are discussed below. In general, each message can be divided in two parts: the *focus* constituent which carries the most informative (new) information and the *background* constituent which represents presupposed (old) information. Focus and background can be signaled on various linguistic levels: in phonology by means of intonation (Gussenhoven,

1983), in syntax by word order modulations and cleft constructions (Selkirk, 1984), and in semantics by means of focus particles (Rooth, 1992). Empirical studies suggest that the exact linguistic means by which speakers indicate the information structure of a message are language-specific. Whereas Germanic languages (e.g., Dutch, German, English) make use of prosody to differentiate focus and background, Romance languages (e.g., Spanish, Italian, Romanian) use syntactic means such as clefts or focus fronting to signal focus and do not differentiate focus and background by prosody (Swerts, 2007; Swerts et al., 2002). As a result, a typological distinction between plastic and non-plastic languages has been proposed (Vallduvi, 2002), with the former languages using prosody for information structure marking and the latter not (see also Cruttenden, 2006). Moreover, the segmentation of information into focus and background indicates how discourse referents are represented in the interlocutors' minds during speech communication (Lambrecht, 1994). Current theories do not agree on the exact definition, number, and grammatical marking of information structural categories (Casieles-Suarez, 2004; Erteschik-Shir, 2007 for a review). The following sections present a brief overview of linguistic and prosodic cues for focus marking.

1.2.1 Pragmatic aspects of information structure

In pragmatics, language is defined as a communicative system driven by cooperative principles of interaction: speakers are supposed to organize their message based on assumptions about the mental state and knowledge of the listener, who then decodes the intended meaning of the message. From the speaker's perspective, communication can be viewed as an intentional speech act (Searle 1969, 1979), by which the speaker describes a state of affairs (*I sent the letter yesterday*) or aims to trigger a particular action by the listener (*It is dark in the room*; i.e., *Could you turn on the light?*).

From the listener's perspective, communication follows cooperation principles referred to as *conversational maxims* (Grice, 1975), which reflect the expectation that the

speaker is as *informative* as possible and provides *briefly* only *relevant* information that she *believes to be true*. Based on these Gricean maxims, listeners perceive accented information as intended to signal that it is important, and thus are inclined to interpret accented elements as 'focus' (Wilson & Wharton, 2006). With the assumption of a cooperative speaker, the listeners attempt to apply a reasonable interpretation to any, even incongruous, linguistic input and to integrate it into the discourse. These pragmatic aspects of speech communication interact with the structural interpretation of focus and background categories.

1.2.2 Identifying focus

As suggested above, according to information structure theory each message consists of an obligatory informative part (*focus*) and an optional less informative part (*background)*. There exist also other ways to package information, for instance in terms of a *topic-comment* dichotomy where *topic* represents what the sentence is about, while *comment* refers to what is being said about the topic (Reinhardt, 1982). Both analyses make different predictions regarding the information structure of sentences like (1) (accent in capitals):

(1) What did Peter read?

a. $[\text{Peter}]_{\text{topic}}$ [read an ARTICLE]$_{\text{comment}}$.

b. $[\text{Peter read}]_{\text{background}}$ [an ARTICLE]$_{\text{focus}}$.

Topic elements in Germanic languages are usually coded as definite noun phrases (NPs) that refer to given information, occur in initial sentence positions as syntactic subjects and do not bear the most prominent accent. Listeners have strong preferences for sentences with a "minimal topic structure", e.g., sentences with a single topic that is continued in conjoined clauses (Hoeks et al., 2002), which corresponds to typological observations that topics tend to be empty across languages (Comrie, 1981). In contrast, focus elements mostly

represent indefinite NPs in sentence final positions, usually coded as syntactic objects that introduce new information and bear the most prominent pitch accent.

The focus-background dichotomy was initially based on the distinction between new and old information respectively (Halliday, 1967; Chafe, 1987; Prince, 1981), without a clear definition of their linguistic marking (but see Baumann et al., 2006). For the correct identification of focus and background it is necessary to consider more factors than only information 'newness', such as semantics and prosody. One way to determine the focus of the message is to use question-answer pairs, as the majority of previous empirical studies have done (Baumann et al., 2006; Hanssen et al., 2008; Botinis et al., 1999). Although question-answer paradigms do not represent the most optimal elicitation of information structure components, this approach is in line with the assumption in information structure theory (Vallduvi, 2002) that focus represents the answer to an explicit (2) or an implicit question (3-4), and discourse context is thus optional for the determination of focus.

(2) Who criticized the government?

a. [The JOURNALIST]$_F$ criticized the government.

b. * [The journalist]$_F$ CRITICIZED the government.

c. * [The journalist]$_F$ criticized the GOVERNMENT.

(3) [The journalist criticized the GOVERNMENT]$_F$.

(4) The journalist criticized the [GOVERNMENT]$_F$.

In context-embedded sentences like (2), focus corresponds to the answer to the wh-element in the question and receives a pitch accent (2a); accents in positions different from the one determined by the question result in incongruous structures (2b, c) (Ladd, 1996). Previous studies have shown that after perceiving a wh-question, listeners have clear

expectations of upcoming focus and its accentuation (Nooteboom & Kruyt, 1987) and reject unaccented focus elements as ungrammatical, but tolerate accented background elements.

Without a preceding discourse context, all elements in the isolated sentence are assumed to be new and in focus. Such structures have neutral prosody that follows the pattern of declination; no element stands out prosodically. The most deeply embedded element, usually in rightmost sentence position, is assumed to be in focus and to project its 'F-feature' or focus-feature to all preceding constituents (cf. Selkirk, 1984) and is perceived as the most prominent one (Chomsky & Halle, 1968; Chomsky, 1971). Thus, an accented element in final position as in (3) and (4) leads to an ambiguity between a broad focus structure (3) where the entire sentence is equally informative and in focus, and a narrow focus structure (4) where only the accented word is in focus. According to the given-new distinction in information structure theory, isolated sentences should contain only new information since no preceding context is present, and hence narrow focus would be incongruous. However, empirical studies do not provide evidence for such a default final focus bias. Rather, listeners seem to apply a bottom-up strategy and analyze the prosodically most prominent accented element as focus, even in non-final sentence positions (Botinis et al., 1999). These results are in line with a pragmatic view that assumes that listeners determine focus by imagining an implicit question that the isolated sentence provides an answer to (Vallduvi, 2002, personal communication). However, these findings are in conflict with other behavioral studies showing that a non-default (i.e., non-final) accent position is likely to be interpreted as indicative of contrastive narrow focus (Swerts, 2007).

1.2.3 Linguistic and prosodic marking of focus

Focus marking can be attributed to a number of language-specific linguistic cues that operate on the syntactic, semantic and phonological levels. For instance, focus can be expressed syntactically by variations in word order like clefts (5) and focus fronting (6), which are more

common in Romance than in Germanic languages. Fronted focus constituents in sentence initial positions are prosodically most prominent, and all post-focal elements are deaccented.

(5) Who ordered the beer (John or Jack)?

It is JOHN who ordered the beer (and not Jack).

(6) JOHN I saw.

Focus can be signaled also on the lexico-semantic level by focus particles such as *only* (7, 8) that introduce focus in a contrastive relation to some other element which may or may not be mentioned in the preceding discourse (Sudhoff, 2010). Focus particles apply to domains of different size (Foolen et al., 2009) and their scope (i.e., their application domain) can vary across and also within a language. When the focus particle's scope is ambiguous, as the scope of English *only*, the focus constituent is identified on the basis of the most prominent pitch accent:

(7) Mary *only* bought the BOOK (and not the pen).

(8) Mary *only* BOUGHT the book (she did not read it).

Focus can be interpreted as contrastive not only when a focus particle is used or when the discourse contains alternatives; if the accented element occurs in a non-default (i.e., non-final) position, listeners tend to interpret it as contrastive focus too (Swerts, 2007). The distinction between *contrastive* and *presentational* focus is central in semantic (Rochemont, 1986) and syntactic approaches to focus (Selkirk, 2004). Others assume that all types of focus are contrasted to everything else that the speaker might have said about the topic (Bolinger, 1972; Gundel, 1994). A number of empirical studies provide evidence that contrastive and non-contrastive foci are produced with different prosodies (Baumann et al., 2006; Selkirk,

2004; Watson et al., 2008), either with distinct pitch accents or with enhanced acoustic features. Some of these focus marking cues have been investigated in this dissertation: Chapter 3 tested how the Dutch focus particle *alleen* (English *only*) is processed in isolated sentences and how it affects accent comprehension, and Chapter 4 focused on the use of different accent types for the marking of corrective and non-corrective focus.

Irrespective of whether it is marked by semantic or syntactic means, focus receives the nuclear pitch accent, which is the most important and most prominent accent in the prosodic phrase (*Nuclear Stress Rule*, Chomsky & Halle, 1968; Chomsky, 1971). While pre-nuclear accents are less prominent and can be associated with focus and background elements, the nuclear accent can only be assigned to focus and is realized as the last pitch accent in the phrase. Nuclear accents involve a pitch movement that can be described on the phonetic and phonological level.

Phonetically, nuclear pitch accents are hyperarticulated and are realized with higher peaks, lower valleys, increased pitch range and longer acoustic duration relative to pre-nuclear accents. Due to the highly idiosyncratic nature of pitch (e.g., absolute fundamental frequency (f0) varies between male and female voices due to anatomical differences in the length of their vocal tract), variations in pitch height do not have a categorical but only a gradient function for focus marking (Baumann et al., 2006). Thus, it is not absolute pitch that is informative but rather the pitch of a particular element in relation to the pitch of another element, which is interpreted functionally.

The psychological correlate of pitch corresponds to the perceived *prosodic prominence*: small variations in f0 may be taken to reflect the cognitive salience of focused information (Ladd, 1996). The perceived prominence of nuclear accents is furthermore enhanced by the deaccentuation of post-focal elements, suggesting that the temporal domain of focus extends beyond pitch accent (Xu et al., 2004; Gussenhoven, 2008). Pitch accents

themselves represent changes in pitch that are associated with a word on the segmental level and can be phonologically represented as combinations of high (H) and low (L) pitch.

The ToBI framework (*Tone and Break Indices*, Beckman & Ayers Elam, 1997, based on the Autosegmental Metrical Theory of Pierrehumbert, 1980) provides a system for the annotation of distinct pitch accents and boundary tones that form the phonological system of a particular language. The Dutch variant of this system is called ToDI (*Transcription of Dutch Intonation*, Gussenhoven, 2005). ToDI identifies a limited set of pitch accents with level pitch (H*, L*) and a pitch movement (e.g., falling H*L, rising L*H) that are associated with the metrically strong syllable of accented words (marked by an asterisk *). ToDI transcribes boundary tones by "%" and shows how the pitch varies at the left and right edge of intonational phrases (e.g., low final boundary: L%; high initial boundary: %H) (Gussenhoven, 2005; Shattuck-Hufnagel & Turk, 1996). Some theories (Pierrehumbert & Hirschberg, 1990) have proposed that prosody carries a compositional semantic meaning: the meaning of a pitch contour is suggested to arise from the meanings of its parts, which implies that every pitch accent and prosodic boundary carries a particular meaning itself (e.g., H* signals that a referent is new), which, however, has been questioned by, e.g., Ladd (1996).

In sum, prominent information expressed as focus combines three phenomena: (i) pragmatic salience related to the interlocutors' attention to the focus constituent; (ii) information structural informativeness that defines focus as the most informative part of the message; (iii) prosodic prominence and phonetic enhancement of elements in focus.

1.3 Investigating the neurobiology of prosody

The present section provides an overview of previous neuroimaging research on the neural correlates of prosody in spoken sentences. In these studies, sentences were either presented in

a discourse context or in isolation; both types of study are important. In real life, sentences seldomly occur without a context. Discourse context provides crucial information with regard to the information structure and prosodic realization of upcoming utterances. Studies looking at sentences in context can thus be said to be more naturalistic. On the other hand, it may be equally informative with respect to the workings of the speech processing mechanism, to see how sentences are processed when they occur outside of context. The present section compares neural evidence regarding spoken language comprehension in both types of study and starts with a brief introduction on language-related ERP components.

1.3.1 ERP components related to language processing

In previous ERP investigations of prosody a wide range of neural mechanisms have been identified. These components are not specific to prosody but apply to linguistic processing in general, as they reflect prosodic functions on a variety of linguistic levels including semantic, syntactic and pragmatic levels.

1.3.1.1 P200

The P200 component represents an early positivity peaking around 200 ms post stimulus onset that has been found for the processing of accented relative to unaccented stimuli (Heim & Alter, 2006; Friedrich et al., 2001). The P200 represents a sensory response to the acoustically strengthened features of accented words, i.e., their longer duration, higher pitch, larger pitch range. Friedrich et al. (2001) have attributed the P200 to the processing of unstressed words with falling pitch as compared to stressed words. Heim and Alter (2006) found a fronto-central P200 with a latency of 300 ms and peaking around 250-350 ms post stimulus, but only for accented words in sentence initial positions. Anterior P200 effects have also been reported for the pre-attentive processing of high rising tones in Swedish accents

(Roll et al., 2010), suggesting that the P200 is evoked by a wider range of prosodic contours than initially thought.

1.3.1.2 P300

Unlike the sensory nature of the P200 for the physical analysis of speech input, higher order cognitive mechanisms engaged in stimulus processing elicit positive waveforms around 300 ms post stimulus onset that are attributed to the P300 component. The P300 has been divided into a novelty-related P3a over fronto-central scalp regions, triggered by the attentive processing of novel or unexpected information, and a memory-related P3b over posterior scalp regions, evoked by the memory storage of a stimulus during a discourse update (for a review, Polich, 2007). The P300 is correlated with how easy it is to discriminate between target and nontarget auditory and visual stimuli, with easy stimuli showing a broad distribution and parietal maxima, and difficult stimuli evoking a parietal P3b (Comerchero & Polich, 1999). Although P300 responses probably do not reflect processing of the linguistic aspects of a stimulus *per se*, they may be elicited during attentive speech comprehension. P300 responses have been reported for incongruous accents in medial sentence positions in context (Magne et al., 2005) and are suggested to reflect the unexpectedness of accents on background information (P3a for superfluous accents) and the processing of task-relevant mismatches such as missing accents on expected focus information (P3b for missing accents).

1.3.1.3 N400

The N400 component represents a negative deflection with a centro-posterior scalp distribution and with a peak around 400 ms after stimulus onset. The N400 is assumed to reflect access to semantic memory, signifying the linking of a stimulus to a memory representation (Kutas & Federmeier, 2011 for a review), or the integration of semantic information into discourse context and world knowledge (Brown & Hagoort, 1993; van

Berkum et al., 1999; Hagoort et al., 2004). Various factors may modify the N400 amplitude, for instance the ease of activating and integrating the semantic features of a stimulus into the larger discourse, with the most expected and plausible words showing the smallest N400 amplitudes (e.g., van Berkum et al., 1999). Differences in N400 amplitude are further related to the semantic plausibility of a stimulus in the preceding context (e.g., *He spread his warm bread with socks* vs. *butter*, Kutas & Hillyard, 1980; Wang et al., 2011) and to its congruity with respect to world knowledge (e.g., *Dutch trains are white* (incongruous) vs. *yellow* (congruous) (Hagoort et al., 2004). Prosody can also elicit the N400, for instance when focus elements are unaccented, which suggests that difficulties with semantic integration arise also due to prosodic incongruity (e.g., Hruska & Alter, 2004; Toepel & Alter, 2004). Recent studies show that the N400 is modified by task-related meta-linguistic attention processes (e.g., Dimitrova et al., submitted; Toepel & Alter, 2004; Wang et al., 2011).

1.3.1.4 P600

The P600 component represents a late positive waveform which reaches its maximum amplitude around 600 ms post stimulus onset and has a centro-posterior or (left) anterior scalp distribution. The P600 is associated with a wide range of linguistic functions. Initially, the P600 has been attributed to syntactic integration difficulties (Kaan et al., 2000) and the syntactic repair of ungrammatical information in sentences like *Die Bluse wurde im gebügelt* (*The blouse was on ironed*, Friederici, 2002). A P600 is also evoked by the processing of garden-path sentences like *The broker persuaded to sell the stock was sent to jail*, where the initial reading of the sentence with *persuaded* as a verb has to be revised at the underlined preposition (Osterhout & Holcomb, 1992). Syntactically ambiguous sentences with an inversed object-before-subject order and with an ambiguous case marking like the German *Die Detektivin hat der Kommissar gesehen* (*The commissar saw the detective*) elicit a P600, reflecting the disambiguation of the initial NP reading as object (Frisch et al., 2002). Left

anterior P600 has been found in ambiguous grammatical sentences like *I cut the cake beside the pizzas that were brought by Jill* (Kaan & Swaab, 2003) where it manifests the processing of discourse complexity, arising due to the ambiguous verb *were*. Late positivities are also reported for semantically complex sentences (Hoeks, Stowe, & Doedens, 2004) and for processes of integrating new information into discourse memory (Burkhardt, 2007).

1.3.1.5 CPS

The *Closure Positive Shift* (CPS), a late positivity around 500 ms post stimulus with a centro-posterior distribution, is related to prosodic parsing (Steinhauer et al., 1999) that does not depend on the presence of silent pauses (Steinhauer & Friederici, 2001) or linguistic information in the signal (Pannenkamp et al., 2005). Previous studies report CPS effects for prosodic breaks that disambiguate temporally ambiguous sentences like *The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang* (Kerkhofs et al., 2008; Boegels et al., 2010). The CPS is sensitive to the interplay between prosody and discourse and is diminished when prosodic breaks are aligned with syntactic breaks in discourse (Kerkhofs et al., 2007). Furthermore, the CPS has been suggested to reflect information segmentation at focus positions in sentences with context (Hruska & Alter, 2004). However, the underlying functional source of the CPS is not entirely clear.

Due to its temporal and topographic overlap, the CPS and the P600 have been difficult to disentangle in previous studies. For instance, focus may activate the CPS due to information structure segmentation but also due to its occurrence close to a phrase boundary. The variety in potential neural sources becomes problematical when late positivities elicited by prosody have to be interpreted, as they may be related to prosodic parsing (CPS) but also to discourse integration of focus (P600) or disambiguation of complex structures (P600). In the present dissertation special care was taken to avoid silent pauses and boundaries in the vicinity of targets that could initiate independent prosodic parsing processes.

1.3.2 Prosody and focus processing in isolated sentences

As isolated sentences are uttered out of the blue, their information structure and prosody cannot be anticipated because no discourse context is available. With neutral prosody, such sentences can be interpreted as having a default *broad focus structure* where all elements are in focus. When, however, a single element stands out prosodically, such sentences are interpreted as having a *narrow focus structure* that reflects the intention of the speaker to highlight a specific element. Behavioral studies provide evidence that listeners have no difficulties to interpret narrow focus in isolated sentences, whereas ERP studies suggest that during on-line processing listeners most likely assume a default broad focus structure.

The comprehension of isolated sentences has been addressed in two ERP studies on German. Hruska & Alter (2004) have shown that when no context is present and sentences are pronounced with neutral prosody, without any element being specifically prominent, listeners segment information at the phrase boundary which gives rise to a CPS, similarly to CPS responses for focus elements in sentences with context. Hruska & Alter's results show that speech processing is guided by expectations of focus and accent in the discourse context and by expectations of default structures in isolated sentences.

In another study, Heim & Alter (2006) investigated the processing of pitch accents in isolated sentences that contain the focus particle *sogar* (English *even*). The authors found that neural responses to prosody depend on the position of the pitch accent in sentences like *Peter verspricht sogar Anna zu arbeiten und das Büro zu putzen* (*Peter even promises Anna to work and to clean the office*). Sentence initial accents (*PETER* vs. *Peter*) evoke the P200 component which implies that when no reference to other prosodic information is available, accentuation is processed in a sensory manner. Accents on the verb (*VERSPRICHT* vs. *verspricht*) elicit an N400, which the authors relate to the unusual position of the pitch accent. Unlike other accent positions, the processing of accents on the second NP (*ANNA* vs. *Anna*) is affected by the preceding focus particle *sogar* which leads to the anticipation of adjacent

focus and accent (see also Sudhoff, 2010). Heim & Alter show that *sogar* modifies the neural response to accentuation and triggers an early anterior negativity when *Anna* is accented. The negativity is interpreted as a response to the expectation of the accent on the basis of the focus particle (*Expectancy Negativity*, *EN*). Similar anterior negativities have been reported for correct accents that are expected in sentences with context (Hruska & Alter, 2004).

1.3.3 Prosody and focus processing in context

By embedding sentences in a discourse, spoken language comprehension is informed by the context which enables the anticipation of upcoming information structure and constrains the set of plausible referents. Previous studies have often applied *wh*-questions for focus elicitation due to their straightforward predictions of focus and accent.

In a number of studies, the processing of expected focus elements in the discourse context gives rise to, among other things, the CPS component (Toepel & Alter 2004; Toepel et al., 2007). Although it is unaffected by the appropriateness of prosody, the CPS is modulated by focus type: after novelty narrow focus questions like *What did he promise you?*, two CPS responses (underlined) are triggered in the answer *He promised me to <u>support ANNA</u> and to clean the kitchen*. After contrastive narrow focus questions like *Did he promise you to support Frauke?*, a single CPS component is elicited in the answer *He promised me to support <u>ANNA</u> and to clean the kitchen* (Toepel & Alter, 2004). The findings are interpreted as evidence that context allows listeners to anticipate the number of focus positions.

Various other neural responses have been attributed to the processing of focus-accent combinations, some of which were discussed in the preceding section. For instance, when discourse context leads to the anticipation of focus and accent, early anterior *Expectancy Negativities* (Hruska & Alter, 2004) occur at the congruously accented element, as in question-answer pairs *Whom did he promise to support? He promised to support <u>ANNA</u>* (accented word in capitals, focus underlined). Most studies have focused on the processing of

prosody-context mismatches when the prosody of a sentence does not meet the expectations projected by the discourse context. When focus does not receive an accent (missing accent) and when background is the prosodically most prominent element (superfluous accent), a number of ERP responses with different polarity and timing are reported.

In general, missing accents trigger a negative N400-like component in ERP paradigms that implement a meta-linguistic task and require listeners to judge the appropriateness of the prosodic realization of experimental stimuli (Hruska et al., 2001; Hruska & Alter, 2004; Toepel & Alter, 2004; Magne et al., 2005). The N400 response is usually related to increased semantic processing costs which arise due to the inappropriate accentuation of the sentence. In studies without a prosodic task, only superfluous accents give rise to an N400 (Dimitrova et al., submitted; Wang et al., 2011; Toepel & Alter, 2004), suggesting that task-related attention processes modulate the neural mechanisms for prosody processing.

ERP responses with a positive polarity are also common for incongruous focus-accent combinations in the discourse context (Magne et al., 2005), however, only when the prosodic mismatch occurs in medial sentence position; in final position, the processing of incongruous prosody gives rise to an N400-like negativity. Magne et al. assign the positivity for incongruous accents in medial positions to the P300 component which reflects the processing of novel information and surprise (e.g., Polich, 2007). Differences in the distribution of the positivity are attributed to differences in the type of prosodic mismatch. Superfluous accents trigger an anterior positivity reminiscent of the P3a for the processing of novel information, due to the unexpected accent on background elements. By contrast, the positivity for missing accents has a posterior distribution and is assumed to belong to the P3b, as the missing accent on focus represents a task-relevant mismatch. Lastly, almost all incongruous accents in the discourse context evoke a P600, which was hypothesized to be evoked by the processing of prosody-context combinations that are addressed in the current dissertation.

1.4 Overview of the dissertation

The dissertation focuses on three aspects of prosody and information structure in spoken language: (i) the pragmatic function of pitch accents to indicate focus, including the interaction of prosody and the focus particle *alleen*; (ii) the semantic function of pitch accents to signal corrective meaning, and (iii) the syntactic function of pitch accents to serve as cues for disambiguation between gapping and nongapping readings of ambiguous sentences with verb ellipsis. All studies refrain from using a meta-linguistic task which requires the additional judgment of prosodic stimulus aspects, and compare speech processing in sentences with and without a preceding discourse context.

1.4.1 Pragmatics: Pitch accents and focus

The first two chapters address the pragmatic function of pitch accents to indicate focused information and compare the processing of focus-accent combinations in congruous and incongruous discourse contexts (chapter 2) and in isolated sentences with and without the Dutch focus particle *alleen* (English *only*) (chapter 3).

Although the pragmatic function of prosody is well studied in the theoretical literature, current behavioral and neuroimaging findings provide conflicting results regarding the processing of prosody. In general, discourse context and accent placement co-determine which element is interpreted as focus. The interpretation process may be more difficult in isolated sentences than in context-embedded sentences, since a preceding discourse facilitates the segmentation of upcoming information and leads to the anticipation of focus. In case of incongruous prosody, listeners have been shown to reject unaccented focus as ungrammatical but to accept accented background information, even if it is inappropriate (Nooteboom & Kruyt, 1987). When sentences are presented out of context, listeners appear to accept any

prosodic realization and assign focus to the element with the most prominent accent (Botinis et al., 1999).

A whole array of neural responses, negative and positive ERP shifts, are associated with the processing of incongruous accents in the discourse context (Dimitrova et al., submitted; Schumacher & Baumann, 2010; Wang et al., 2011, 2010; Toepel et al., 2007; Magne et al., 2005; Toepel & Alter, 2004; Hruska & Alter, 2004) and in isolation (Heim & Alter, 2006; Hruska & Alter, 2004). Besides the distinct analyses and functional interpretations of these ERP components, previous studies vary also with respect to the type of secondary (meta-linguistic) tasks and experimental materials they used. To provide an uncluttered look at processing prosody and information structure, the studies in this dissertation apply strictly controlled stimuli and are matched for a number of parameters, such as the avoidance of phrase boundaries close to targets, the use of identical accented syllables and appropriate matching and time locking procedures.

Of particular interest was the question when and how strong (in)appropriate focus-accents combinations affect neural processing, particularly in context-embedded sentences like *Heeft de club een premie aan de speler of aan de trainer gegeven? – Ze hebben een PREMIE (background) aan de speler (focus) gegeven* (English: *Did the club give a bonus to the player or to the trainer? – They gave a BONUS to the player*). The study in chapter 2 focuses on the brain's sensitivity to missing accents on focus elements (*player*) and to superfluous accents on background elements (*BONUS*).

Chapter 3 investigated how the brain analyzes prosody in sentences without a discourse context where listeners cannot predict where accents will be placed and which element will be in focus. Even in sentences without a context, however, focus can be predicted on the basis of focus particles such as the Dutch *alleen* (English *only*) which assigns focus and accent to the elements in its scope. Chapter 3 compares accent processing in sentences with and without the focus particle *alleen*, cf. *Ze hebben (alleen) een PREMIE*

aan de speler gegeven (English: *They (only) gave a bonus to the player*). The focus particle was hypothesized to trigger the anticipation of focus and accent as suggested by Heim & Alter (2006), in a similar way as context does, and to affect the neural processing of prosody.

1.4.2 Semantics: Pitch accents and focus

The question whether pitch accents carry any semantic meaning has been widely discussed in the literature on prosody and information structure. The Autosegmental-Metrical Theory (Pierrehumbert, 1980; Pierrehumbert & Hirschberg, 1990) proposes a compositional approach of intonational meaning and claims that the meaning of a pitch contour can be derived from the meaning of its parts, that is pitch accents, phrase accents and boundary tones. The theory assumes that each pitch accent has a categorically distinct semantic meaning: high level pitch accents (H*) signal new information, low level pitch accents (L*) given information and rising pitch accents (LH*) contrastive or corrective information. The AMT approach is based on the pragmatic assumption that speakers use accentuation to link a proposition to the common knowledge between interlocutors. The AMT theory has received severe criticism by Ladd (1996) but has been supported by empirical studies on German (Baumann, 2006; Baumann et al., 2006) and English (Watson et al., 2008), whereas for Dutch there is conflicting evidence (Kramer et al., 2002; Swerts et al., 2002; Swerts, 2007; Gussenhoven et al., 1997; Gussenhoven & Rietveld, 2000; Hanssen et al., 2008).

A number of behavioral studies provide phonetic and phonological evidence that some pitch accents can be interpreted as *contrastive* (Alter et al., 2001; Baumann et al., 2006; Selkirk, 2004) and *corrective* (Stavropoulou et al., 2010; Krahmer et al., 1999, 2002; Swerts et al., 2000). It has been shown that elements in contrastive and corrective focus have higher pitch, larger pitch range and longer duration than the corresponding elements in neutral non-contrastive and non-corrective focus. The impression of contrast is attributed to the phonetic strengthening of accents (Gussenhoven et al., 1997), the use of phonologically distinct accent

types (Stavropoulou et al., 2010; Watson et al., 2008; Weber et al., 2006; Toepel, 2005), and a non-default placement of accents regardless of their accent type (Swerts, 2007).

Two behavioral and two ERP experiments presented in chapter 4 compare the neural processing of rising L*H and falling H*L accents in Dutch. These accents have been shown to differ not only in pitch direction but also with respect to their semantics: L*H accents are used when information represents a correction (Krahmer et al., 2002) while H*L accents are used with neutral non-corrective meaning and are considered the default focus accent in Dutch (Hanssen et al., 2008; Gussenhoven, 2005). The present studies test whether these accents are processed differently, both in context and in isolation, and whether their processing depends on contextual congruity. The behavioral experiments measure whether listeners perceive differences in the appropriateness of distinct accent-context combinations and how pitch accents are interpreted when no context is present. One of these behavioral studies asked participants to imagine and reconstruct a hypothetical preceding context, similarly to Swerts et al. (2002) who have applied such tasks to test listeners' sensitivity to contrastive prosody. The current ERP studies contribute to the ongoing discussion about the corrective meaning of prosody and provide insights into the neural mechanisms engaged in the processing of correction.

1.4.3 Syntax: Pitch accents and gapping

Prosody can contribute to syntactic disambiguation as well (Cutler et al., 1997; Carlson, 2001). For instance, in sentences like *John invited Peter on Monday and Martin on Tuesday*, the second clause can be interpreted as a verb phrase coordination (gapping) with *Martin* as subject, or as a clause coordination with *Martin* as object (nongapping). Reading preferences in such clauses are modified by a number of factors, including the thematic role restrictions of the elided verb (e.g., whether it allows human objects), the prosodic contour (which elements receive parallel accents), and the presence of a discourse context. Behavioral studies

have addressed some of these factors (Carlson, 2001; Carlson et al., 2005; Hoeks et al., 2006, 2007, 2009); however, no evidence exists regarding the neural mechanisms that underlie their on-line interaction and disambiguation.

Chapter 5 presents two ERP experiments on the neural processing of ambiguous sentences with verb ellipsis and compares how they are interpreted when discourse context is present or absent. The studies show how linguistic factors such as thematic fit impact prosody processing and reading preferences. In sentences with good thematic fit where the verb allows for human objects, the interpretation of the second clause is biased towards nongapping as in *John zag Peter op een maandag en Martin op een dinsdag* (English: *John saw Peter on a Monday and Martin on a Tuesday*). In sentences with poor thematic fit the verb does not allow for human objects and a nongapping interpretation is blocked, which leads to an enforced preference for gapping as in *John schilde de mandarijn met een mes en Martin met zijn handen* (English: *John peeled the orange with a knife and Martin with his hands*). Prosody, in particular the parallel accents on the ambiguous target *Martin* and one of the elements (*John* vs. *Peter*) in the main clause, also influences interpretation preferences. The studies provide new insights into the neural mechanisms of constructing a gapping representation of ambiguous sentences with and without a discourse context.

In sum, the following chapters discuss the similarities and differences in the processing of prosody between sentences with and without a discourse context. The studies presented in this dissertation aim to account for the timing and nature of neurocognitive processes that underlie the processing of pitch accents in Dutch spoken sentences.

2

Less is not more

Neural responses to missing and superfluous accents in context

Abstract

Prosody, particularly accent, aids comprehension by drawing attention to important elements such as the information that answers a question. A study using Event Related brain Potentials (ERP) registration investigated how the brain deals with the interpretation of prosodic prominence. Sentences were embedded in short dialogues and contained accented elements that were congruous or incongruous with respect to a preceding question. In contrast to previous studies, no explicit prosodic judgment task was added. Our results show that incongruously accented elements, i.e., *superfluous* accents, activate a specific set of neural systems that is inactive in case of incongruously unaccented elements, i.e., *missing* accents. Superfluous accents triggered an early positivity around 100 ms post-stimulus, followed by a right-lateralized negative effect (N400). This response suggests that redundant information is identified immediately and leads to the activation of a neural system that is associated with the activation of semantic information (N400). No such effects were found when contextually expected accents were missing. In a later time window, both missing and superfluous accents triggered a late positivity on midline electrodes, presumably related to 'making sense' of both kinds of mismatching stimuli. These results challenge previous findings of greater processing for missing accents. Furthermore they suggest that the natural processing of prosody involves a set of distinct, temporally organized neural systems.

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2.1 Introduction

In spoken communication, speakers use prosody – the melody and rhythm of speech – in ways that help the listener understand the message. Speakers assign pitch accents to the most important information in the utterance, the *focus* element, and leave less important parts unaccented, the *background* elements. For instance, as an answer to the question *What did the club give to the player?,* the sentence *They gave (background) a BONUS (focus) to the player (background)* is appropriate, as it emphasizes the segment that answers the question, while a sentence would be inappropriate in which background information was accented instead, as for example *They gave (background) a bonus (focus) to the PLAYER (background)*. In this sense, accents 'focus' the listener's attention to the most important information (Wilson & Wharton, 2006), facilitating utterance interpretation (reviewed in Cutler, Dahan, & Donselaar, 1997). The importance of accent in guiding attention to important information is clear from the fact that implausible information which is unaccented tends not to be noticed (Wang et al, 2011). The link between prosody and focus is very prominent in West-Germanic languages such as Dutch, German and English (Vallduvi, 2002; Ladd, 1996). Languages differ in the exact instantiation of accent on elements in focus, so we will use the generic term *focus accent* to refer to the phenomenon in this paper.

The distinction between focus and background information within an utterance, also called 'information structure', derives from the discourse context, which determines which information is familiar and therefore backgrounded. In context, listeners may expect the important information in a certain position within the sentence to be marked prosodically as focus. Nooteboom and Kruyt (1987) have shown that listeners are capable of recognizing inappropriate accentuation based on the context: in their off-line rating study, listeners rejected sentences containing unaccented elements where focus was expected (i.e., 'missing' focus accents). Oddly, they tolerated accent on background elements (i.e., 'superfluous'

background accents), despite the fact that focus accent is hypothesized to have the effect of focusing attention on the accented element: this result suggests that less is indeed sometimes more, as in minimalist design. However, given the fact that accent is argued to direct attention to information, one would have expected that a superfluous accent on backgrounded information would be ***more*** noticeable. This sort of behavioral judgment data is important but relies on a conscious judgment.

Event related potentials (ERPs) have been used in a number of recent studies to investigate the neural substrates of the processing of linguistic prosody. ERPs are useful because they directly measure brain activity; differences between various conditions can reveal the time point at which a difference is recognized without the need of an explicit judgment task, as well as giving an indication about the nature of the brain responses involved. From these studies it appears that the brain uses context not only to anticipate upcoming words (Federmeier, 2007; Kutas & Hillyard, 1980) but also their associated prosodic patterns (Hruska et al., 2001; Hruska & Alter, 2004).

Two linguistic functions of prosody have received the most attention in the ERP literature to date: the processing of prosodic boundaries, and the use of pitch accents for focus marking (see Table 1 for an overview). Prosodic boundaries, typically consisting of slowed speech tempo and a pitch change, are used to break speech into segments, usually at syntactic boundaries. The processing of prosodic boundaries per se, as compared to a sequence without a break, consistently evokes early positive effects resembling the P2 component for acoustic differences (Li et al., 2010), and a late positive effect, sometimes called the *Closure Positive Shift* (CPS, Steinhauer & Friederici, 2001).

In contrast, it is less clear which electrophysiological components underlie the interplay of focus and accent. Since focus accent is a potential guide to important information during language comprehension, a number of recent studies have used ERPs to investigate how this information is processed, in particular the response to a missing focus accent and

superfluous background accent. However, an extensive list of neural components (responses with different latencies, polarity and scalp distributions) has been reported in the literature, interpreted as reflecting various neural processes (see Table 1). We believe this is due to the large variation in materials, methods, and experimental designs used in these studies, rather than a large variability in the processing of focus accent and prosody. Most important in our eyes, in all but two previous ERP studies on the processing of pitch accents, participants had to explicitly judge the prosodic wellformedness of the utterance.

First let us examine the variability among studies. On the one hand, some studies (Hruska & Alter, 2004; Toepel & Alter, 2004; Magne et al., 2005; Heim & Alter, 2006) found effects with a *negative* polarity. These have frequently been interpreted as evidence for semantic processing difficulty due to mismatch with the context, producing an effect similar to the N400, an increased negativity seen over central and parietal electrodes in response to words which do not fit semantically (Kutas & Hillyard, 1980). The second part of Table 1 lists studies which address the relationship between semantic processing and focus, whether indicated by syntactic structure (clefts) or intonation.

Alternatively, as suggested by Magne et al. (2005), the negativity could be interpreted as task-related effects such as the 'Contingent Negative Variation' (CNV), a task-related negativity that reflects the cognitive preparation for an upcoming stimulus to which the participant must react (Walter et al., 1964; Rugg & Coles, 1995). The fact that negativities have been found in tasks in which an explicit judgment has been used makes this a plausible alternative to the N400 and leads to a completely different view of why the negativity occurs. Unfortunately it is difficult to tell the two effects apart. The CNV has approximately the same scalp distribution as the N400; it can be more prolonged in duration and has an onset latency varying between 260 to 470 ms (Folmer et al., 2011). If the negativity disappears when no explicit judgment task is carried out, that would suggest that the explicit task contributes to the effect and that the reported negativity should be considered a CNV rather than an N400.

Table 1. Overview of previous ERP studies on prosody processing

STUDY	TASK	PARADIGM	CONDITIONS	EFFECT	INTERPRETATION	POSSIBLE PROBLEMS
Focus – Accent						
Hruska et al., 2001 (German)	prosodic	auditory; question-answer pairs	superfluous accent missing accent	none NEG-POS	 N400-P600	time locking (1a) matching (2a, b) boundary (3)
Hruska & Alter, 2004 (German)	prosodic	auditory; question-answer pair	superfluous accent missing accent	POS NEG-POS	CPS N400-P600	matching (2a, b)
Toepel & Alter, 2004 (German)	comprehension prosodic	auditory; dialogues with contrastive/ neutral focus	superfluous missing superfluous missing	NEG-POS POS POS NEG-POS	NEG-CPS CPS CPS NEG-CPS	time-locking (1a) matching (2a)
Magne et al., 2005 (French)	prosodic	auditory; question-answer pairs	medial superfluous final superfluous medial missing final missing	POS NEG POS NEG	P3a+P3b N400/ CNV P3b N400/ CNV	time-locking (1b) matching (2a) boundary (3)
Heim & Alter, 2006 (German)	comprehension	auditory; isolated sentences with *even*	accent superfluous missing[3]	NEG POS POS	EN	
Toepel et al., 2007 (German)	prosodic	auditory; dialogues with contrastive focus	superfluous missing	POS visual NEG-POS	CPS N400-CPS	time-locking (1a, c) matching (2a, b)
Semantics – Prosody Mismatch						
Wang et al., 2009 (Chinese)	comprehension	**reading**; dialogues with semantically in/appropriate focus/non-focus	focus inappropriate vs. appropriate non-focus inappropriate vs. appropriate appropriate non-focus (vs. focus)	NEG none (NEG) NEG	N400 (very reduced N400) larger N400	time-locking (1d) boundary position unclear
Wang et al., 2011 (Dutch)	none reported	auditory; dialogues with prosodic/semantic mismatch	missing superfluous focus accent > no accent non-focus accent = no accent sem. incongruent	none NEG NEG none NEG	 N400 N400 N400	time locking (1d) matching (2b)
Prosodic Boundaries						
Kerkhofs et al., 2007 (Dutch)	none	auditory; dialogues, with prosodic/syntactic mismatch	mismatch prosodic/syntactic break match prosodic/syntactic break	POS POS	CPS (right) CPS	time-locking (1e) matching (2a, b)
Bögels et al., 2009 (Dutch)	comprehension	auditory; prosodic breaks in single sentences	prosodic break	POS	CPS (larger with object verbs)	time-locking (1f) boundary (3)
Li et al., 2010 (Chinese)	comprehension	auditory; dialogues with prosodic/syntactic mismatch	missing prosodic boundary superfluous prosodic boundary prosodic boundary	NEG NEG POS	LAN LAN + N400 P2 (fronto-central)	time-locking (1d) matching (2a) boundary (3)

Note. NEG=negative shift in ERPs; POS=positive shift in ERPs; EN=Expectancy Negativity; LAN=Left Anterior Negativity; CPS=Closure Positive Shift; CNV=Contingent Negative Variation;

(1a) Time locking to sentence onset; (1b) Time locking to focus accent onset; (1c) Time locking to verb onset; (1d) Time locking to target onset; (1e) Time locking to offset of word before boundary; (1f) Time locking to onset of stressed syllable before break; (2a) Targets not matched for frequency; (2b) Targets not matched for lexical stress position; (3) Targets at phrase boundary. "Prosodic task" refers to the judgment of the prosodic wellformedness of stimuli.

A number of *positivities* have also been reported either instead of or in addition to negativities and their interpretation has also varied widely. First, several researchers (Hruska & Alter, 2004; Toepel & Alter, 2004; Toepel et al., 2007) have linked a positive deflection to the CPS positivity found for prosodic boundaries. A number of studies have presented words with focus accent at potential phrase boundaries, further complicating the issue. Discourse context, syntactic ambiguity and prosody have been shown to interact (see third part of Table 1). The syntactic ambiguity present in these studies combined with discourse context may have contributed to the results.

Regardless of phrasal ambiguity, the response to the pitch accent may have interacted with the presence of a prosodic boundary. Magne et al. (2005) found that a medial prosodic mismatch is not the same as that at the end of the sentence: of the most extreme of phrasal boundaries, so to speak. These results do not actually support the CPS claim. In the Magne et al. study prosodic incongruity in the final position was confounded with the availability of information earlier in the sentence indicating that the prosody was incorrect, however. It is thus important to carry out an experiment in which the accent does not occur at a prosodic boundary or at a point where prosodic information can resolve an ambiguity. If the positivity elicited by prosodic mismatch persists, then prosodic mismatch elicits a positivity which cannot be interpreted as due to the phrasal boundary per se.

The CPS interpretation is not the only one available. First, another possibility is that the positivity is a form of the P600, a response found when language processing becomes effortful or reanalysis or repair is necessary (Osterhout & Holcomb, 1992). Second, the

positivity seen in a number of studies may actually be related to the P300 component, as suggested by Magne et al. (2005). The P3 is a broadly distributed positive deflection in the waveform which is seen in response to novel or unexpected stimuli primarily when participants are instructed to pay attention to the stimuli. The P3 has been divided into two parts: the P3a which is thought to be evoked by the identification of task related novel events and the P3b which is generally linked to task-related decision processes (Picton, 1992; Donchin & Coles, 1988). Examining the results when no secondary task is included may shed light on the extent to which novelty and decision related processes elicit the positivity reported in these studies.

Biphasic responses have also been reported, a negativity followed by a positivity. These have been generally interpreted as an N400 followed by either a CPS or a P600. These biphasic responses have the same issues with regard to interpretation as discussed above for the negativities and positivities taken alone. The CNV is often followed by a *positive* component called the CNV-Resolution (CNV-R), which is claimed to reflect executive functions that re-establish a cognitive equilibrium such as set-shifting or resetting motor programs (Jackson et al., 1999). Thus, the negativity may reflect expectation violation, and the positivity the resolution of the decision process. In all, it is difficult to establish whether the findings of previous studies reflect the natural processing of prosody in context.

We have already mentioned that we feel that task may play a role in the variety of responses which have been reported in the literature. The task-related nature of the CNV and P300 emphasize this possibility. In fact, there is existing evidence that changing the metalinguistic task modifies the neural response to linguistic prosody. Toepel and Alter (2004) showed that 'neutral accents in a contrastive context' (where some type of focus accent could be expected) did not affect processing relative to appropriate accents when participants performed a comprehension task, but led to a significant biphasic (negative-positive) ERP pattern when listeners performed a prosodic judgment task. For 'contrastive

accents in a neutral context,' a negativity was seen for the comprehension task as opposed to a positivity for the prosodic judgment task. This pattern of no effect for a superfluous accent accompanied by a clear effect for a missing accent has been reported a number of times in the literature in studies using a prosodic judgment task; a goal of the current experiment is to see whether less is indeed more when no explicit judgment task is employed.

2.1.1 The present study

To further investigate 1) whether task affects processing of focus accent and 2) whether task effects can explain the asymmetry between missing and superfluous accents seen in the literature, we applied a strictly controlled naturalistic paradigm in the present study. The phenomenon under study is the interaction of prosody and the information structure provided by the linguistic context in short dialogues in Dutch (for materials, see Table 2). In one context, the direct object included a contrast set and the focus information expected in the answer was the resolution of this choice. In the second version, the direct object was background, with the contrast set and focus on the prepositional object. The intonation pattern of the answer was either congruent or incongruent with the context.

To avoid task-related effects arising due to a prosodic task, participants performed a delayed semantic relatedness judgment in a limited number of trials (25 %). Special care was taken to control for the following factors known to affect ERP responses: sentences were matched for length (in words), syntactic structure, plausibility, word frequency and targets' expectation likelihood. Special attention was paid to semantic plausibility and expectation (see Section *Semantics* of Table 1), because it has been shown that semantic plausibility interacts with focus accent (Wang et al., 2011).

Table 2: Experimental materials

Questions introduced a contrastive focus on the direct object (Question 1) or on the prepositional object (Question 2). Answers had a congruous accentuation (1a, 2a) or incongruous accentuation (1b, 2b). Incongruous answers always included a *missing* accent (1b: 'bonus') and a *superfluous* accent (1b: 'PLAYER'). Accented elements are displayed in capitals, focus elements in bold; original Dutch stimuli are displayed in italics. The linear order of the contrastive elements in the question (e.g., 'bonus' and 'fine') was counterbalanced across trials.

FOCUS	**ACCENT** **Direct object**	**Prepositional object**
Direct object	1a (congruous)	1b (incongruous)
Did the club give a bonus or a fine to the player?	They gave a **BONUS** to the player.	They gave a **bonus** to the PLAYER.
Heeft de club een premie of een boete aan de speler gegeven?	*Ze hebben een **PREMIE** aan de speler gegeven.*	*Ze hebben een **premie** aan de SPELER gegeven.*
Prepositional object		
Question 2	2b (incongruous)	2a (congruous)
Did the club give a bonus to the player or to the trainer?	They gave a BONUS to the **player**.	They gave a bonus to the **PLAYER**.
Heeft de club een premie aan de speler of aan de trainer gegeven?	*Ze hebben een PREMIE aan de **speler** gegeven.*	*Ze hebben een premie aan de **SPELER** gegeven.*

All targets had lexically stressed initial syllables with long vowels, which reduced variance in word and accent identification points and allowed us to measure accent processing exclusively without any stress variation (Ladd et al., 2000). ERPs were time-locked to the acoustic onset of each target word rather than to the sentence onset, which could jitter and mask short-lasting effects. Since congruous and incongruous sentences were identical (see Table 2), the baseline was not an issue. Most importantly and in contrast to previous studies, special care was taken to place targets away from phrase boundaries and to make sure that no prosodic breaks (i.e., no intermediate or intonational phrases) were present at or close to the onset and offset of targets, as this may elicit a Closure Positive Shift (cf. Steinhauer & Friederici, 2001). By having taken these measures, our study provides a relatively uncluttered view on the neural substrate underlying prosody processing in context.

To conclude, we hypothesize that missing accents are not more noticeable than superfluous accents in normal processing. On the basis of the function of focus accent (drawing attention to important information) we expect the contents to be attended and the presence of background information to be noted. Missing accents may be responded to in the same way, but if more attention is going to be paid to one sort of violation, we expect it to be to the superfluous accents.

2.2 Methods

2.2.1 Participants

Twenty-nine right-handed Dutch native speakers (13 male, age 18-29, mean 21) with normal or corrected-to-normal vision and without any reported neurological, psychiatric, hearing or language impairments were paid for participation after signing an informed written consent in accordance with the Declaration of Helsinki. Additional six participants (2 male) were not included due to data loss of more than 40 % for any electrode in any condition. On average, the analysis was performed on 85 % valid data over all conditions.

2.2.2 Stimuli

Stimulus construction started with 120 dialogue items (a question followed by an answer) in Dutch, the language used in this study, as illustrated in Table 2. Each question contained a contrastive set with a target noun (selected in the answer; *bonus*) and a non-target noun (not selected in the answer; *fine*). To avoid variability in word identification points, both words had a syllable-initial lexical stress and equivalent average lemma frequencies (taken from the CELEX corpus (Baayen et al., 1993)). The context with a backgrounded noun contained only the noun used in the answer in direct object position; two options occurred in the following

focused preposition instead (e.g., "… to the player or to the trainer …"). Two further versions of each question were created, in which the linear order of the two contrasted items (e.g., "… bonus or fine …") was reversed (e.g., "… fine or bonus …"); these versions were counterbalanced to avoid effects of linear presentation. Questions were followed by answers that were either prosodically congruous with accent on one of the contrasted elements (answers (a) in Table 2) or prosodically incongruous with accent on a backgrounded element from the question (answers (b) in Table 2). None of the answers contained semantically inappropriate information. Of interest in these answers were the direct object (i.e., *bonus*) and the prepositional object (i.e., *player*).

The plausibility of all target words was tested in an offline study 1 ('target fit study') with 96 non-Linguistics students who did not participate in the ERP experiment. Participants rated how appropriate each target (*bonus*) and non-target (*fine*) was to serve as an answer to the question (on a scale of 1 = very poor fit, to 7 = very good fit). Targets' selection preference was measured by asking participants to indicate which word of the pair (*bonus* or *fine*) they would select as the best answer to the question. Based on the results (Table 3), the 120 dialogue items were assigned to four item-groups with thirty dialogues each. These target-related factors did not differ significantly between conditions or across lists (all p's>.24).

To investigate prosody processing in *naturally* elicited speech, experimental stimuli were recorded as dialogues between two phonetically naive speakers: a male speaker producing the questions and a female speaker producing the answers. No instructions regarding pronunciation were given. The speakers recorded clearly accented dialogues as a unit in a natural speech rate (6.4 syllables/second) without any excessive emphasis.

Table 3: Stimulus characteristics

Characteristics of the four experimental item groups (group 1-4) based on the results of an offline study 1 (*question-target fit study*, n=96, see Methods). Item group refers to group of items that all occur in the same condition across lists. Frequency (*freq*) indicates lemma frequency in the CELEX lexical database (in number of occurrences per million). Plausibility (*plaus*) is measured on a scale from 1 to 7 (1=very bad fit, 7=very good fit). Selection preference (*select*) refers to the proportion of participants who selected the target from the contrastive set as an answer to the question. Average number of words per sentence is given under *words*.

Item group	**direct object**			**prepositional object**			**sentence**
	freq	*plaus*	*select*	*freq*	*plaus*	*select*	*words*
group 1	1.1	5.1	0.45	1.2	5.2	0.49	7.9
group 2	1.1	5.3	0.48	1.2	5.1	0.44	7.9
group 3	1.0	5.1	0.42	1.1	5.1	0.44	8.2
group 4	1.1	5.3	0.45	1.3	5.3	0.48	8.0

None of the stimuli contained any disfluencies or phrase boundaries; in fact, all utterances were produced as a single intonation phrase with a single phonological phrase (Gussenhoven, 2005). To prevent unintended intonational differences between conditions, only congruous dialogues were recorded; incongruous dialogues were generated by duplicating and re-combining questions and answers from congruous conditions.

A total of 960 dialogues (120 dialogues x 2 linear orders x 2 question types x 2 answer types) were assigned to 8 lists. Each participant was presented with one list of 120 dialogues (30 items x 4 conditions) using the Latin square format. None of the participants listened to more than one version of each sentence, and every participant listened to the experimental stimuli in a pseudo-randomized order excluding more than two consecutive presentations of the same condition.

In each list, half of the dialogues had focus on the direct object (n=60) and the other half had focus on the prepositional object (n=60). In each focus condition, half of the answers were prosodically congruous (focus word was accented, n=30), while the other half was prosodically incongruous (focus word was unaccented, n=30). ERP processing differences cannot be attributed to differences in the acoustic characteristics of the stimuli, since we used

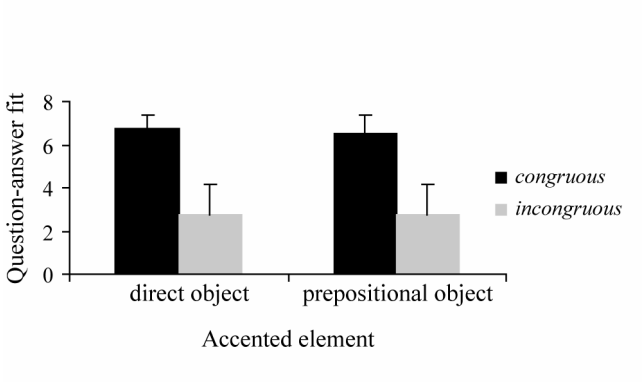
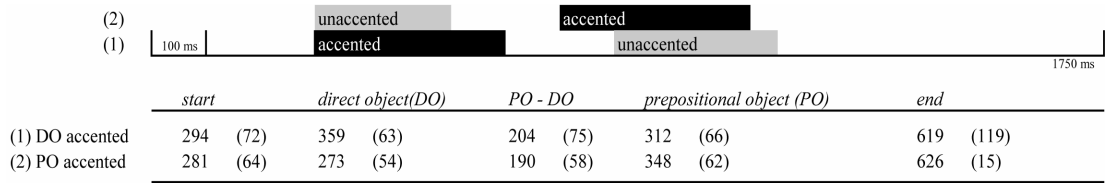


Figure 1: Results of offline study 2 (question-answer fit study)
Offline study 2 tested whether listeners are able to differentiate between congruous and incongruous conditions in recorded dialogues. Participants indicated the overall match of question and answer on a scale from 1 (= very poor fit) to 7 (= very good fit) without any explicit instruction to attend to prosody.

physically identical sentences for the congruous and incongruous conditions (1a=2b, 1b=2a). All stimuli were normalized in loudness and analyzed acoustically.

An additional offline study 2 ('question-answer fit study') was created with a subset of the stimuli to test whether mismatch conditions can be discriminated correctly. Seventeen Linguistics students that did not participate in the ERP study or offline study 1 listened to dialogues taken from all conditions and indicated whether the question and the answer of a dialogue matched (scale of 1 = very poor fit, to 7 = very good fit). No instruction was given with respect to prosodic wellformedness. A Repeated Measures ANOVA with *Accented Element* (direct object vs. prepositional object) and *Correctness* (correct vs. incorrect) as within-participants factors showed a highly significant main effect of *Correctness* ($F(1,16)=245.6$; $p<.001$), indicating that listeners were able to discriminate between congruous and incongruous prosody. No other effects were significant (all *p*'s >.18). See Figure 1 for average scores.



	start		*direct object(DO)*		*PO - DO*		*prepositional object (PO)*		*end*	
(1) DO accented	294	(72)	359	(63)	204	(75)	312	(66)	619	(119)
(2) PO accented	281	(64)	273	(54)	190	(58)	348	(62)	626	(15)

Figure 2a: Acoustic duration of target sentences.

The figure presents the average acoustic duration of segments in sentences with accented direct objects (1) and accented prepositional objects (2) (in ms, standard deviation in brackets) and shows the duration of accented (black bars) vs. unaccented elements (grey bars). Abbreviations: *start*=interval from sentence onset until direct object onset; *DO*=duration of direct object; *PO-DO*=interval from direct object offset until prepositional object onset; *PO*=duration of prepositional object; *end*=interval from prepositional object offset until sentence offset.

2.2.3 Acoustic analysis

Acoustic measures were performed using the software package *Praat* (Boersma & Weenink, 2010) and are displayed in Figure 2a and 2b. Accented direct and prepositional objects had a longer acoustic duration and a higher fundamental frequency (f0) relative to unaccented ones. Segmental lengthening under accentuation was larger for direct objects (86 ms) than for prepositional objects (36 ms). Accentuation also affected pitch excursion (difference between f0 max and f0 min), which was higher for accented elements (80 Hz) than for unaccented elements (28 Hz) (Figure 2b).

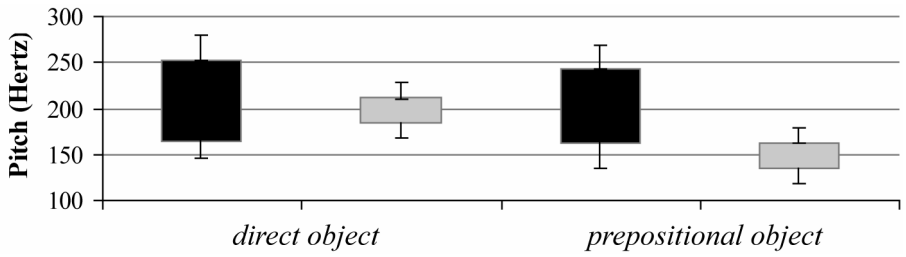


Figure 2b: Fundamental frequency and pitch excursion of target stimuli.

The figure displays targets' absolute fundamental frequency values (f0, in Hz) and pitch excursion (difference between maximal and minimal f0) for accented (black) and unaccented (grey) direct and prepositional objects.

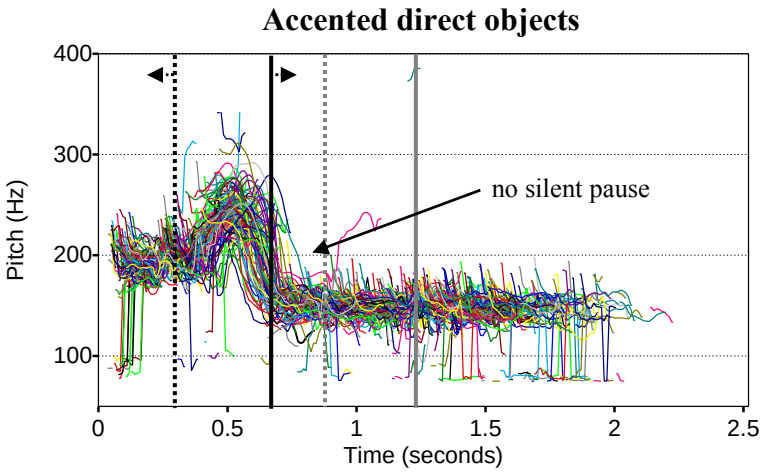


Figure 3a: Plot of all pitch contours of accented direct objects.
Black vertical lines indicate the onset (dotted line) and offset (solid line) of direct objects, and grey lines display the onset (dotted line) and offset (solid line) of prepositional objects. The small dotted horizontal lines on the top close to the 400 Hz line display the standard deviation of onset and offset times for direct objects.

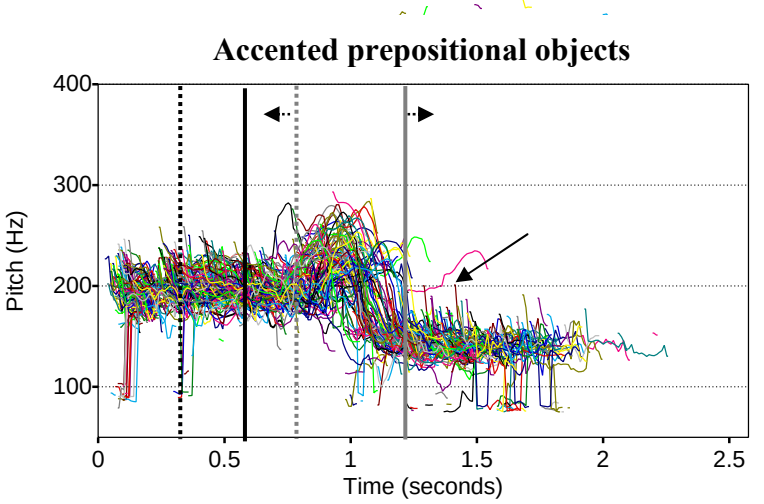


Figure 3b: Plot of all pitch contours of accented prepositional objects.
Grey vertical lines indicate the onset (dotted line) and offset (solid line) of prepositional objects, and black lines display the onset (dotted line) and offset (solid line) of direct objects. The small dotted horizontal lines on the top close to the 400 Hz line display the standard deviation of onset and offset times for prepositional objects.

We transcribed the f0 of experimental stimuli according to the Transcription of Dutch Intonation convention (ToDI; Gussenhoven, 2005) and plotted them together in Figure 3a and

Figure 3b. Focus accents on direct objects (Figure 3a) and prepositional objects (Figure 3b) showed the typical falling pitch contour for Dutch focus accents. In the ToDI convention, the contour is transcribed as an H*L accent where the letters indicate the direction of pitch movement in the accented syllable, here falling from H (high) to L (low) pitch, whereas the star denotes the pitch of the tone target in the accented syllable, here H (high). As displayed in Figure 3a and Figure 3b, the signal did not contain any disruptions of the f0 in the vicinity of targets such as silent pauses or phrase tones that would indicate a phrase boundary.

2.2.4 EEG procedure and recordings

After electrode application, participants were seated in front of a computer screen in an electrically shielded room and completed a trial session prior to the actual experiment. Stimuli were presented auditorily via loudspeakers and divided in two blocks of 60 dialogues (approximate block duration was 12 minutes). In order to minimize eye movement artifacts, participants fixated a black cross against a grey background, which appeared 100 ms prior to stimulus presentation and remained there until the end of the dialogue. In each trial, a question was presented (average duration 2000 ms), followed by silence (500 ms), an answer (average duration 2000 ms), and silence again (1200 ms). To encourage attentive processing, participants performed a comprehension task on 25 % of all trials and indicated whether a probe word that was presented on the screen was semantically related to the preceding dialogue. Correct and incorrect responses were counterbalanced. After the response (or after the last silence period in trials without the judgment task), four stars appeared on the screen (duration 2000 ms) to indicate that participants had the opportunity to blink.

The EEG was recorded at 250 Hz using a 64-channel-cap with Ag/AgCl electrodes, placed according to the international extended 10-20 system (Electro Cap International). All channels were amplified against the average of all connected inputs of the amplifier (TMS international). The amplifier measured DC without a highpass filter but with a digital FIR

filter (cutoff frequency of 67.5 Hz) to avoid aliasing effects. After recording, electrodes were re-referenced to the algebraic average of left and right mastoid electrodes. Vertical eye movements and blinks were monitored via electrodes below and above the left eye, and horizontal movements from electrodes at the left and right canthus of each eye. Impedances were kept below 5Ω. All data were filtered offline with a band-pass filter of 0.01-30 Hz.

2.2.5 EEG analysis

We rejected trials containing movement artifacts, ocular artifacts or electrode drifts (determined by a ± 75 μV voltage maximum). Only participants with at least 60 percent valid data per electrode for any condition entered the analysis (n=29) and six other participants were excluded. On average, EEG analysis was performed on 85 % data per condition (SD = 24 %). Number of rejected trials did not differ between conditions. ERPs were time-locked to the acoustic onset of each target word that was identical to the onset of its accented syllable.

After a visual inspection of grand averages, we identified ERP differences in three time windows post target onset: Early time interval: 100-220 ms, N400 time interval: 300-500 ms, and Late P600 time interval: 700-1000 ms. Average ERPs for a number of Regions of Interest (ROIs) were computed as the average over several electrodes. Lateral ROIs included: *left anterior* (FP1, AF3, AF7, F3, F5, F7), *right anterior* (FP2, AF4, AF8, F4, F6, F8), *left central* (FC3, FC5, C3, C5, CP3, CP5), *right central* (FC4, FC6, C4, C6, CP4, CP6), *left posterior* (P3, P5, P7, PO3, PO7, O1), and *right posterior* (P4, P6, P8, PO4, PO8, O2). Midline ROIs included: *anterior* (FPz, AFz, Fz), *central* (FCz, Cz, CPz), and *posterior* (Pz, POz, Pz). We conducted repeated measure ANOVAs separately for lateral and midline ROIs.

ANOVAs for lateral electrodes were calculated with four within-subject factors: *Accent* (accented vs. unaccented element), *Congruity* (contextually congruous prosody vs. contextually incongruous prosody), *Anteriority* (anterior vs. central vs. posterior regions), and *Hemisphere* (left hemisphere vs. right hemisphere). ANOVAs for midline ROIs included all

factors except *Hemisphere*. ANOVAs were performed on mean voltage values and adjusted with the Huynh-Feldt correction for nonsphericity where appropriate. For direct objects, a 200 ms pre-stimulus baseline correction was calculated for segments with a duration of 1300 ms. For prepositional objects, a 100 ms within-stimulus baseline was chosen since processing differences were expected to have had arisen after the perception of mismatches on direct objects (for similar reasoning and procedure, see, e.g., Philips et al., 2005; Mueller, 2009).

2.3 Results

2.3.1 Behavioral results

Participants judged the semantic relatedness of a probe word to the preceding dialogue in 25 % of all trials. Participants were attentive and comprehended dialogues successfully (average accuracy of 87 % correct). Task performance was not affected by prosodic congruity.

Table 4: Statistical results for direct objects.

Note. ACC = Accent, CONG = Congruity, ANT = Anteriority, HEM = Hemisphere. Table 4 displays only effects and interactions that were significant in at least one time window. F values with $p \geq .1$ are not included, and all marginal effects with $.05<p \leq .1$ are displayed in italics for future reference.

Direct object			**100-220 ms**		**300-500 ms**		**700-1000 ms**	
		df	F	p	F	p	F	p
Lateral	ACC	1,28			6.207	.019		
	ACC x CONG	1,28			3.388	*.076*		
	CONG x ANT	2,56			3.513	*.058*	9.292	.002
	ACC x HEM	1,28	3.832	*.06*			3.569	*.069*
	CONG x HEM	1,28			7.466	.011		
	ACC x CONG x HEM	1,28	3.256	*.082*	4.416	.045		
	ACC x CONG x ANT x HEM	2,56	3.223	.048				
Midline	ACC	1,28			9.726	.004	3.677	*.065*
	CONG x ANT	2,56					3.378	.043

2.3.2 ERP results: Direct object

ERP analyses concentrate on the direct object, while data for prepositional objects are regarded as exploratory: half of the time, prepositional objects were preceded by a direct object in a mismatch condition, which will have contaminated their processing (cf. Figure 2a for the average position of both elements in the sentence). Effects involving scalp distribution will be reported only if modified by the cognitive factors.

Statistical results are presented in Table 4, and ERP waveforms for all conditions are displayed in Figure 4. Marginally significant effects and interactions will be reported for future reference in footnotes but will not be followed up or interpreted.

2.3.2.1 Early time window 100-220 ms

A four-way interaction of *Accent* x *Congruity* x *Anteriority* x *Hemisphere* ($F(2,56)=3.223$, $p<.05$) was found. Follow-up analyses with *Anteriority* as the split variable revealed an *Accent* x *Congruity* x *Hemisphere* interaction that was significant on posterior ($F(1,28)=6.935$, $p<.05$), marginal on central ($F(1,28)=3.817$, $p=.06$) and not significant on anterior regions ($F(1,28)=.075$, $p=.79$). Following up on the posterior interactions with *Accent* as a split variable, the interaction *Congruity* x *Hemisphere* was not significant for accented direct objects ($F(1,28)=2.54$, $p=.12$) or for unaccented direct objects ($F(1,28)=2.659$, $p=.11$).[1] When looking at the *Congruity* effect on posterior regions separately for accented and unaccented direct objects, we found that it is marginal for accented direct objects only ($F(1,28)=3.492$, $p=.07$), due to a positivity for incongruously accented elements; no *Congruity* effect was found for incongruously unaccented direct objects ($F(1,28)=.725$, $p=.4$).

[1] The mean voltage data show that the *Congruity* x *Hemisphere* interaction is triggered by left-sided posterior positivities for incongruously accented direct objects relative to congruously accented ones, probably coupled with a greater positivity for incongruously relative to congruously unaccented elements on the right.

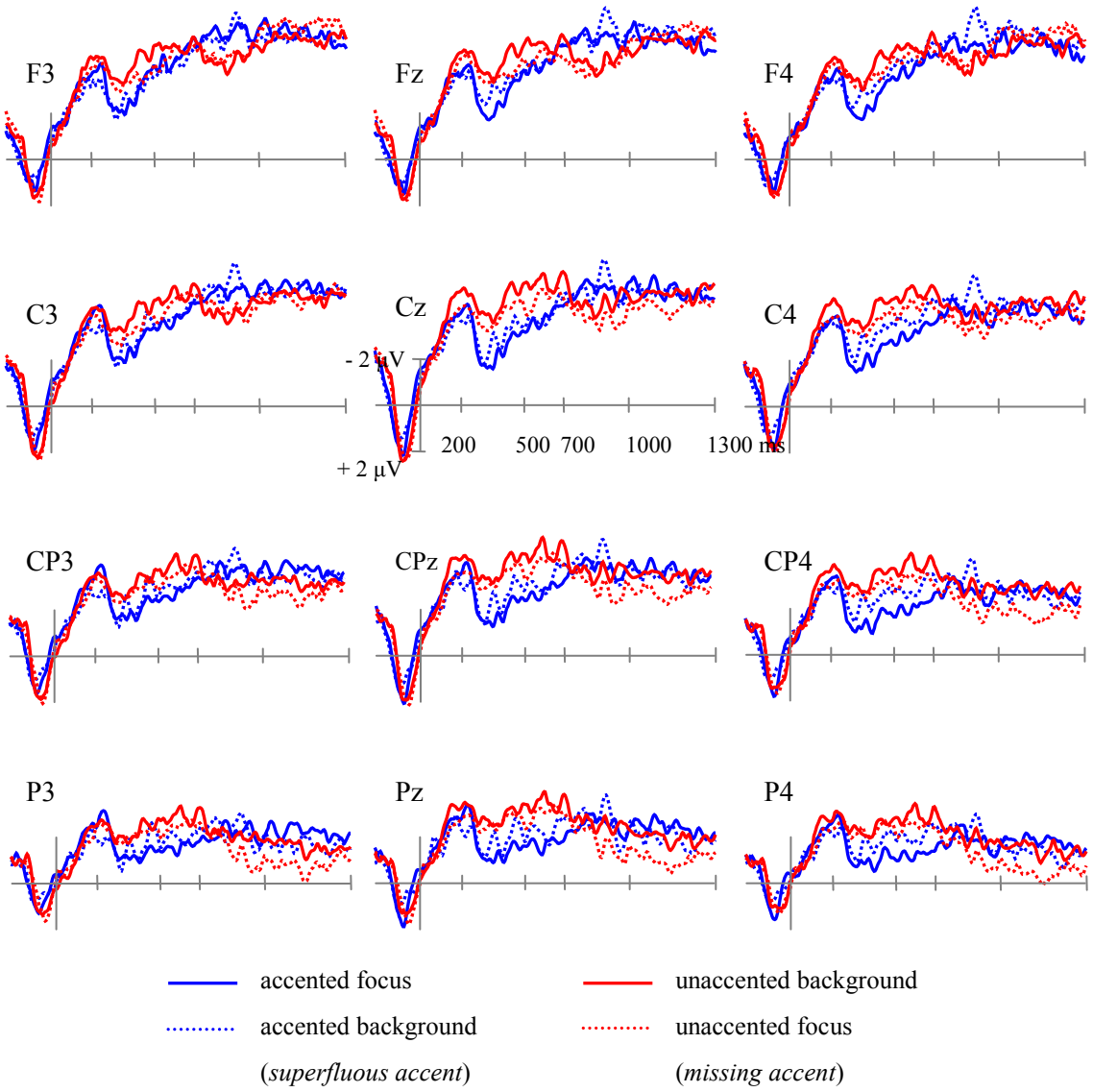


Figure 4: ERP waveforms for direct objects.
ERPs are time-locked to the onset of the direct object with a pre-stimulus baseline of -200 to 0 ms and show waveforms to accented (blue) and unaccented (red) direct objects. Solid lines represent congruous accentuation, and dotted lines represent incongruous accentuation.

2.3.2.2 N400 time window 300-500 ms

There was a main effect of *Accent* ($F(1,28)=6.207$, $p<.05$) showing that accented direct objects elicited positive waveforms relative to unaccented direct objects. There was a three-way interaction of *Accent* x *Congruity* x *Hemisphere* ($F(1,28)=4.416$, $p<.05$) showing a

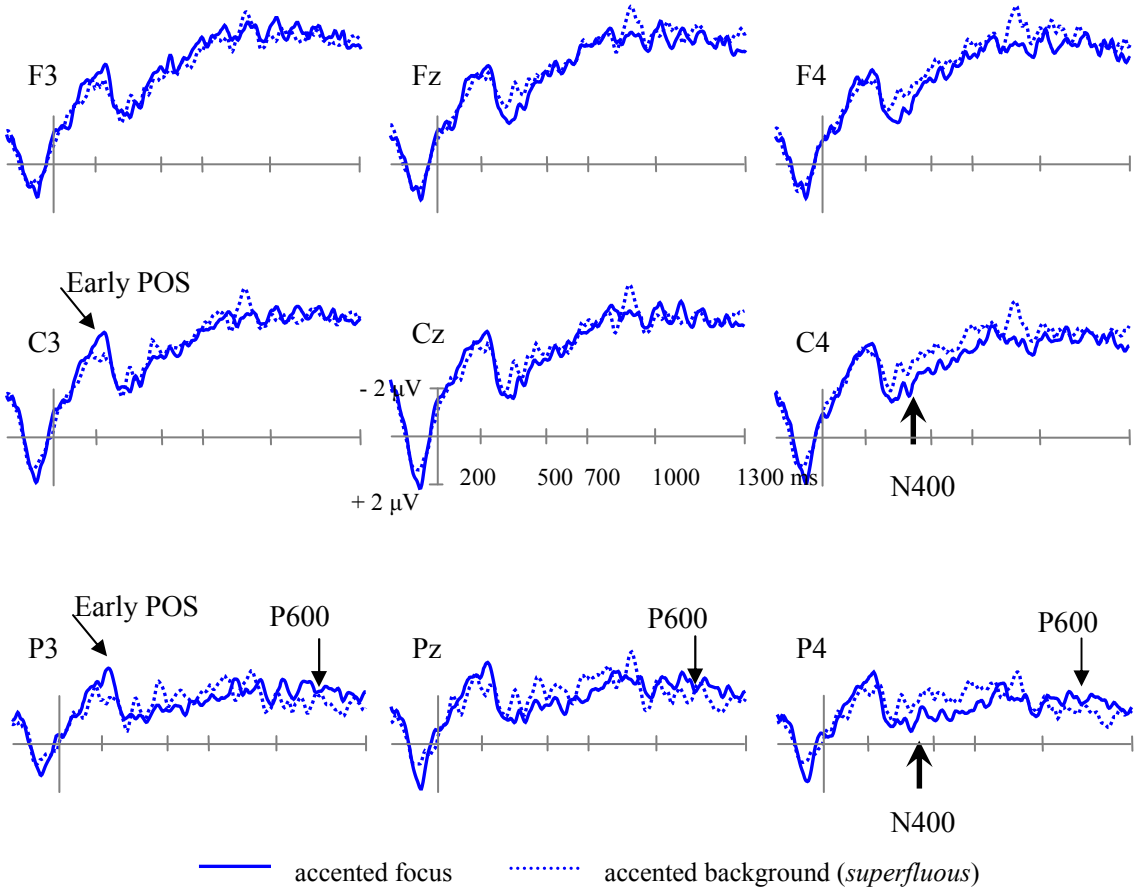


Figure 5: ERP waveforms for accented direct objects: superfluous vs. congruous accents. Incongruously accented elements (i.e., superfluous accents, dotted line) elicited early left-lateralized positive effects on central sites (100-220 ms) and right-lateralized centro-posterior negative deflections (N400, 300-700 ms) as compared to congruously accented elements (solid line). Between 700 and 1000 ms, incongruously accented elements triggered late posterior positivities (P600).

significant *Congruity* x *Hemisphere* interaction for accented elements ($F(1,28)=11.807$, $p<.01$), but not for unaccented elements ($F(1,28)=.319$, $p=.58$). Post-hoc tests on accented direct objects revealed a significant *Congruity* effect over right sites ($F(1,28)=4.8$, $p<.05$), but not over left sites ($F(1,28)=.190$, $p=.67$). The mean voltage values show a right-lateralized negativity for incongruously accented elements (i.e., superfluous accents on background elements) as compared to congruously accented ones (i.e., focus accents) (Figure 5). No such negative effect was elicited by incongruously unaccented elements (i.e., missing accents on focus elements, cf. Figure 6). For midline electrodes, there was a main effect of *Accent*

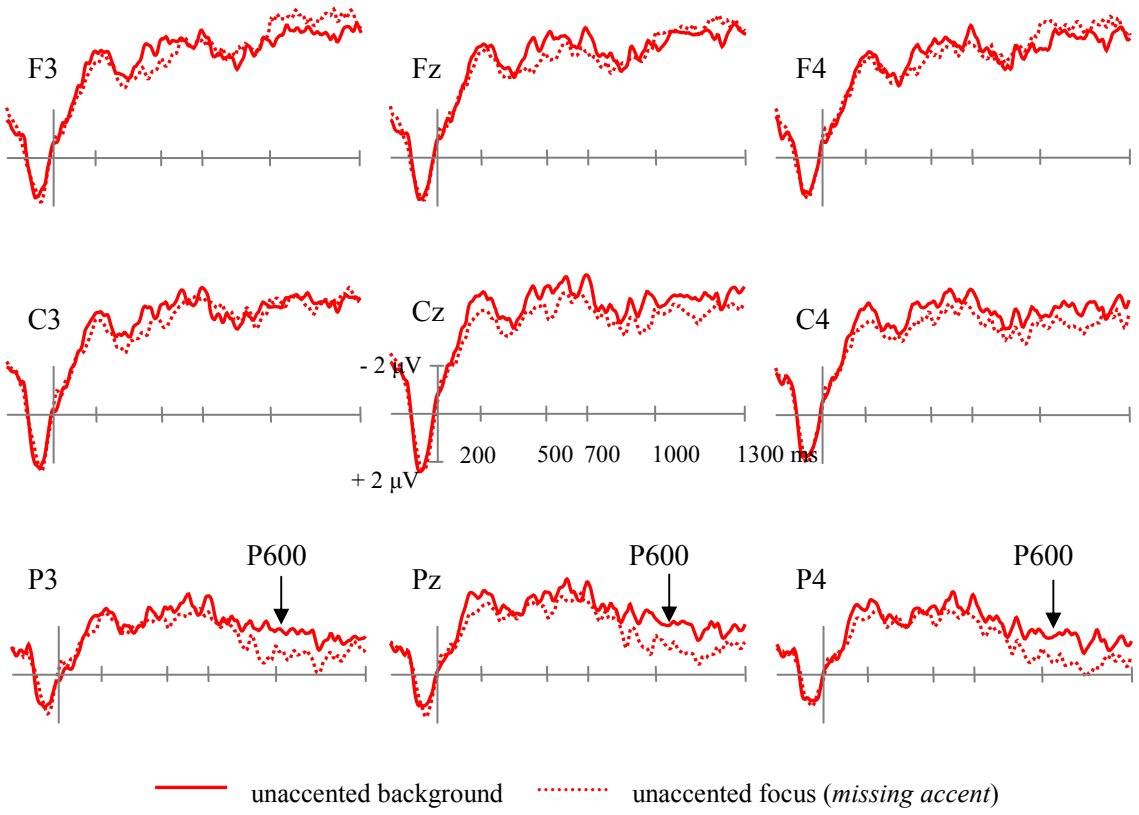


Figure 6: ERP waveforms for unaccented direct objects: missing vs. congruous accents. Incongruously unaccented elements (dotted line) elicited late posterior positive effects with a latency of 700 1000 ms post-stimulus onset as compared to congruously unaccented elements (solid line). No other early effects were significant.

(F(1,28)=9.726, p<.01), indicating that ERPs to accented direct objects were more positive than ERPs to unaccented ones. No other main effects or interactions were significant.

2.3.2.3 Late P600 time window 700-1000 ms

For lateral electrodes, we found a *Congruity* x *Anteriority* interaction (F(2,56)=9.292, p<.01). Follow-ups suggested that this was due to a marginal effect of *Congruity* (incongruous more positive than congruous) on posterior regions (F(1,28)=3.842, p=.06)[2] and the absence of

[2] In addition, the *Accent* x *Hemisphere* interaction was marginally significant (F(1,28)=3.569, p=.07), reflecting a trend for unaccented elements to be more positive than accented elements, but only on left-sided electrodes.

such an effect on anterior and central sites (all *p*-values >.1). On midline electrodes, there was also a significant interaction of *Congruity* x *Anteriority* (F(2,56)=3.378, p<.05); together these suggest that irrespective of accentuation, incongruous direct objects were more positive than congruous direct objects, but only at posterior sites. No other effects were significant.

2.3.3 ERP results: Prepositional object

As mentioned above, the analysis of prepositional objects has an exploratory character since the ERPs to the prepositional object will be affected by the processing of the preceding violation on the direct object (see Figure 2a). Statistical results are presented in Table 5, and ERP waveforms for all four conditions are displayed in Figure 7.

Table 5: Statistical results for prepositional objects.

Note. ACC = Accent, CONG = Congruity, ANT = Anteriority, HEM = Hemisphere. Only effects and interactions that were significant in at least one time window are presented. F values with p ≥ .1 are not included, and all marginal effects with .05<p≤.1 are displayed in italics for future reference.

Preposition object			**100-220 ms**		**300-500 ms**		**700-1000 ms**	
		df	F	p	F	p	F	p
Lateral	ACC	1,28	4.027	*.055*	9.732	.004	4.391	.045
	ACC x ANT	2,56			7.281	.007	19.591	.000
	CONG x ANT	2,56	4.158	.04	9.942	.002	6.014	.013
	CONG x HEM	1,28	5.420	.027			3.801	*.061*
	ACC x ANT x HEM	2,56			7.195	.002		
	ACC x CONG x ANT x HEM	2,56	3.315	*.059*	3.361	.049		
Midline	ACC	1,28	6.314	.018	14.924	.001	6.714	.015
	ACC x ANT	2,56			5.214	.017	13.308	.001
	CONG x ANT	2,56			6.789	.009	4.727	.021

2.3.3.1 Early time window 100-220 ms

On lateral electrodes, there was a *Congruity* x *Hemisphere* interaction (F(1,28)=5.420, p<.05), presumably due to an effect of congruity occurring only at right hemisphere sites. In addition, we found a significant *Congruity* x *Anteriority* interaction (F(2,56)=4.158, p<.05)

most probably due to prosodically incongruous elements giving rise to a negativity on anterior sites and to a positivity on posterior sites. On midline electrodes, we found a main effect of *Accent* ($F(1,28)=6.314$, $p<.05$), showing that accented prepositional objects elicited more positivities relative to unaccented ones. No other effects reached significance.[3]

2.3.3.2 N400 time window 300-500 ms

The ERPs for prepositional objects did not show the negativity that we found in this time window for incongruously accented direct objects. Rather, we found a positivity for accented prepositional objects (main effect of *Accent*, $F(1,28)=13.255$, $p=.001$), as well as large positive-going waves starting around 300 ms that were elicited for both accented and unaccented incongruous elements (*Accent* x *Congruity* x *Anteriority* x *Hemisphere* ($F(2,56)=3.361$, $p<.05$)). Follow-up analyses suggested that this interaction resulted from centro-posterior positivities associated with incongruity, for both accented and unaccented words, with the effects for accented words larger in the right hemisphere. The positivities were accompanied by anterior negativities that were larger for unaccented words, most clearly so at left frontal sites. For midline electrodes, accented prepositional objects were more positive than unaccented ones (main effect of *Accent,* $F(1,28)=14.924$, $p=.001$). In addition, both accented (*Accent* x *Anteriority* ($F(2,56)=5.214$, $p<.05$)) and incongruous prepositional objects (*Congruity* x *Anteriority* ($F(2,56)=6.789$, $p<.01$)) triggered positive centro-posterior effects.

[3] We found a number of marginally significant effects, including a main effect of *Accent* ($F(1,28)=4.027$, $p=.055$) due to positivities for accented prepositional objects, and a marginal interaction of *Accent* x *Congruity* x *Anteriority* x *Hemisphere* ($F(2,56)=3.315$, $p=.059$), most probably due to missing accents giving rise to a positivity on right anterior and central sites, and to a negativity on right posterior sites.

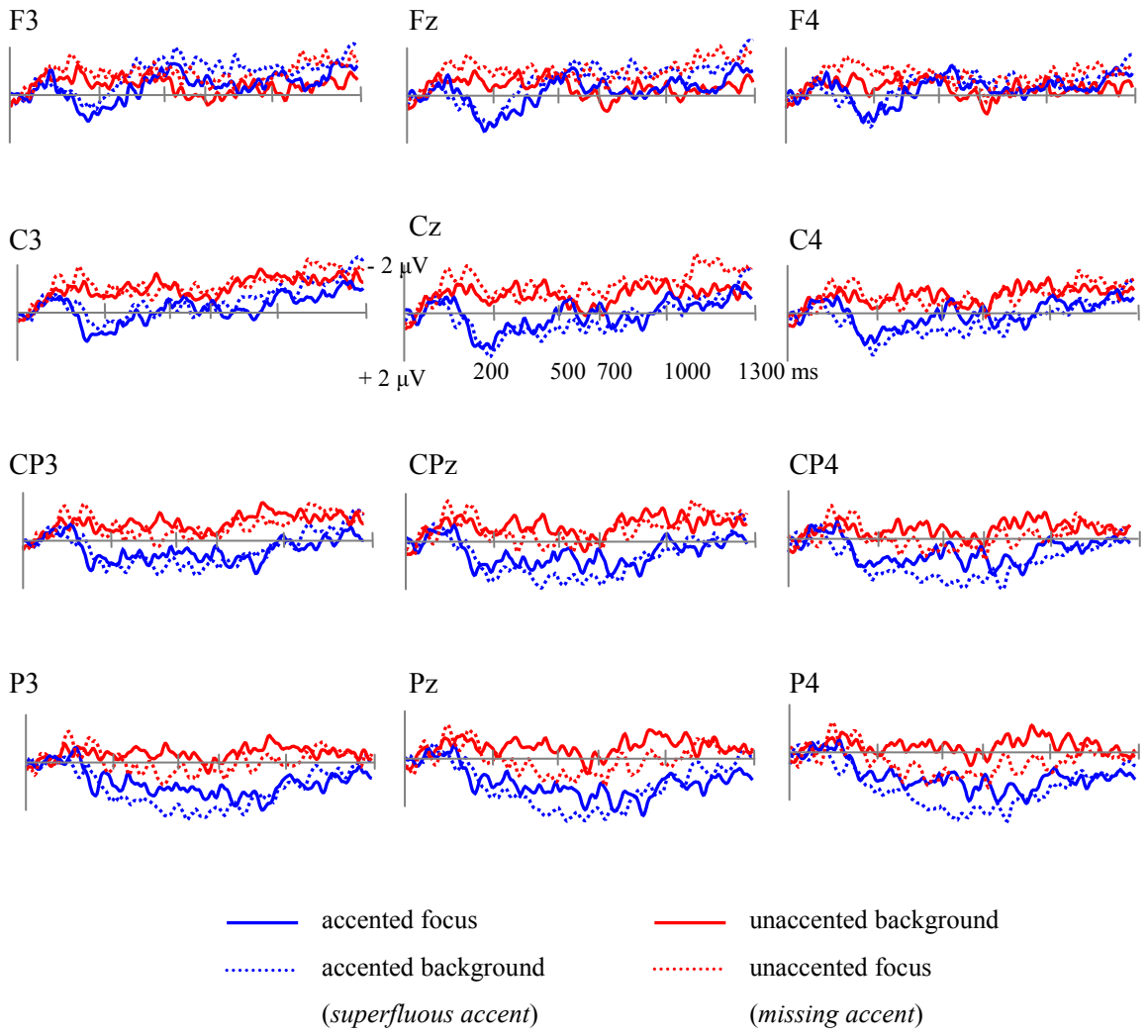


Figure 7: ERP waveforms for prepositional objects.
ERP waveforms are time locked to the onset of the prepositional object with a within-stimulus baseline of 0 to 100 ms post-stimulus onset. The figure displays accented (blue) and unaccented (red) prepositional objects. Solid lines indicate congruous accentuation, and dotted lines indicate incongruous accentuation.

2.3.3.3 Late P600 time window 700-1000 ms

Accented prepositional objects were more positive than unaccented ones due to a main effect of *Accent* ($F(1,28)=4.391$, $p<.05$). The positivity for accented elements had a centro-posterior distribution (*Accent* x *Anteriority* interaction ($F(2,56)=19.591$, $p<.001$; *Accent* effect on central sites ($F(1,28)=4.237$, $p<.05$) and posterior sites ($F(1,28)=35.282$, $p<.001$)). Incongruous prepositional objects elicited posterior positivities relative to congruous ones

(*Congruity* x *Anteriority* (F(2,56)=6,014, p<.05)) that was due to a *Congruity* effect only on posterior sites (F(1,28)=5.091, p<.05)). On midline electrodes, accented prepositional objects were more positive than unaccented ones due to a main effect of *Accent* (F(1,28)=6.714, p<.05). The positivity had a centro-posterior distribution as revealed by an *Accent* x *Anteriority* interaction (F(2,56)=13.308, p=.001) with an *Accent* effect for central (F(1,28)=7.081, p<.05) and posterior regions (F(1,28)=30.403, p<.001)).

2.3.4 Summary of results

Accent (present vs. absent) and *Congruity* (match vs. mismatch) interacted with each other at the direct object in both the early and the N400 time windows, but not in the later time window. In the early time window (100-220 ms), *Congruity* had an effect primarily on accented words: direct objects with incongruous prosody elicited early positivities on left posterior sites, relative to direct objects with congruous accentuation. In the N400 time window (300-500 ms), incongruent accents elicited a right-lateralized centro-posterior negativity. No such effect was obtained for incongruously unaccented words. In the P600 time window (700-1000 ms), there was no interaction: Both missing and superfluous accents were more positive than congruous ones. The exploratory analyses for the prepositional objects showed posterior positivities for incongruent relative to congruent prosody in both the N400 time window and the late time window, similar to the positivity for incongruence elicited by the direct object. In general, the processing of physical stimulus differences, i.e., accentuation, was evident from a broadly distributed positive main effect of *Accent* (300-500 ms), showing that accented direct objects were more positive than unaccented ones. This effect was also apparent for accented prepositional objects, although the effect started somewhat earlier (100-200) and reappeared in a later time window (700-1000). The following discussion addresses only ERP patterns associated with the *direct objects*.

2.4 Discussion

The current study investigated the processing of linguistic prosody in context, particularly whether superfluous accents on background information and missing accents on focus information evoke distinct neural mechanisms in a natural paradigm without a prosodic task. Earlier studies have shown effects which we conjectured might be due to the specific tasks used in those studies. Additional variability in the results may have resulted from issues involving the presence of prosodic boundaries, time-locking and matching of stimuli which we controlled in the current study.

Thanks to our strict time-locking and stimulus selection procedures, we were able to discover very early effects (around 100 ms after target onset) for incongruous prosody, even in the absence of explicit instructions to attend to prosodic aspects of the stimuli. This early congruity effect (incongruous more positive than congruous) is present for accented words, but absent for unaccented words. Further evidence for more attention to the processing of accented elements was the negativity in the N400 time window that was triggered by superfluous accents but absent for missing ones. This is not to say that missing accents on focused information went unrecognized. Both missing and superfluous accents triggered a late posterior positivity, resembling a P600. Thus, the neural response to prosodic congruity is crucially different between superfluous and missing accents early on, but very similar in the later (P600) time window.

Our results are strikingly different from most of those reported in previous studies in which a prosodic judgment task was employed, which frequently find more effect of a ***missing*** accent than a superfluous one. However, they are consistent with Toepel and Alter (2004), who found a clear difference between the response to focus accent depending on whether a prosodic judgment task was used or not. In their paradigm without a prosodic task they found a broadly distributed negativity for superfluous accents (see also Wang et al.,

2011) but no effect of incongruity for missing accents. Like Toepel and Alter, we found a negativity for superfluous accents, but there were also important differences: for superfluous accents, we found an additional early positive effect (100-220 ms); for both types of incongruity we found a late posterior positivity (700-1000 ms). The use of stimuli which allowed time-locking to the direct object might have been responsible for our divergent results, as well as avoidance of phrase boundaries in the vicinity of target words, which allowed us to provide a clearer view on the neural correlates of processing focus accent per se. Last, we replicated earlier reports (Heim & Alter, 2006; Wang et al., 2011) of a positivity associated with the occurrence of a pitch accent, regardless of its congruity.

2.4.1 Adding a prosodic judgment task

Our results make it clear that specific, task-related neurocognitive mechanisms are active when a prosodic task is added (Table 1; current results; Toepel & Alter, 2004). We suggested in the introduction that previous findings in studies applying a prosodic task can be accounted for by what we know about task-related ERP components. Under a prosodic judgment task a missing accent elicits a biphasic N400-P600 pattern (Hruska et al., 2001; Hruska & Alter, 2004; Toepel & Alter, 2004), whereas a superfluous accent gives rise to (i) no effect (Hruska et al., 2001), (ii) a negativity (however, only with a comprehension task, Toepel & Alter, 2004), or (iii) a later positivity (Hruska & Alter, 2004).

Missing and superfluous accents both represent violations of information structure rules, namely the requirement of focus to be accented and background unaccented. Despite this, there is an apparent asymmetry in neural processing between missing and superfluous accents which becomes clear if one considers that their detection proceeds qualitatively differently, depending on the task at hand. With a prosodic task, the listener may very well exploit the linguistic context, i.e., the focus elements, to predict the position of accented focus; thus the detection of a missing accent where one is expected provides sufficient

evidence for a prosodic mismatch decision. This may give rise to some form of the CNV (Contingent Negative Variation), a task-related negativity that reflects the cognitive preparation for an upcoming stimulus to which the participant must react (cf. Magne et al., 2005). This negativity is often followed by a *positive* component called the CNV-Resolution (CNV-R), which is claimed to reflect executive functions that re-establish a cognitive equilibrium such as set-shifting or resetting motor programs (Jackson et al., 1999). Thus, the negativity often found for missing accents may reflect expectation violation, and the positivity could then index the resolution of the decision process: the participant becomes aware that the expected accent is indeed missing, and that the stimulus is prosodically not well-formed.

Processing a ***superfluous*** accent in the prosodic task condition is different. There is no 'warning' signal in the context that a critical stimulus is imminent and that a choice must be made at this particular point in the sentence. The superfluous accent is unexpected and most likely creates a surprise effect that might evoke a P300-like positivity for unexpected events (Picton, 1992; Donchin & Coles, 1988) rather than a CNV-like negativity for task-related expectation mismatch. In some cases, though, the superfluous accent may, for unknown reasons, escape detection altogether (Hruska et al., 2001). In sum, the findings in earlier studies seem to us to be artifacts of the added prosodic judgment task, obscuring the processes that are operational during 'normal' speech processing.

2.4.2 Processing prosody in context without a prosodic task

Without a prosodic task that can modify the effects of incongruous prosody, we still find asymmetries in the processing of missing and superfluous accents. However, these seem to go in the opposite direction, with superfluous accents noticed earlier than missing ones. Superfluous accents give rise to an early positivity and an N400-like negativity, while no such effects are obtained for missing accents. This does not mean that the missing accent was

'missed': we did find a later positivity/P600 in response to missing accents, and, in addition, sentences with missing accents were clearly recognized as infelicitous in our offline study 2. The exact nature of the late positivity is not completely clear. It resembles a P600, which, in line with previous accounts of late positivities in cases where creating a coherent representation is difficult for various reasons (Burkhardt, 2007; Hoeks et al., 2004; Kaan et al., 2000), we interpret as indicating effortful processing initiated in order to arrive at a coherent interpretation with respect to the preceding context. We will discuss the interpretation of this effect more extensively below.

Superfluous accents also gave rise to prominent earlier effects. They triggered an early positive effect (100-220 ms). This early congruity effect has not been reported before, and we believe that it was due to our straightforward time-locking procedure and extended matching of experimental stimuli that we were able to detect it. The exact nature of the early positivity, however, is still a puzzle. It could be related to the 'P200' for changes in pitch direction (Friedrich et al., 2004), but this seems unlikely as our positivity is triggered in physically identical accented elements (congruous focus accents versus superfluous focus accents) and must thus be related to their incongruity with respect to the preceding discourse context. Exploration of the functional meaning of this effect awaits further research.

Around 300 ms after the onset of a direct object with superfluous accent, a right-lateralized centro-posterior negativity was found, which resembles a standard N400 effect and is superimposed on the positive main effect of accentuation. The negativity might reflect semantic integration demands caused by the interpretation of the prosodic mismatch and straightforwardly be interpreted as an N400 effect. That is, the superfluous accent may hinder the interpretation of background information and require its re-interpretation as focus. Similarly, superfluous accents may suggest that the speaker intends contrast though none is given by the context. Since Dutch focus accents can be used with contrastive and non-

contrastive meaning, listeners may experience difficulties with the interpretation of a superfluous accent (Watson et al., 2008).

These effects are very similar to information structure mismatches such as in the Repeated Name Penalty (Gordon et al., 1993; LeDoux et al., 2006), where using a reference form that is more prominent and elaborate than strictly required gives rise to an increase in N400. For instance, in a sentence such as "Pam washed the dishes while Pam talked about politics", the second occurrence of Pam (underlined), in a position where a reduced form (e.g., *she*) is expected, engenders a significantly larger N400 than in a control sentence. In our experiment, the accent on the word in the superfluous accent condition signals that the word contains important new (focus) information (e.g. Wilson & Wharton, 2006; Gussenhoven, 2005) which turns out to be not the case, giving rise to an N400 effect. Exactly what the N400 reflects in this case is not completely clear: does it merely signal an information structure mismatch, or does it also reflect (semantic) reprocessing? This should be looked into in new experiments.

2.4.3 P600 as reanalysis of prosodic incongruity

As we have shown, late P600-like positivities on midline electrodes were elicited by both superfluous and missing accents in the present study and likely reflect effortful processing aimed at salvaging an ill-formed utterance, as listeners try to *make sense* of what the speaker just communicated. Our interpretation differs from previous studies that have attributed similar late positivities to the *Closure Positive Shift* (CPS, see Table 1) that is implicated in the processing of prosodic boundaries (Steinhauer & Friederici, 2001). Yet other studies (Hruska & Alter, 2004; Toepel & Alter, 2004) have interpreted the CPS as reflecting information segmentation at focus positions in context and at phrase boundaries out of context. Since target words in previous studies have often occurred in sentence final positions

or close to phrase boundaries, their CPS effects possibly reflect boundary processing rather than focus assignment or the processing of prosodic congruity.

In contrast, the late positivities in our study have a distinct functional interpretation as we strictly controlled our stimuli to avoid confounds with boundary-induced effects. As shown in Figure 3a and Figure 3b, none of the experimental conditions contained any silent pauses, breaks or pitch changes in the vicinity of targets in the signal which could have been confounded with a CPS response for prosodic parsing. The positive effect in the present study is elicited by physically identical stimuli separately in conditions for (1) accented and (2) unaccented direct objects and hence the prosodic phrasing within each condition is identical; the only source for the positivity is the contextual congruity of the prosodic realization. Most importantly, the strongest evidence that our late positivities do not reflect boundary processing is the fact that they occur not only after incongruously *accented* targets (Ladd, 1986) but also after incongruously *unaccented* targets. Even if one assumes that accented words might generate the impression of a boundary due to their acoustic lengthening (instead of the impression of prominence), no such segmental lengthening has been measured for unaccented words that also triggered late positivities in the incongruous condition. The distribution of the positive congruency effect over posterior lateral and midline electrodes is identical for both conditions, which represents further evidence for its similar, if not identical neural source.

We would like to claim that the late positivities in our data are part of the P600-family, and reflect general processes of *making sense* that are activated by prosodic mismatches (similar to Schumacher & Baumann, 2010). These positivities mark the workings of a general mechanism for the extended analysis of complex information, in this case prosodically mis-realized information, and its integration in the discourse (e.g., Burkhardt, 2007; Hoeks, Hendriks, Redeker, & Stowe, 2010). A number of the studies reported in the literature have found late positivities for prosodic mismatch, regardless of whether a prosodic

task was carried out, which suggests that at least some of these late positivities may differ in functionality from the decision-related CNV-R. One possibility is that the late process of information re-interpretation and making sense of prosody-context mismatches is independent of the presence or lack of a prosodic task, though future research using strictly controlled materials like those used in the current study combined with a prosodic task will be needed to determine whether this is the case.

2.5 Conclusion

The current study has demonstrated that when listeners are not engaged in a conscious prosodic judgment task, they respond more strongly to superfluous accents than to missing accents, although they clearly react to the incongruity of both sorts of contextual mismatch, underlining the importance of prosodic information to normal processing and integration of incoming information into the discourse context. Unlike previous studies in which a prosodic judgment task was used, however, our participants did not find that "less is more."

3

Only the *only*

Prosody processing in Dutch sentences with and without the focus particle “alleen”

Abstract

An ERP study tested the processing of pitch accents in isolated sentences with and without the Dutch focus particle *alleen* (English: *only*), which can both signal the focus of a message. In sentences like *Hij heeft (alleen) water na de training gedronken* (*He (only) drank water after the workout)*, the placement of accents (direct object vs. prepositional object) and the presence of *alleen* were varied. *Alleen* elicited sustained positive ERP shifts that possibly reflect additional processing due to the computation of a contrast set. Accentuation triggered a right-lateralized positivity (200-500 ms) in sentences with and without *alleen*, which is taken as a response to the prosodic prominence of accented words at any sentence position. This 'accent positivity' was delayed when accented direct objects were preceded by *alleen*, presumably due to additional processing after the particle or the anticipation of accent. In addition to this positivity, accented prepositional objects in sentences with *alleen* elicited early anterior negativities (100-200 ms), reflecting the expectation of accent and an increased working memory load, as well as left anterior positivities (500-700 ms) for the processing of the dispreferred complex structure in these sentences (left anterior P600). Our findings provide evidence that the comprehension of accents in different positions in isolated sentences activates the same neural mechanism, a form of a P200-like "accent positivity", and that adding *alleen* to the isolated sentence increases complexity and processing costs.

3.1 Introduction

In speech comprehension, listeners weight a number of linguistic and non-linguistic cues on-line to identify which word or phrase carries the most important information. With the help of context, listeners segment upcoming information into important focus elements and less important background elements and arrive at the intended meaning of the message. When no context is available, information segmentation is impeded and listeners must rely on other cues to determine the focus of the message, such as accents and focus particles. The present study investigates how the brain processes accents and the particle *only* in isolated sentences.

In out-of-the-blue sentences like *He drank water after the workout*, the most deeply embedded, usually rightmost element is identified as focus and perceived as prosodically most prominent (*Nuclear Stress Rule*, Chomsky & Halle, 1968; Chomsky, 1971; Bolinger, 1985, 1987; Libermann & Prince, 1977; Ladd, 1996). This final element projects focus to all constituents in the isolated sentence (Gussenhoven, 1985, 2008), suggesting a broad focus structure where all information is new. The prosody of such sentences is "neutral", e.g., no element stands out prosodically and the pitch contour follows the pattern of declination: it decreases as the sentence unfolds, which is referred to as *downstep* (Baumann et al., 2006).

Isolated sentences with a single accented non-final element like *He drank WATER after the workout* (capitals for accent) are in conflict with the theoretical assumption of a broad focus structure (Chomsky & Halle, 1968) since their prosody implies a narrow focus reading. Although theoretically incorrect, such prosodic realizations of isolated sentences have not been shown to cause comprehension difficulties in empirical studies (cf. Botinis et al., 1999). Rather, listeners use prosodic cues, in particular the position of the most prominent pitch accent, to disambiguate the sentence reading and to identify which element is in focus (Botinis et al., 1999). Depending on accent position, listeners may interpret the meaning of an isolated sentence as "it is water that he drank, not coffee" or "he drank water not on the way

home, but after the workout" and so on. Botinis et al.'s finding is in line with pragmatic theories on prosody, suggesting that listeners' attention is drawn to accented elements which are then assumed to carry the most important information (Wilson & Wharton, 2006).

Whether specific types of prosodic realization cause difficulties during the on-line interpretation of isolated sentences can be investigated by the event-related brain potential technique (ERP) which identifies changes in neural activity time-locked to a stimulus. In our previous ERP study on prosody processing in context (Dimitrova et al., submitted), we found that inappropriate prosody in context changes the pattern of neural activity in the brain. For instance, if background information is incongruously accented (e.g., *Did they give a bonus to the trainer or to the player? – They gave a BONUS to the player*; background underlined), an N400 effect is elicited. This neural response suggests that the processing of inappropriate accentuation is related to increased efforts with the semantic integration of a stimulus (Kutas & Hillyard, 1980; Kutas & Federmeier, 2011). However, not all types of inappropriate prosody trigger the same response: when focus elements are incongruously unaccented, no N400 is elicited (see also Toepel & Alter, 2004; Wang et al., 2011). Furthermore, our results provide evidence for a P600-like positivity for the making sense of all types of incongruous prosody in the discourse, as well as for an early P200-like 'accent positivity' for accented elements (Dimitrova et al., submitted).

Comparing the neural mechanisms for processing isolated sentences may show whether the brain handles accents at final and non-final positions differently. While the theoretical view predicts that single accented elements are less appropriate in isolated sentences, the empirical view suggests that any accent should be acceptable. Previous ERP studies do not report changes in neural activity for accented words in isolated sentences (Hruska & Alter, 2004), presumably because they used "neutral" prosody where the final element at the phrase boundary is interpreted as focus. It is not surprising that in these studies processing costs are increased at phrase boundaries and give rise to late positive components

reminiscent of the *Closure Positive Shift* (CPS, Steinhauer et al., 1999; Steinhauer & Friederici, 2001). The CPS, initially proposed as a correlate of prosodic parsing, has been re-interpreted as a response to information segmentation at boundary positions in sentences without context and at focus positions in sentences with context (Hruska & Alter, 2004; Toepel & Alter, 2004). These studies provide important insights into the processing of neutral prosody, however, the neural correlates of single prominent accents in isolated sentences remain less clear. The goal of the present study is to examine whether such accents facilitate information processing in isolated sentences because they identify focus, or whether they impede processing due to the absence of context.

Prosody is not the only means that speakers can use to mark focus within a sentence. Semantic cues such as the focus particle *only* have a similar function and assign focus and accent to the elements in their scope, even when no context is present (Bayer, 1996). Corpus studies on Dutch (Foolen et al., 2009) suggest that in 88 % of all occurrences, the particle *alleen* (English *only*) has a scope on its right-adjacent element, which also bears an accent, as in *Hij heeft alleen WATER na de training gedronken* (scope underlined, accent in capitals; *He only drank WATER after the workout*). In 10 % of all occurrences, *alleen* has scope on a nonadjacent element, and the resulting structure is referred to as "focus extraposition": *Hij heeft alleen water na de TRAINING gedronken (He only drank water after the WORKOUT*).[4] The strong preference for adjacent focus after *alleen* might thus lead to the anticipation of focus and accent on elements that follow the focus particle. In the present study, we manipulate the position and presence of *alleen* in isolated sentences and investigate whether it has an immediate impact on the identification of focus and the processing of pitch accents.

[4] The remaining 2 % are distributed as follows: In 1% of all cases, *alleen* occurs after the focus element, and in the other 1 %, *alleen* precedes focus but occurs in the fore field rather than in the middle field (Foolen et al., 2009).

Prior ERP evidence suggests that the brain is sensitive to the interplay of focus particles and accents in isolated sentences (Heim & Alter, 2006). German *sogar* (English *even*) generates the expectation of upcoming focus and accent, and as a result, accented elements after *sogar* trigger an early anterior negativity which the authors label as *Expectancy Negativity* (EN). Hruska & Alter (2004) report similar expectancy negativities for the processing of congruously accented focus in context, suggesting that focus particles and context may have similar functions related to the anticipation of accents. In Heim & Alter's study (2006), neural responses changed depending on the sentence position of accented words. In initial positions, accented words elicited early positivities, interpreted as a P200 for the processing of physical stimulus characteristics. In medial positions, accented verbs triggered N400 effects which indicated that accents were unusual in these positions. To minimize variability of neural responses due to variability in accent position, the current study directly compares isolated sentences with and without *alleen* where targets occurred in identical final or non-final sentence positions.

The reason why focus and accent processing may be facilitated by focus particles has to do with their function: particles introduce contrast into the discourse model, even if no preceding context is available to provide a contrast set. For instance, ambiguous sentences like (*Only*) *businessmen loaned money at low interest were told to record their expenses* (Sedivy, 2002) are processed more easily when the particle *only* is present at the sentence onset. In sentences with *only*, listeners easily infer that the noun phrase *businessmen* is contrasted with another group of people, and hence "loaned money" is more likely to be a modifier ("businessmen who loaned money") than to a verb phrase ("businessmen loaning money") (Ni et al., 1996; Sedivy, 2002, but see Paterson et al., 1999). In sentences without *only*, processing difficulties arise at the disambiguating verb "were" because listeners have not initially inferred contrast. Thus, although the interpretation of the focus particle requires additional processing costs related to the construction of a contrastive set, it facilitates

information comprehension in ambiguous clauses. Children, for example, encounter difficulties with the interpretation of isolated sentences with *only,* because they fail to exploit pragmatic knowledge needed for the mental representation of a contrastive set (Paterson et al., 2003). Contrastive prosody appears to have a similar effect on the construction of contrast in the discourse representation: when Dutch listeners perceive a noun phrase with a single accent like "BLUE square", they reconstruct a contrastive set in the discourse context, such as "red square" (Swerts et al., 2002).

In sum, focus particles facilitate prosody processing in isolated sentences because they assign focus, but also increase processing costs due to the complex computations that are required when listeners infer a contrastive set. The neural correlates of such additional processes can only become clear when sentences with focus particles are directly compared to sentences without focus particles as in the present study.

3.1.1 The present study

The current ERP study was set up to investigate the neural processing of accents in isolated sentences in Dutch and the impact of the focus particle *alleen* (English *only*) on their interpretation. Sentences were presented without a discourse context and varied with respect to: (i) the presence of *alleen* prior to the direct object as in *Hij heeft (alleen) water na de training gedronken* (*He drank (only) water after the workout*), and (ii) the placement of the pitch accent on the direct object *(water)* or on the prepositional object *(training)*. Accent placement corresponds to the scope of *alleen* in Dutch (Table 6), that is the preferred adjacent focus analysis with accented direct object (88 %), and the dispreferred nonadjacent focus analysis with accented prepositional object (10 %, Foolen et al., 2009).

The main goal of the present study is to examine how the brain responds to accents and the particle *alleen* in isolated sentences. No prosodic judgment task was applied in the present experiment as it can introduce additional ERP effects and modify linguistic

processing (Dimitrova et al., submitted; Toepel & Alter, 2004; Astesano et al., 2004). Stimuli were strictly controlled to minimize interference with other factors that may affect neural processing. First, special care was taken to match stimuli for sentence length, syntactic structure, and target word frequency. Second, targets had lexical stress on the first syllable to guarantee identical accent identification points across all stimuli (Ladd et al., 2000). Third, appropriate baseline and time-locking procedures were used and ERPs were time locked to the acoustic onset of each target element rather than to the sentence onset, which could jitter short-lasting effects. Lastly, and unlike most previous studies, special care was taken to avoid any prosodic breaks or phrase boundaries in the vicinity of targets that could induce effects of prosodic parsing as the abovementioned CPS (Steinhauer & Friederici, 2001).

Based on behavioral evidence, it was hypothesized that the particle *alleen* initiates the computation of a contrastive set, the effort of which may be reflected in a positive ERP effect for discourse update (e.g., Burkhardt, 2007). Sentences without *alleen* were not expected to elicit additional mechanisms for the activation of contrast due to the lack of *alleen* in these sentences. However, it is still possible that prosody has triggered a contrastive interpretation even in sentences without *alleen*, as single prominent accents in these sentences do not correspond to the neutral downstep prosody pattern and may imply a contrastive reading. The processing of similar prosody in sentences with context has been found to elicit P200-like positivities (Dimitrova et al., submitted). It is assumed that accented words would elicit differential neural responses relative to unaccented words. The effect of accentuation may take the form of early positive responses (P200) reflecting the processing of physical stimulus characteristics (Heim & Alter, 2006; Friedrich et al., 2001), similarly to the processing of accents in sentences in context (Dimitrova et al., submitted). Alternatively, if accents are considered inappropriate or occurring in unusual positions, they may trigger an N400 (Heim & Alter, 2006). Focus particles were expected to facilitate the interpretation of accented

words due to their anticipatory function, which may elicit early expectancy negativities (Heim & Alter, 2006).

Table 6. Experimental conditions

The table presents the four experimental conditions. Processing is measured at the direct object (*water*) and the prepositional object (*training*). Accented elements are presented in capitals.

Accent on	Focus particle	Target sentence
Direct object	without *alleen*	Hij heeft WATER na de training gedronken.
	with *alleen*	Hij heeft *alleen* WATER na de training gedronken.
Prepositional object	without *alleen*	Hij heeft water na de TRAINING gedronken.
	with *alleen*	Hij heeft *alleen* water na de TRAINING gedronken.
	English	*He (only) drank water after the workout.*

Dispreferred sentences where *alleen* was combined with an accent on a nonadjacent element were expected to increase processing costs (e.g., *Hij heeft alleen water na de TRAINING gedronken)*. In these complex sentences focus is preferably assigned by *alleen* to the adjacent direct object but the accent on the nonadjacent prepositional object establishes a less preferred interpretation with focus extraposition (Foolen et al., 2009). This structure may initiate re-computations of the discourse model that will likely be reflected in late positive effects, previously reported for the effort to construct a coherent representation (Hagoort et al., 1993; Hoeks et al., 2004; Kaan et al., 2000) or the revision of an initial analysis (Hagoort et al., 1999). The processing of such complex sentences with two conflicting focus cues may also give rise to left frontal P600 effects that have been found in complex sentences like *I cut the cake beside the pizzas that were brought by Jill* (Kaan & Swaab, 2003). Lastly, the construction of a coherent discourse model may be reflected in sustained frontal negativities that have been previously reported for the interpretation of sentences with ambiguous referents (Nieuwland et al., 2007).

3.2 Methods

3.2.1 Participants

Thirty right-handed Dutch native speakers (9 male, range 18-29 years, mean 20) with normal or corrected-to-normal vision, none of whom had studied Linguistics, were paid for participation after signing a written informed consent in accordance with the Declaration of Helsinki. None of the participants reported any neurological, psychological, language or hearing impairment. Five other female participants were discarded due to data loss of more than 40 percent data on at least one electrode in at least one condition.

3.2.2 Stimuli

Experimental stimuli consisted of 120 sentence items that were recorded in four conditions (see Table 6) by varying *accent position* (accent on direct object vs. accent on prepositional object) and the presence of the *focus particle alleen* (sentences with *alleen* vs. sentences without *alleen*). Targets were the direct and prepositional objects that were matched for lexical stress on the initial syllable (Ladd et al., 2000) and for word frequency (CELEX corpus, Baayen et al., 2003). Target length varied between one and three syllables, and sentences were matched for length (8 words on average).

To ensure natural intonation, a phonetically naive female speaker recorded the stimuli at a normal speech rate (5.9 syllables/second). Care was taken that each sentence was realized as a single intonation phrase with one phonological phrase (Gussenhoven, 2005) without any breaks or prosodic boundaries. All 480 sentences (120 items x 2 accent positions x 2 particle conditions) were assigned to four experimental lists of 120 sentences each (30 sentences x 4 conditions) using the Latin square format.

Stimuli were presented in two separate blocks with sentences without *alleen* first in order to have a pure index of how accents in non-final position are processed, without

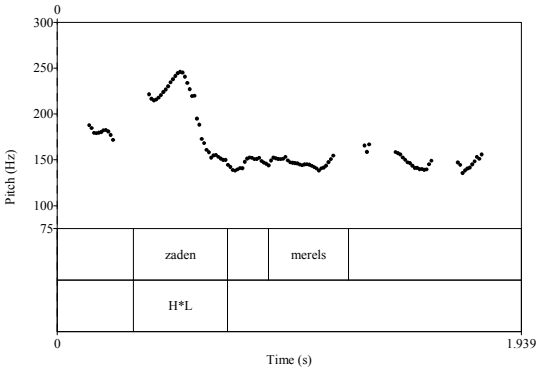
participants considering that such an accent may be licensed by a focus particle. In each experimental list, half of the sentences had the focus particle *alleen* prior to the direct object like *Hij heeft alleen water na de training* gedronken (*He drank only water after the workout*) (*n*=60), and half of the stimuli did not have a focus particle like *Hij heeft water na de training* gedronken (*He drank water after the workout*) (*n*=60). Within each focus particle condition, the element that received the most prominent accent (given in capitals) was varied. In half of the stimuli the direct object was accented like *Hij heeft (alleen) WATER na de training gedronken* (*n*=30), and in the other half the prepositional object was accented like *Hij heeft (alleen) water na de TRAINING gedronken* (*n*=30). No participant listened to more than one version of each sentence, and every participant listened to the items in a pseudo-randomized order with no more than two successive uses of the same condition.

3.2.3 Acoustic analysis

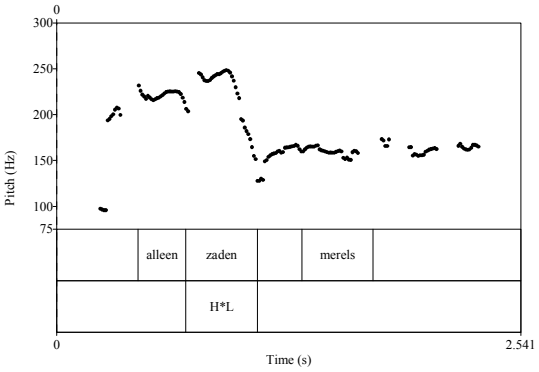
Acoustic analysis was performed in PRAAT (Boersma & Weening, 2010). We measured the duration and fundamental frequency (f0) of accented and unaccented direct objects and prepositional objects. Table 7 shows that accented elements had longer duration and larger pitch range (difference between maximal and minimal f0) than unaccented words irrespective of the presence of *alleen*. All pitch contours were annotated according to the Transcription of Dutch Intonation (ToDI) system (Gussenhoven, 2005). Figure 8 displays representative examples of pitch contours for each condition and shows that irrespective of the presence of *alleen* all accented targets carried an H*L accent. This ToDI annotation is used to describe accents with a falling pitch movement from high (H) to low (L) pitch; the tonal target of the accented syllable is given by an asterisk (*), here a high tone (H*).

Accented direct object

(a) ***Without "alleen"***

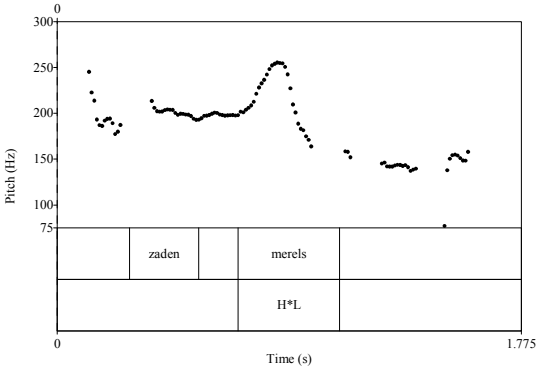


(b) ***With "alleen"***



Accented prepositional object

(c) ***Without "alleen"***



(d) ***With "alleen"***

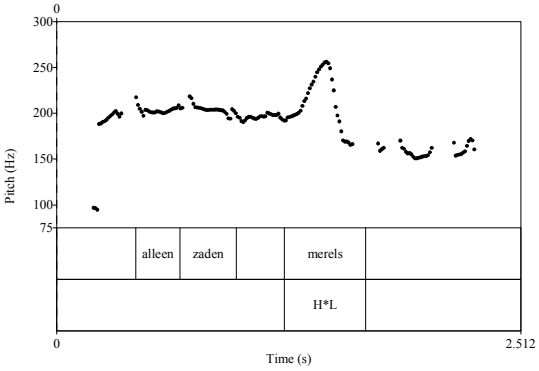


Figure 8. Representational pitch contours to the experimental conditions

The figures display a representative sentence in all four conditions: without the focus particle *alleen* (8a, 8c) vs. with the particle *alleen* (8b, 8d), and with accent on the direct object (upper panel, 8a, 8b) vs. accent on the prepositional object (lower panel, 8c, 8d). The onset and offset of direct and prepositional objects correspond to the vertical left and right lines of the boxes that display the words. Pitch accents are annotated at the bottom tier as a falling H*L accent (ToDI system, Gussenhoven, 2005). Displayed sentence: *Ze hebben (alleen) zaden aan de merels gegeven* (English *They (only) gave seeds to the blackbirds*).

Table 7. Acoustic stimulus characteristics

The table presents means (M) and standard deviations (SD) to the acoustic features of accented and unaccented targets in sentences with the focus particle (*alleen*) and without the focus particle (no *alleen*). Duration is measured in milliseconds (ms) and fundamental frequency (f0) and pitch range in Hertz (Hz).

Direct object	Accented				Unaccented			
	alleen		no *alleen*		*alleen*		no *alleen*	
	M	SD	M	SD	M	SD	M	SD
Duration	409	64	359	63	314	66	273	54
F0 min	186	34	165	27	190	20	184	16
F0 max	273	26	253	20	223	14	212	16
Pitch range	87		88		33		28	
Prepositional object	Accented				Unaccented			
	alleen		no *alleen*		*alleen*		no *alleen*	
	M	SD	M	SD	M	SD	M	SD
Duration	408	64	348	62	340	64	312	66
F0 min	171	33	163	26	152	11	135	19
F0 max	265	33	243	28	177	22	163	23
Pitch range	94		80		25		28	

3.2.4 EEG procedure and recordings

We used a cap with 64 Ag/AgCl electrodes in accordance with the international extended 10-20 system (Electro Cap International). The EEG signal was sampled at 250 Hz and amplified on-line against the average of all inputs of the amplifier (TMS international). The amplifier measured DC with a digital FIR filter (cutoff frequency 67.5 Hz) to avoid aliasing. Electrodes were re-referenced offline to the algebraic average of left and right mastoid electrodes. Vertical eye movements and blinks were recorded via electrodes below and above the left eye, and horizontal eye movements via electrodes at the left and right canthus of each eye. Impedances were kept below 5Ω. All data were filtered offline with a band-pass filter of 0.01-30 Hz.

After electrode application, participants completed a trial session and then proceeded to the actual experiment that consisted of two blocks of 60 sentence items each, which were presented auditorily via loudspeakers. To minimize eye movement artifacts, participants fixated a black cross against a grey computer screen during stimulus presentation. Each trial started with silence (100 ms), followed by presentation of the sentence (2000 ms on average), silence (1500 ms), and a blinking period (2000 ms). After the last silence period, on 25 percent of all trials, a probe word was displayed on the screen and participants indicated whether its meaning was semantically related to the preceding sentence; related and unrelated answers were counterbalanced.

3.2.5 EEG analysis

Trials with ocular, movement and other artifacts and electrode drifts (± 75 μV) were rejected. Subject inclusion criterion was set at a minimum of 60 % valid data per electrode per condition; five female participants were excluded. The number of rejected trials did not vary per condition. ERPs were time locked to the acoustic onset of each target.

We identified ERP differences in four time windows: *Early time window* 100-200 ms; *Intermediate time window* 200-350 ms, *N400 time window* 350-500 ms, and *P600 time window* 500-700 ms post target onset. Average ERPs were computed separately for groups of electrodes in pre-defined lateral and midline Regions Of Interest (ROI). Lateral ROIs included *left frontal* (FP1, AF3, AF7, F3, F5, F7), *right frontal* (FP2, AF4, AF8, F4, F6, F8), *left central* (FC3, FC5, C3, C5, CP3, CP5), *right central* (FC4, FC6, C4, C6, CP4, CP6), *left parietal* (P3, P5, P7, PO3, PO7, O1), *right parietal* (P4, P6, P8, PO4, PO8, O2). Midline ROIs included *frontal* (FPz, AFz, Fz), *central* (FCz, Cz, CPz), and *parietal* electrodes (Pz, POz, Pz).

Repeated measures ANOVAs were conducted separately for direct and prepositional objects with four within-participants factors on lateral electrodes: *Accent* (accented element

vs. unaccented element)[5], *Focus Particle* (sentences with *alleen* vs. sentences without *alleen*), *Anteriority* (anterior vs. central vs. posterior region), and *Hemisphere* (left vs. right hemisphere). ANOVAs for midline electrodes contained the same factors except for *Hemisphere*. Statistical analyses were performed on mean voltage data and were adjusted with the Huynh-Feldt correction for nonsphericity where appropriate. Baseline correction was calculated within target stimuli between 0 and 100 ms post target onset, to compensate for potential differences arising due to the presence or absence of the focus particle prior to the direct object (for similar reasoning and procedure, see Philips et al., 2005; Mueller, 2009). All computed average waveforms represent segments of 1300 ms duration from target onset.

3.3 Results

3.3.1 Behavioral results

After 25 percent of all sentences in the experiment, a probe word was presented on the screen and participants judged whether it was semantically related to the target sentence. The task performance of 84.3 % correct responses shows that participants were paying attention to the experimental stimuli.

3.3.2 ERP results: Direct object

ANOVAs were conducted separately for direct and prepositional objects. Significant interactions were followed up in post-hoc tests. Lower order effects will not be reported if they are covered by higher order interactions, and effects of *Anteriority* and *Hemisphere* will

[5] The factor *Accent* refers to the actual accentuation of the direct object or the prepositional object. In each sentence, only one element is accented: when the direct object is accented, the prepositional object is unaccented and *vice versa*.

only be discussed if they are modified by the cognitive factors. Marginally significant effects and interactions (.05<p≤.1) are presented in footnotes and not included in the discussion.

Statistical results for direct objects are presented in Table 8, and the ERP waveforms showing the interaction of all conditions are displayed in Figure 9.

Table 8: Statistical results for direct objects

Table 8 presents significant effects and interactions of all time windows (in ms) for direct objects. Marginal interactions with .05<p≤.1 are presented in italics for future reference. ANOVAs include the factors: ACC=Accent, FOC=Focus Particle, ANTER=Anteriority, and HEM=Hemisphere.

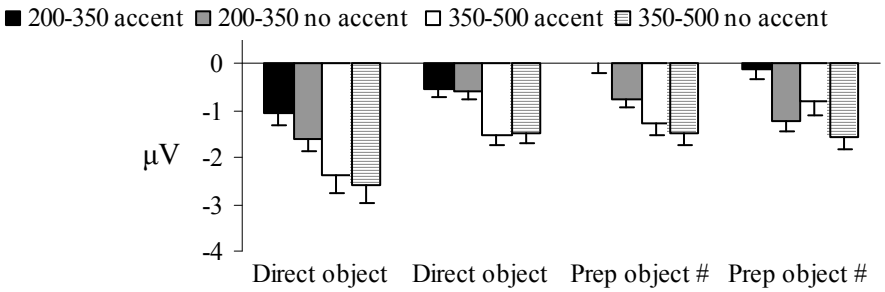
Direct object			**100-200 ms**		**200-350 ms**		**350-500 ms**		**500-700 ms**	
		df	F	p	F	p	F	p	F	p
Lateral	ACC	1,29			3.123	*.088*				
	FOC	1,29	27.406	.000	13.253	.001	12.178	.002	12.389	.001
	FOC x ACC	1,29			3.314	*.079*				
	FOC x ANTER	2,58	3.102	*.071*			6.404	.012	3.848	*.051*
	ACC x ANTER	2,58								
	ACC x HEM	1,29	3.493	*.072*	14.444	.001	9.444	.005		
	FOC x ACC x HEM	1,29			5.327	.028				
	FOC x ANTER x HEM	2,58			4.098	.022				
Midline	ACC	1,29			5.702	.024				
	FOC	1,29	19.851	.000	7.316	.011	7.875	.009	5.342	.028
	FOC x ANTER	2,58	3.104	*.062*			8.384	.003	4.803	.023
	ACC x ANTER	2,58								

3.3.2.1 Early time window 100-200 ms

Focus Particle had a main effect on lateral electrodes (F(1,29)=27.406, p<.001) that was due to positive waveforms[6] for sentences with *alleen* relative to sentences without *alleen.*[7]

[6] The positivity for sentences with *alleen* can be interpreted in the opposite way, as a negativity (N100) in sentences without *alleen*. However, since the effect represents a main effect of *Focus Particle* rather than a main effect of *Accent*, it seems unlikely to belong to the N100, which is related to pre-attentive acoustic processing.

[7] There was also a marginal interaction of *Focus Particle* x *Anteriority* on lateral (F(2,58)=3.102, p=.07) and midline electrodes (F(2,58)=3.104, p=.06) that showed that the positivity for *alleen* was the largest on anterior regions. There was also a marginal interaction of *Accent* x *Hemisphere* on lateral electrodes (F(1,29)=3.493, p=.07) due to right-lateralized positivities for accented direct objects relative to unaccented ones.



	Direct object # no alleen	Direct object # alleen	Prep object # no alleen	Prep object # alleen
200-350 accent	-1,070	-0,533	0,010	-0,122
200-350 no accent	-1,625	-0,595	-0,751	-1,227
350-500 accent	-2,390	-1,505	-1,268	-0,805
350-500 no accent	-2,591	-1,462	-1,464	-1,575

Figure 9. Means for the effect of *Accent* for direct objects and prepositional objects

The figure displays means for the *Accent* effect (accented vs. unaccented element) for direct objects and prepositional objects in two time windows: 200-350 ms and 350-500 ms. ERP deflections to accented prepositional objects were more positive (e.g., in terms of a relative difference between conditions) as compared to deflections to unaccented ones in both time windows of both sentence types. There was a similar positive accent effect for direct objects only in sentences without *alleen* and was very weak in sentences with *alleen*.

The main effect of *Focus Particle* was significant also on midline electrodes ($F(1,29)=19.851$, $p<.001$) and was also due to a positivity for sentences with *alleen*.

3.3.2.2 Intermediate time window 200-350 ms

On lateral electrodes, there was a main effect of *Focus Particle* ($F(1,29)=13.253$, $p=.001$), showing that sentences with *alleen* elicited positive effects relative to sentences without *alleen*.[8] This effect was modified by an interaction of *Focus Particle* x *Accent* x *Hemisphere* ($F(1,29)=5.327$, $p<.05$). Follow-ups with *Focus Particle* as the split variable showed a significant *Accent* x *Hemisphere* interaction in sentences without *alleen* ($F(1,29)=19.337$,

[8] There was a marginal main effect of *Accent* on lateral electrodes ($F(1,29)=3.123$, $p=.09$) due to positivities for accented direct objects relative to unaccented ones.

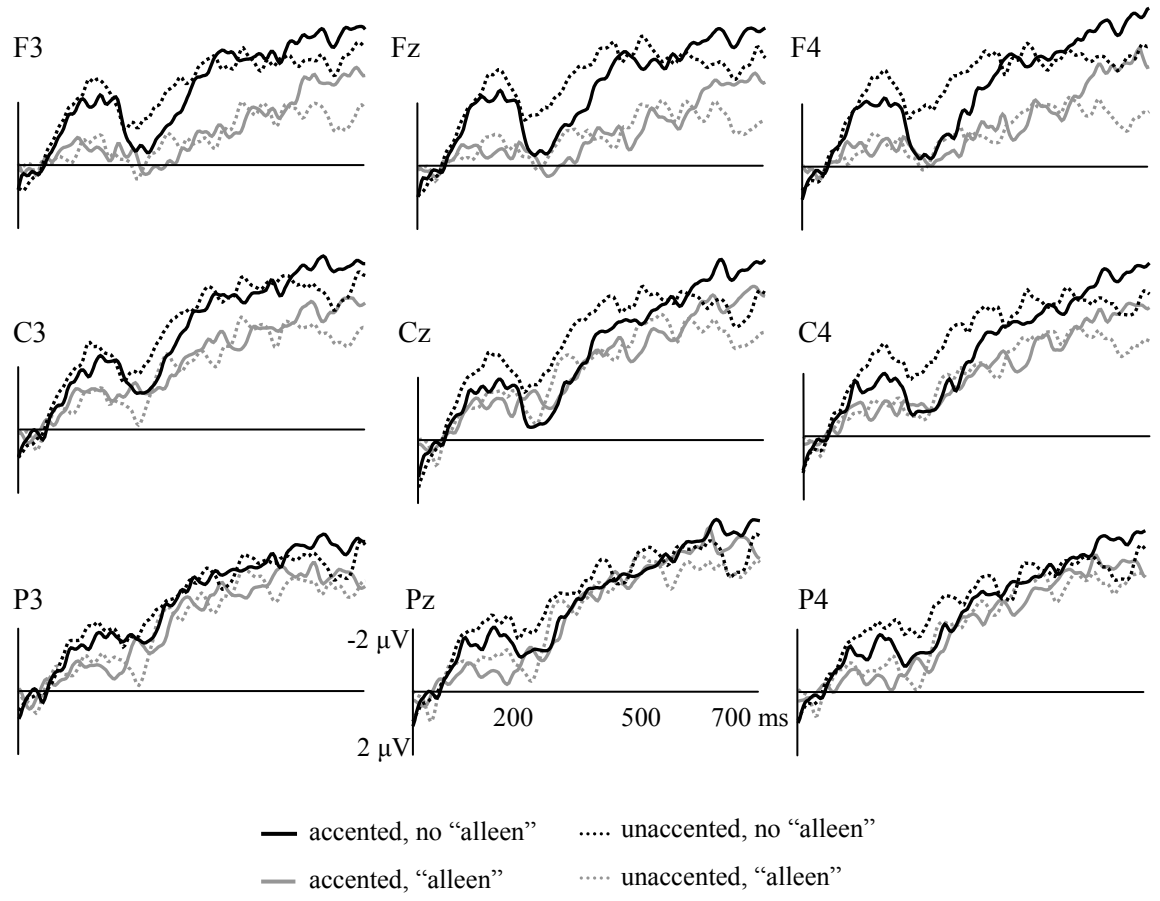


Figure 10a. Interaction plots for direct object

ERP waveforms display the interactions of accented (solid line) and unaccented (dotted line) direct objects that occurred in sentences without *alleen* (black lines) vs. sentences with *alleen* (grey lines). ERP effects are presented for segments of 700 ms duration post onset of the direct object, time locked at its onset.

p<.001), whereas in sentences with *alleen* neither the *Accent* x *Hemisphere* interaction (F(1,29)=1.593, p=.22) nor the *Accent* effect ((F1,29)=.089, p=.768) were significant. Post-hocs on the *Accent* x *Hemisphere* interaction in sentences without *alleen* revealed a significant positive effect of *Accent* only on right sites (F(1,29)=12.324, p=.001), but not on left sites (F(1,29)=.812, p=.38). Thus, in sentences without *alleen*, accented direct objects triggered a right-lateralized positivity relative to unaccented direct objects; no such accent-positivity was found for accented direct objects in sentences with *alleen*.

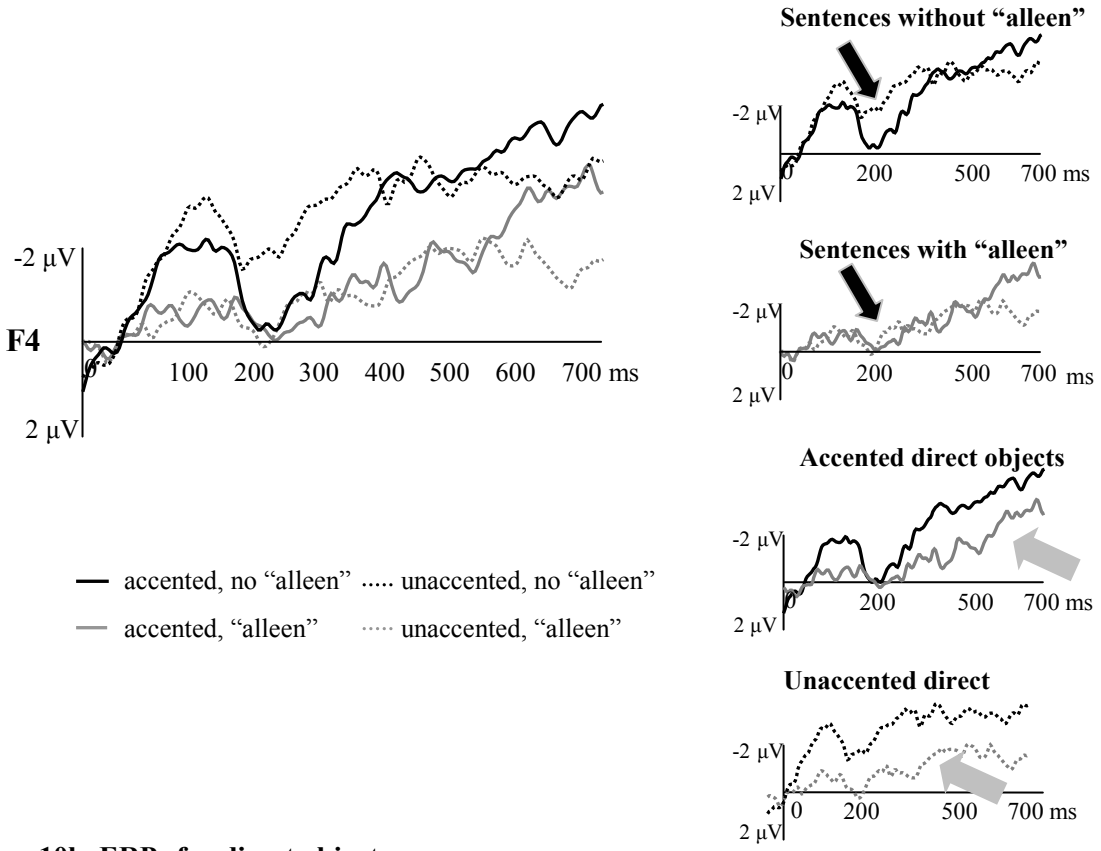


Figure 10b. ERPs for direct objects

The figure displays ERPs to direct objects on the F4 electrode (right anterior). Both accented and unaccented direct objects (two right bottom panels) elicited sustained positive waveforms in sentences with *alleen* as compared to sentences without *alleen*. Accented direct objects triggered right-lateralized positivities (200-500 ms) in sentences without *alleen* (first right upper panel) and a very weak positivity (350-500 ms) in sentences with *alleen* (second right upper panel).

On midline electrodes, there was a main effect of *Focus Particle* ($F(1,29)=7.316$, $p<.05$) that was due to positive fluctuations for sentences with *alleen*. There was also a main effect of *Accent* ($F(129)=5.702$, $p<.05$) due to positivities for accented direct objects.

3.3.2.3 N400 time window 350-500 ms

On lateral electrodes, there was a significant main effect of *Focus Particle* ($F(1,29)=12.178$, $p<.01$) due to a positivity in sentences with *alleen* relative to sentences without *alleen*. The positivity was qualified by a *Focus Particle* x *Anteriority* interaction ($F(2,58)=6.404$, $p<.05$), showing a distribution over anterior regions ($F(1,29)=8.488$, $p<.01$) and central regions

(F(1,29)=18.580, p<.000), but not over posterior regions (F(1,29)=1.389, p=.248). There was also a significant *Accent* x *Hemisphere* interaction (F(1,29)=9.444, p<.01), but the effect of *Accent* was not significant in the left vs. the right hemisphere (all *p*'s >.26). The mean voltage values revealed that on right sites, accented direct objects were more positive than unaccented ones; there was no such positivity for accented elements on left sites. The mean voltage values for the accent effect are presented in Figure 9 which shows that the positive effect of accentuation is considerably weak in sentences with *alleen*.

On midline electrodes, there was a main effect of *Focus Particle* (F(1,29)=7.875, p<.01) due to positivities for sentences with *alleen*. There was an interaction of *Focus Particle* x *Anteriority* (F(2,58)=8.384, p<.01) that revealed that the positivity for *alleen* had an anterior (F(1,29)=12.576, p=.001) and central (F(1,29)=7.621, p=.01) distribution; the effect was not significant on posterior sites (F(1,29)=,016, p=.9).

3.3.2.4 P600 time window 500-700 ms

There was a main effect of *Focus Particle* on lateral electrodes (F(1,29)=12.389, p=.001), continuing to show a positivity for sentences with *alleen* versus sentences without *alleen*.[9]

On midline electrodes, we found a main effect of *Focus Particle* (F(1,29)=5.342, p<.05) due to positive fluctuations for sentences with *alleen*. The effect was qualified by a *Focus Particle* x *Anteriority* interaction (F(2,58)=4.803, p<.05), which revealed an anterior (F(1,29)=7.775, p<.01) and central distribution (F(1,29)=5.279, p<.05) of the positivity; the effect was not significant on posterior sites (F(1,29)=.165, p=.67).

[9] The *Focus Particle* x *Anteriority* interaction did not reach significance on lateral electrodes (F(1,29)=3.848, p=.051), but showed the same anterior and central distribution of the positivity for *alleen* as reported for midline electrodes.

3.3.3 ERP results: Prepositional object

Prepositional objects also varied with respect to their accentuation and the presence of the focus particle *alleen* prior to the direct object which preceded the prepositional object. Accented prepositional objects occurred in sentences where the direct object was unaccented, and *vice versa*. The factor *Accent* refers to the realization of the prepositional object. To overcome interference with ERP changes prior to the prepositional object, the baseline correction was calculated within the target stimulus (0-100 ms post onset). Statistical results for prepositional objects are presented in Table 9, and ERP data in Figure 11a and 11b.

Table 9: Statistical results for prepositional objects

Table 9 presents significant effects and interactions of all time windows (in ms) for prepositional objects. Marginal results with .05<p≤.1 are presented in italics for future reference. ANOVAs were performed with the factors: ACC=Accent, FOC=Focus Particle, ANTER=Anteriority, and HEM=Hemisphere.

Prepositional object			**100-200 ms**		**200-350 ms**		**350-500 ms**		**500-700 ms**	
		df	F	p	F	p	F	p	F	p
Lateral	ACC	1,29			20.990	.000	4.420	.044		
	FOC	1,29								
	FOC x ANTER	2,58	3.573	.048						
	ACC x ANTER	2,58	3.420	*.060*	11.607	.000			3.634	*.051*
	ACC x HEM	1,29	13.407	.001	13.389	.001	3.591	*.068*		
	FOC x ACC x HEM								13.977	.001
	FOC x ANTER x HEM				3.773	.042				
	ACC x FOC x ANTER x HEM	2,58	4.964	.011					4.880	.023
Midline	ACC	1,29			24.589	.000	7.789	.009		
	FOC x ANTER	2,58	6.748	.002	6.946	.006				
	ACC x ANTER	2,58	3.258	.046	13.201	.000	3.918	.036		

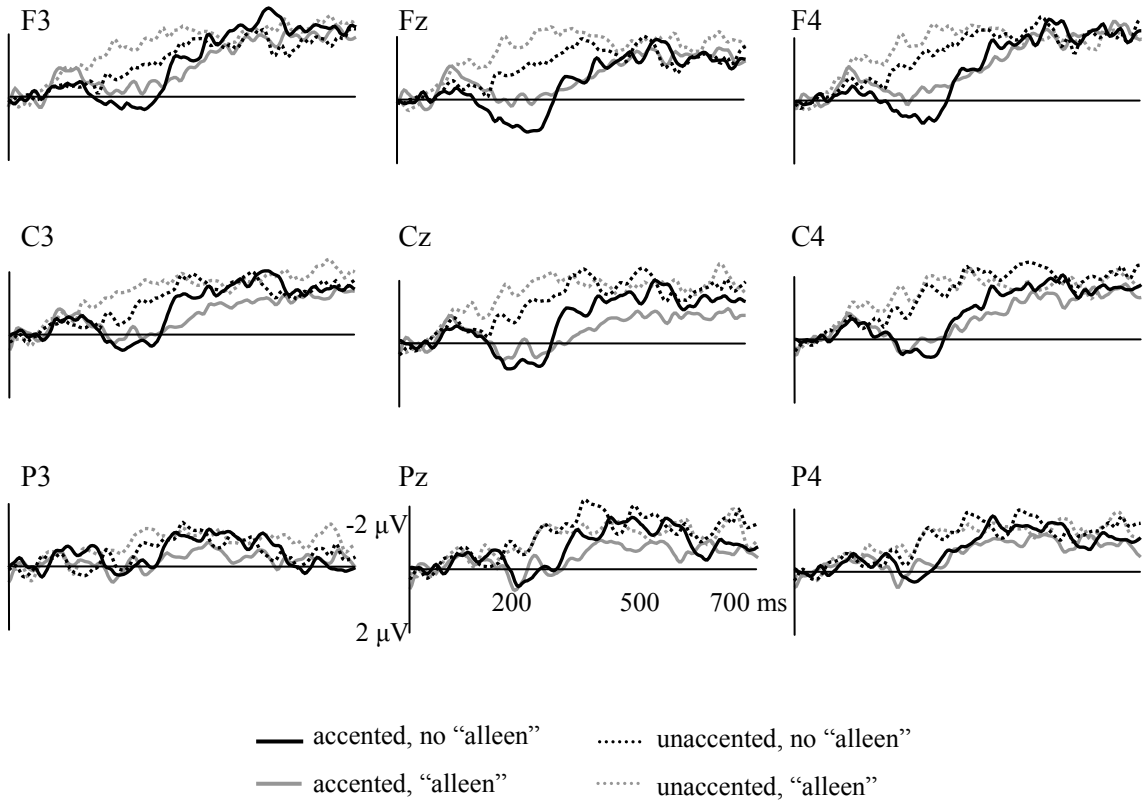


Figure 11a. Interaction plots for prepositional object

ERP waveforms display the interactions of accented (solid line) and unaccented (dotted line) prepositional objects in sentences without *alleen* (black lines) vs. sentences with *alleen* (grey lines). ERP effects are presented for segments of 700 ms duration post onset of the prepositional object.

3.3.3.1 Early time window 100-200 ms

There was a four-way interaction of *Focus Particle* x *Accent* x *Anteriority* x *Hemisphere* on lateral electrodes ($F(2,58)=4.964$, $p<.05$) that was split by the factor *Accent*. For unaccented prepositional objects, the interaction of *Focus Particle* x *Anteriority* x *Hemisphere* was significant ($F(2,58)=3.605$, $p<.05$). Post-hocs revealed that the interaction of *Focus Particle* x *Hemisphere* was marginal on posterior regions ($F(1,29)=4.013$, $p=.055$), and not significant on anterior ($F(1,29)=.562$, $p=.46$) and central ($F(1,29)=2.074$, $p=.16$) regions. The means for posterior regions suggest that the *Focus Particle* x *Hemisphere* interaction must have been

due to a left posterior negativity for unaccented prepositional objects in sentences with *alleen* relative to unaccented prepositional objects in sentences without *alleen*.

For accented prepositional objects, the *Focus Particle* x *Anteriority* x *Hemisphere* interaction was not significant (F(2,58)=.632, p=.48). There was a lower order interaction of *Focus Particle* x *Anteriority* (F(2,58)=4.836, p<.05) for accented prepositional objects; post-hocs split by *Anteriority* did not show a statistically reliable effect in any region (all *p*'s >.1). The means showed that the interaction must be due to an anterior negativity for accented prepositional objects in sentences with *alleen* as compared to accented prepositional objects in sentences without *alleen*; no such negativity was found on central or posterior regions.

On midline electrodes, we found an *Accent* x *Anteriority*[10] interaction (F(2,58)=3.258, p<.05) but post-hocs were not statistically reliable (all *p*'s >.14). Mean voltage data suggest that accented prepositional objects were more positive on anterior and central regions but not on posterior regions. There was a *Focus Particle* x *Anteriority* interaction (F(2,58)=6.748, p<.01) due to an anterior negativity for sentences with *alleen* (F(1,29)=11.579, p<.01).

3.3.3.2 Intermediate time window 200-350 ms

We found a main effect of *Accent* on lateral electrodes (F(1,29)=20.990, p<.001) due to a positivity for accented prepositional objects relative to unaccented ones. The positivity was qualified by an *Accent* x *Hemisphere* interaction (F(1,29)=13.389, p=.001) that was larger in the right hemisphere (F(1,29)=27.091, p<.001) than in the left hemisphere (F(1,29)=12.441, p=.001). There was an *Accent* x *Anteriority* interaction (F(2,58)=11.607, p<.001) suggesting that the accent positivity was significant at anterior sites (F(1,29)=29.515, p<.001) and at central sites (F(1,29)=24.662, p<.001), but it was considerably weaker at posterior sites (F(1,29)=3.090, p=.09). Means for the accent positivity are presented in Figure 9.

[10] The *Accent* x *Anteriority* interaction was marginal on lateral electrodes (F(2,58)=3.420, p=.06) and was due to an anterior negativity for sentences with *alleen*.

Focus Particle was also involved in a significant interaction with *Anteriority* x *Hemisphere* (F(2,58)=3.773, p<.05). Post-hocs split by *Anteriority* did not show a significant interaction of *Focus Particle* and *Hemisphere* but a main effect of *Focus Particle* on anterior regions only (F(1,29)=5.328, p<.05). The effect was an anterior negativity for sentences with *alleen* relative to sentences without *alleen* that was larger on right than on left sites.

On midline electrodes, there was a main effect of *Accent* (F(1,29)=24.589, p<.001) due to positivities for accented relative to unaccented prepositional objects. The effect was qualified by an *Accent* x *Anteriority* interaction (F(2,58)=13.201, p<.001), showing that the accent positivity was significant at anterior (F(1,29)=37.026, p<.001) and at central sites (F(1,29)=27.907, p<.001), but considerably weaker at posterior sites (F(1,29)=4.405, p<.05). A *Focus Particle* x *Anteriority* interaction (F(2,58)=6.946, p<.01) revealed a negative effect of *Focus Particle* at anterior sites (F(1,29)=11.150, p<.01), showing that sentences with *alleen* triggered anterior negativities as compared to sentences without *alleen*.

3.3.3.3 N400 time window 300-500 ms

On lateral electrodes, there was a main effect of *Accent* (F(1,29)=4.420, p<.05) that was due to a positivity for accented prepositional objects relative to unaccented ones (see Figure 9).[11]

On midline electrodes, there was a main effect of *Accent* (F(1,29)=7.789, p<.01) due to a positivity for accented relative to unaccented prepositional objects. The main effect was licensed by an *Accent* x *Anteriority* interaction (F(2,58)=3.918, p<.05), showing that the accent positivity was significant over anterior (F(1,29)=10.609, p<.01) and central regions (F(1,29)=10.722, p<.01), but not over posterior regions (F(1,29)=1.089, p=.305).

[11] There was also a marginal interaction of *Accent* x *Hemisphere* (F(1,29)=3.591, p=.068) that showed that the positivity for accented elements was distributed in the right hemisphere.

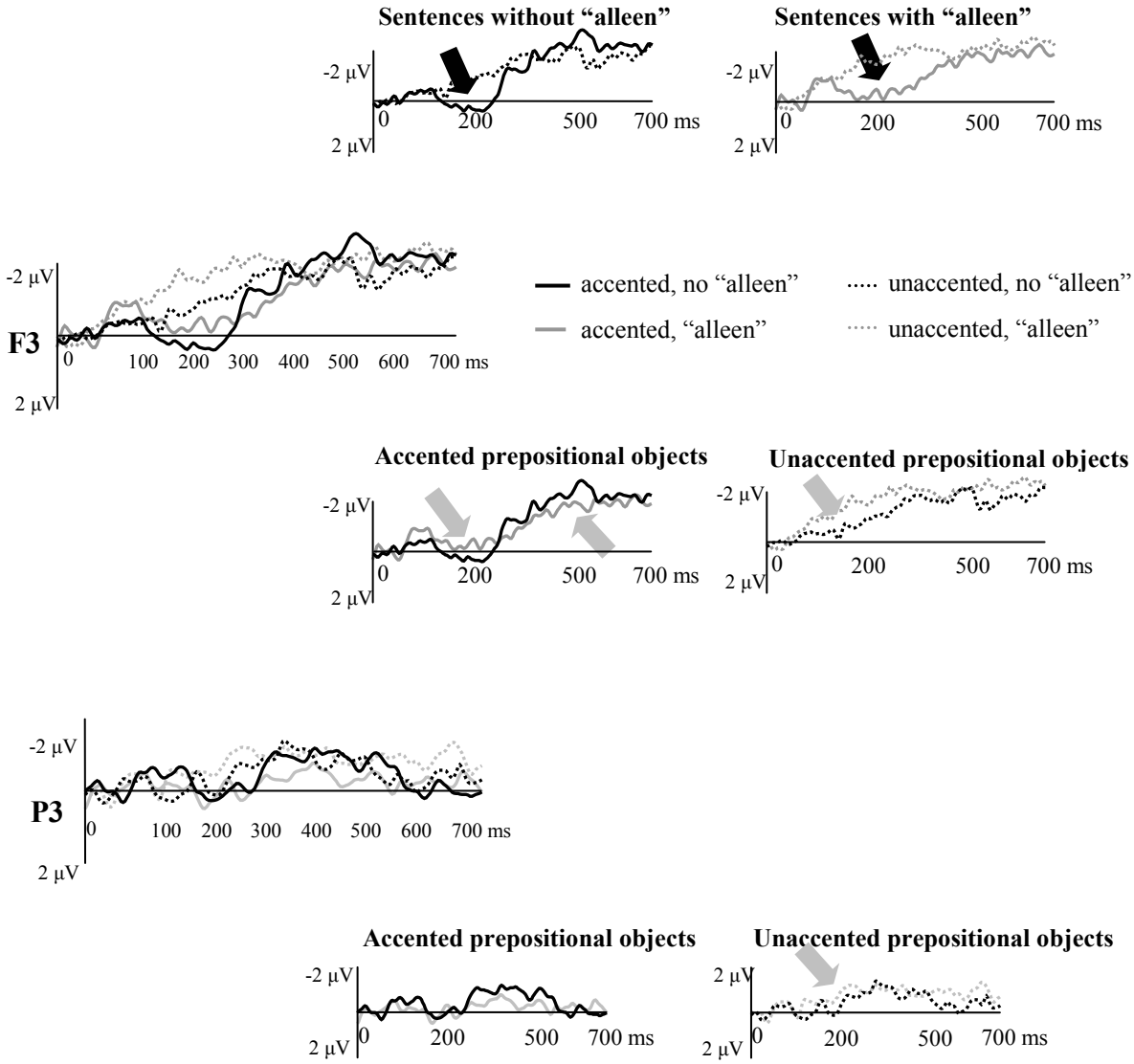


Figure 11b. ERPs to prepositional objects

The figure displays ERPs to prepositional objects on the F3 (left frontal) and P3 (left posterior) electrodes. Unaccented prepositional objects in sentences with *alleen* (right upper panel of the P3) elicited a left posterior negativity (100-350 ms), whereas accented prepositional objects elicited an anterior negativity (100-200 ms, two bottom panels of the F3). The right upper panels of the F3 show also a right-lateralized accent positivity for accented prepositional objects in sentences with and without *alleen* (200-500 ms). In sentences with *alleen*, accented prepositional objects (bottom panel of the F3) triggered a late anterior positivity.

3.3.3.4 P600 time window 500-700 ms

There was a four-way interaction of *Focus Particle* x *Accent* x *Anteriority* x *Hemisphere* on lateral electrodes ($F(2,58)=4.880$, $p<.05$) that was split by the factor *Accent*. For accented

prepositional objects, we found a significant *Focus Particle* x *Anteriority* x *Hemisphere* interaction ($F(2,58)=7.610$, $p<.01$). Follow-ups revealed a significant *Focus Particle* x *Hemisphere* interaction on anterior regions ($F(1,29)=6.623$, $p<.05$), but not on central ($F(1,29)=.758$, $p=.391$)[12] or posterior regions ($F(1,29)=.988$, $p=.328$). Post-hocs on anterior regions of accented prepositional objects revealed a marginal effect of *Focus Particle* in the left hemisphere ($F(1,29)=2.969$, $p=.09$), but not in the right hemisphere ($F(1,29)=.034$, $p=.86$). The effect was an anterior positivity for accented prepositional objects which tended to be left-lateralized in sentences with *alleen*. No such positivity was found for accented prepositional objects in sentences without *alleen*.

For unaccented prepositional objects, the interaction of *Focus Particle* x *Anteriority* x *Hemisphere* was not significant ($F(2,58)=.590$, $p=.5$). There was, however, a lower order interaction of *Focus Particle* x *Hemisphere* ($F(1,29)=6.037$, $p<.05$) that was due to a left-lateralized negativity for sentences with *alleen* relative to sentences without *alleen*. No effects or interactions were significant on midline electrodes.

3.3.4 Summary of results

Sentences with the focus particle *alleen* triggered an early positivity already 100 ms post onset of the direct object (100-200 ms) as compared to sentences without *alleen* (main effect of *Focus Particle*). After that, there was an interaction with *Accent*: accented direct objects elicited right-lateralized positivities relative to unaccented direct objects in sentences without *alleen*. This accent positivity was absent between 200-350 ms in sentences with *alleen* but occurred in the later time window (350-500 ms) and was weaker. The interaction was followed by a main effect of *Focus Particle* between 350-500 ms and 500-700 ms, where

[12] At central sites of accented prepositional objects, the lower order effect of *Focus Particle* was marginal ($F(1,29)=3.456$, $p=.073$), showing a positivity for accented prepositional objects in sentences with *alleen* relative to sentences without *alleen*.

sentence with *alleen* were more positive (on anterior and central sites) than sentences without *alleen*, irrespective of accentuation.

Prepositional objects elicited an early negativity (100-200 ms) in sentences with *alleen* as compared to sentences *without alleen* (left posterior negativity when unaccented, anterior negativity when accented). In the following time window (200-350 ms), the negativity had an anterior distribution for all prepositional objects. Accented prepositional objects elicited a right-lateralized positivity relative to unaccented prepositional objects (2000-500 ms). In the P600 time window (500-700 ms), there was a left anterior positivity for accented prepositional objects in sentences with *alleen* as compared to sentences without *alleen*. For unaccented prepositional objects, there were similar left-lateralized positivities, which were considerably weaker and broadly distributed.

3.4 Discussion

The goal of the present study was to investigate whether accent placement affects the neural processing of isolated sentences and whether the focus particle *alleen* facilitates sentence comprehension due to its focus anticipatory function. The results show a global effect of *alleen* on the processing of isolated sentences which takes the form of a sustained positive shift. Accentuation also affected neural processing: In sentences without *alleen,* accented direct and prepositional objects triggered a P200-like 'accent positivity'. In sentences with *alleen*, the accent positivity was present for prepositional objects but weakened and delayed for direct objects. *Alleen* modified the processing of accented prepositional objects and triggered early anterior negativities and late left anterior positivities, suggesting expectation and interpretation processes.

3.4.1 Early accent positivity for accent processing

Pitch accents triggered an early positive response when associated with direct objects (non-final position) and with prepositional objects (final position, prior to the finite verb) in isolated sentences without any focus signaling cues such as the particle *alleen* (see Figure 9, 10b, 11b). The neural correlate of pitch accent represents an early right-lateralized positivity between 200-500 ms post onset of the accented element. In line with previous findings that report a similar early positivity for accented elements, peaking around 250 ms and with a latency of 300 ms in isolated sentences (Heim & Alter, 2006; Friedrich et al., 2001) and in context (Dimitrova et al., submitted), the present effect is interpreted as belonging to the P200 component for the processing of physical stimulus differences.

As the positivity is clearly a response to the prosodic prominence of accented words, it could represent some kind of "accent positivity". The timeline and long latency of the effect (i.e., until about 500 ms) suggest that its underlying mechanism is not limited to sensory processing but rather involves the cognitive evaluation of pitch accent. The right lateralization of the positive effect is consistent with prior evidence that linguistic prosody, and in particular the accentuation of focus, activates neural processing mechanisms in the right hemisphere. Previous studies using functional magnetic resonance measures (fMRI) have shown that right superior temporal areas are involved in prosody comprehension (Hickok & Poeppel, 2000; Friederici & Alter, 2004). Frontal and temporal areas have been found to interact during prosody processing, showing activation primarily in the right frontal operculum, the right superior temporal cortex and the right temporo-frontal circuit (Friederici, 2002).

The finding of a P200-like accent positivity for pitch accents has two important implications. First, it suggests that single prominent accents in isolated sentences are not incongruous or unusual at any sentence position, as they had otherwise triggered an N400 response (Heim & Alter, 2006; Hruska & Alter, 2004). N400 effects have been previously

reported for the processing of incongruous prosody: when accent is missing on a focus element in context (Hruska & Alter, 2004; Toepel & Alter, 2004), when accent position is unusual like accents on verbs (Heim & Alter, 2006), when accent type is inappropriate in context (Schumacher & Baumann, 2010), and when accent is superfluous because the word is repeated (Toepel & Alter, 2004; Wang et al., 2011; Dimitrova et al., submitted). We conclude that both types of accent placement, in non-final and final sentence positions, are equally appropriate in the present stimuli. Secondly, the fact that the positive response is similar for accented direct and prepositional objects in sentences without *alleen* suggests that the interpretation of isolated sentences is not biased towards the expectation of default final focus with a salient accent. Rather, accent interpretation seems independent of sentence position, which is in contrast to the assumption of a broad focus structure in isolated sentences.

As discussed in the introduction, the prosody of the current stimuli did not fully correspond to the neutral downstep contour which is assumed default in isolated sentences with broad focus. Rather, in each sentence in the present study one single element stood out prosodically and carried a prominent pitch accent which may have triggered a narrow focus interpretation of the sentence. This may have been responsible for the fact that all accented elements across all conditions elicited a similar P200-like accent positivity. Our data show that prosody which suggests a dispreferred narrow focus interpretation of an isolated sentence does not lead to semantic processing difficulties or to an incongruity response (no N400). The finding is in line with previous behavioral data showing that listeners have no sentence-final bias for focus interpretation in isolated sentences and assign focus to the prosodically most prominent element (Botinis et al., 1999).

The positive ERP response to accented words in isolated sentences changed when the focus particle *alleen* was added prior to the direct object. This suggests that the brain does not process accentuation as a mere change in physical stimulus characteristics but rather links it on-line to the preceding linguistic context.

3.4.2 "Alleen" modifies accent processing

When the focus particle *alleen* occurred prior to accented direct objects, it elicited early positivities (100-200 ms) and modified the accent response to the adjacent accented direct object, which no longer elicited a right-lateralized accent positivity as in the intermediate time-window (200-350 ms) in sentences without *alleen*. The accent positivity for accented direct objects in sentences with *alleen* was weakened and delayed (350-500 ms), in contrast to the positive response to accented prepositional objects which did not change as a function of the focus particle (see Figure 10b). The presence of *alleen* modified the processing of accented prepositional objects in a different way: it elicited additional early anterior negativities (100-200 ms) and late left anterior positivities (500-700 ms) (see Figure 11b). The immediate change of neural response due to *alleen* indicates that the focus particle affects the accommodation of pitch accents and the overall sentence interpretation.

The modification of the accent positivity by the presence of *alleen* can be interpreted in two ways. First, accented direct objects in sentences with *alleen* may be fully expected because the focus particle assigns focus and accent to its adjacent element, in this case the direct object (Foolen et al., 2009; Sudhoff, 2010). The expectancy-related modification of the P200, which is weaker and delayed prior to expected accented direct objects, is in conflict with previous findings in the literature. Accents that are expected due to a focus particle in isolated sentences have been found to trigger an anterior negativity (Heim & Alter, 2006), similarly to accents that are expected due to a preceding context (Hruska & Alter, 2004). In our previous study on prosody processing in context, we did not find such expectancy effects (Dimitrova et al., submitted), presumably because unlike previous studies, we did not use a meta-linguistic prosody judgment task that affects attention and anticipatory processing.

Second, the delayed and weaker P200 for accented direct objects in sentences with *alleen* might be related to additional computations required for the processing of the focus particle, which may cause a shift in the timeline of prosody processing. The exact nature of

the temporal shift, its amplitude decrease as well as its relatedness to the P200 is subject to future research. The additional processes underlying the comprehension of the focus particle *alleen*, most likely a computation of a contrastive set, are discussed below.

Evidence for a possible expectancy effect comes from the early anterior negativities (100-200, 200-350 ms) which were elicited by accented and unaccented prepositional objects in sentences with *alleen*. The main effect of *alleen* on the processing of prepositional objects indicates that listeners may have anticipated the prosody of prepositional objects on the basis of direct objects: in each sentence with an unaccented direct object, the prepositional object was accented, and *vice versa*. However, it appears unclear why no such early negativity was found in sentences without *alleen* where the same cues were available for prosody anticipation. It is possible that the two sentence types have been processed in a qualitatively different way: in sentences without *alleen*, the identification of a pitch accent may be sufficient for focus assignment, whereas in sentences with *alleen*, listeners may pay more attention to the accentuation of adjacent and nonadjacent elements in order to choose between a preferred and a dispreferred focus analysis. The early negativity may thus reflect the memory storage of the focus particle and prior accent pattern until focus can be licensed.

Alleen affected neural processes also in the late time windows of accented prepositional objects and elicited left anterior positivities between 500-700 ms. Similar left-lateralized though broadly distributed positivities were found for unaccented prepositional objects in sentences with *alleen*. Generally speaking, late positive ERP effects reflect processes of integration of incongruous input and have been attributed to the P600 component (Hagoort et al., 1993; Kaan et al., 2000; Hoeks et al., 2004), related to the repair of syntactically ungrammatical structures (Friederici et al., 2002), the integration of new referents in the discourse (Burkhardt, 2007), and the making sense of inappropriate prosody in context (Dimitrova et al., submitted; Schumacher & Baumann, 2010).

The left anterior distribution of the late positivity in the present experiment is in line

with a number of previous findings of similar positivities which have been attributed to the processing of dispreferred (Hagoort et al., 1999) or complex ambiguous structures (Kaan & Swaab, 2003). Kaan & Swaab (2003) found a posterior P600 for the syntactic revision and repair of both dispreferred and ungrammatical structures (e.g*., I cut the cake beside the pizza(s) that <u>were</u> brought by Jill*). In contrast, anterior P600 effects were attributed to the processing of discourse complexity of ambiguous vs. simple unambiguous sentences (*I cut the cake beside the pizzas that <u>were</u> brought by Jill* vs. *The man in the restaurant doesn't like the hamburgers that <u>are</u> on his plate*). The left anterior P600 in the present sentences with *alleen* and accented prepositional objects are in line with these studies and provide evidence that dispreferred ambiguous focus structures activate mechanisms for the processing of structural complexity. The broadly distributed left P600 for unaccented prepositional objects in sentences with *alleen* may reflect similar discourse integration processes.

Overall, sentences with the focus particle *alleen* gave rise to sustained positive shifts starting 100 ms after the onset of direct objects, which likely reflect additional interpretation processes triggered by *alleen*. The underlying neural source of these positivities can be understood when one considers the results of the behavioral studies discussed in the introduction. For English, Sedivy (2002) and Ni et al. (1996) have shown that the particle *only* leads to the assumption of a contrast set and disambiguates ambiguous sentences like *Only businessmen loaned money at low rates were told to record their expenses*. In a similar vein, listeners in the current study may have been active to generate a contrast set after they perceived *alleen* in sentences like *Hij heeft alleen WATER na de training gedronken (He drank only WATER after the workout)*, for instance *only water but no coffee/ food*.[13] This process of inferring a contrast set along with the processing of accentuation should be more effortful than the mere comprehension of accentuation in sentences without *alleen*. The

[13] Note that due to the final position of the finite verb *drink*, listeners may have constructed a contrast set to *only water*, including other actions which one could perform with *water*, e.g., *buy*, *give* etc.

sustained positive shift after *alleen* in the current experiment shows that the brain is sensitive to the presence and the contrastive function of focus particles, which is consistent with previously reported positivities for the integration of new referents in the discourse (Burkhardt, 2007).

In conclusion, the current study demonstrated that pitch accents may occur at any position in isolated sentences and that they activate a similar neural mechanism: an early accent positivity in the right hemisphere. The data suggest that the processing of accents in isolated sentences interacts with the processing of other linguistic cues such as the focus particle *alleen*. *Alleen* requires additional computations of a contrast set that modify the interpretation of adjacent accents, presumably because the particle licenses a preferred focus interpretation, but it increases processing efforts in complex structures with nonadjacent accented elements.

4

Correct me if I'm wrong

Interpreting corrective and neutral accents in sentences with and without discourse context

Abstract

Two event-related brain potential studies investigated brain responses to corrective and non-corrective accents in spoken Dutch sentences like *I think TARA bought the flowers* where *TARA* carried a corrective or a non-corrective accent. Stimuli were presented in isolation (experiment 1) and in a discourse context (experiment 2). Accent-context mismatches elicited a late positivity (P600) for the making sense of incongruous prosody in the context, and the incongruous combination of non-corrective accents and corrective contexts triggered early posterior positivities already 100 ms after the onset of *TARA*. The early effect likely reflects the expectation of a specific prosodic realization projected by corrective contexts; no such expectancy effects were found in non-corrective contexts. Unlike previous studies applying a prosody judgment task, the present studies without such a task show robust effects of accentuation in the form of a late posterior positivity (P600) for corrective accents, related to finding out what needs to be corrected and carrying out this correction. The present studies show that the brain interprets fine-grained tonal differences in accentuation, also with respect to their appropriateness in the discourse context.

4.1 Introduction

In speech conversation, speakers use accents to draw attention to what is important (focus) and listeners integrate new information into the preceding context (background). Although context and wh-questions in particular are sufficient for focus identification, e.g., *Who bought the flowers? – TARA bought the flowers* (accent in capitals), the type of accent may change the interpretation of focus. With so-called neutral non-corrective accents[14], *TARA* is interpreted as new information that is added to the discourse, whereas with so-called corrective accents, *TARA* is interpreted as new information that replaces an alternative in the preceding discourse (Zimmerman & Onea, 2011). Besides by prosody, corrective focus can be signaled also by the preceding context, for instance by a statement or a yes/no-question like (*Did you know that) Petra bought the flowers? – TARA bought the flowers*. The present studies investigate whether the processing of corrective and non-corrective accents engages similar neural mechanisms in sentences with and without context and whether the brain is sensitive to the combination of different types of accent and context.

To date, no consensus exists regarding the semantic interpretation of prosody and the categorical nature of corrective vs. non-corrective accents (Pierrehumbert & Hirschberg, 1990; Ladd, 1996; Gussenhoven, 1983; Swerts et al., 2002). While some researchers propose a semantic taxonomy of prosody with distinct accents carrying distinct meanings such as *surprise* or *contrast* (Pierrehumbert & Hirschberg, 1990), others claim that accents do not carry any meaning (Ladd, 1996). To this theoretical uncertainty comes empirical cross-linguistic evidence (Table 15) that in some languages speakers use distinct pitch accents to discriminate corrective from non-corrective information. For instance, corrective focus in Greek is realized with a rising L*H accent, an annotation showing that the pitch rises from

[14] In the present paper, non-corrective new information focus is referred to as "non-corrective focus" with a corresponding "non-corrective accent", to distinguish it from "corrective focus" with a "corrective accent".

low (L) to high (H) pitch and the tonal target in the stressed syllable has a low pitch (L*) (Stavropoulou et al., 2010; notation according to the Autosegmental-Metrical Theory of Pierrehumbert, 1980). In English, corrective information is perceptually more salient than non-corrective information not due to its distinct accent type but because its surrounding elements are deaccented (Gussenhoven, 2008). Other studies on English claim that it uses prosody to disambiguate contrast: contrastive focus is signaled with rising LH* accents and neutral focus with high level H* accents (Selkirk, 2004; Watson et al., 2008). A similar distinction of accent types has been reported for German where contrastive and corrective focus is marked by an LH* accent (Alter et al., 2001) or an H*L accent (Toepel, 2005).

Table 10. Prosodic realization of corrective and non-corrective focus across languages
Pitch accents are described in accordance with the ToBI system for intonation annotation (*Tones and Break Indices*, Beckman & Ayers Elam, 1997) and the ToDI system (*Transcription of Dutch Intonation*, Gussenhoven, 2005). Pitch accents are presented as movements of high (H) and low (L) pitch, for instance rising pitch (LH) and falling pitch (HL). The tonal target in the accented syllable is indicated by an asterisk (*).

	Corrective accents	**Non-corrective accents**
English	H* + deaccentuation	H*
German	LH* or H*L	L*H
Greek	LH*	H*
Dutch	LH* or H*L	H*L

In Dutch, the language of the current study, there is conflicting evidence regarding the existence of corrective accents. Studies on human-computer interactions have shown that the prosody of the response "no" varies depending on whether the speaker intends the response as a correction or as a confirmation. When used as a correction to a preceding miscommunicated utterance (e.g., *Do you want to go from Eindhoven to Swalmen?*), the response "no" is produced with a rising L*H accent and a high boundary tone H% (Krahmer et al., 1999, 2002; Swerts et al., 2000). In contrast to the confirmative use of "no" (e.g., *Do*

you want me to repeat the connection?), the corrective use of "no" requires more prosodic effort and is louder, longer and has a higher pitch. These accentual differences are perceptually salient: listeners successfully arrive at the intended corrective or non-corrective meaning of phrases when presented with different prosodic realizations of "no" (Krahmer et al., 2002).

Although these findings suggest that correction has a distinct phonological form, the use of a specific accent type for correction has been questioned theoretically. It has been proposed that the low rise contour L*H H% (which Krahmer et al., 2002 found for correction) and the high level contour H* H% are categorically distinct (Gussenhoven & Rietveld, 2000). However, the L*H contour has not been explicitly attributed to correction (Gussenhoven, 2005), although Dutch listeners perceive L*H accents as more emphatic than neutral falling H*L accents. The perception of corrective meaning and emphasis has been attributed to more pronounced prosody, including higher pitch, later peaks and larger pitch range (Gussenhoven et al., 1997). Empirical studies suggest furthermore that when corrective focus is marked by the lexical marker "no" (e.g., *Do you want to stay in Montfort? - <u>No</u>, we want to stay in Manderen*), speakers do not discriminate correction by prosody and use non-corrective H*L accents for all focus types (Hanssen et al., 2008).

Does context compensate for the prosodic marking of correction? Neuroimaging studies suggest the contrary. While context determines the focus of an utterance, speakers signal focus also by accentuation and listeners' brains are sensitive to the presence and congruity of accents in the discourse, cf. *Did they give a bonus or a fine to the player? – They gave a fine to the PLAYER* (Dimitrova et al., submitted). In our previous study we found that listeners try to make sense of incongruous prosody in the discourse context as reflected in late positivities (P600; Kaan et al., 2000; Hoeks et al., 2004) for missing accents on focus (*fine*) and superfluous accents on background (*PLAYER*). In the current study, we speculated that in

a similar way, neural systems might be sensitive to the appropriate combination of corrective vs. non-corrective accent and context type.

The only ERP study on corrective prosody so far tested the processing of corrective and non-corrective accents in congruous and incongruous German dialogues (Toepel, 2005). Corrective contexts with focus on the object like *Did he promise to support FRAUKE?*[15] and non-corrective contexts[16] with focus on the object like *What did he promise you?* were combined with answers like *He promised to support ANNA and to clean the kitchen* where *ANNA* carried a corrective H*L or a non-corrective L*H accent[17]; these accents are categorically distinct in German. Toepel found that all incongruous accent-context combinations elicited late positive waveforms that were interpreted as instances of the *Closure Positive Shift* (CPS, Steinhauer & Friederici, 2001), a positivity elicited by prosodic phrasing in speech. Incongruous non-corrective accents in corrective contexts were judged as most inappropriate, however, their ERP effects (early negativities) were not significant. No effect of accent type was found *per se*, suggesting that the brain might not be sensitive to acoustic differences between corrective and non-corrective accents. As listeners performed a concurrent prosody judgment task, this may have shifted their attention towards prosodic congruity. Furthermore, Toepel's conditions differed also with respect to the size of the focus domain projected by the context (larger for non-corrective accents and narrow for corrective accents), which might have interfered with the processing of fine-grained tonal differences. It is also possible that phrase boundaries prior to the target *Anna* have increased the variability across conditions, making it more difficult to detect subtle accentual differences.

[15] Note that the accent on FRAUKE suggests that it is intended as a to-be-corrected or to-be-confirmed assertion, hence the question projects a narrow focus structure with object focus of the upcoming answer.

[16] Note that Toepel (2005) uses the terms "correction focus" vs. "novelty focus" to distinguish the conditions.

[17] Interestingly, German accent types have the opposite direction as compared to Dutch: Dutch L*H denotes correction and a Dutch H*L marks neutral non-corrective information.

To avoid inference from task-related processes on listeners' attention that may modify neural responses to incongruous prosody (Toepel & Alter, 2004; Astesano et al., 2004), the present ERP study used a natural paradigm with strictly controlled stimuli and without any judgment of prosodic congruity. It was hypothesized that if listeners are sensitive to differences in accent type, this should be reflected in a main effect of accent. The main effect may reflect a preference for L*H accents to mark corrective focus and H*L accents to mark neutral focus. If listeners take contextual information into account and anticipate corrective and neutral accents, the incongruity of prosody-context combinations may be reflected in early and late positive ERP effects that have been previously reported for the processing of prosodic incongruity (Dimitrova et al., submitted).

4.1.1 The present study

The present study investigated how the brain handles corrective and non-corrective accents in Dutch and whether prosody processing is affected by the type of preceding discourse context. Sentences with corrective L*H accents and non-corrective H*L[18] accents were presented in isolation (experiment 1) or embedded in short dialogues (experiment 2). In experiment 2, two types of context were used, a non-corrective context with a wh-question like *Who bought the flowers?* that did not contain information to correct, and a corrective context with a yes/no-question like *Did you know that Maria bought the flowers?* that provided an alternative (underlined) that could be corrected. Unlike the different focus types in Toepel's study (2005), all conditions in the present experiments had a narrow focus on the subject. This was not expected to be problematical since previous studies suggest that isolated sentences with single prominent accents do not cause any processing difficulties (Botinis et al., 1999).

[18] Note that H*L accents were elicited in neutral contexts with wh-questions and hence, H*L accents did not contain any excessive pitch height or pitch slope variation that would have suggested correction. This is supported by the offline rating of the stimuli (section 2.2.2) and their acoustic analysis (section 2.2.2.3).

Target sentences in the present study always started with the phrase *volgens mij*, lit. "according to me", which can be best translated as "I think" (*I think TARA bought the flowers*) and which allows for factual statements that are appropriate with corrective and non-corrective readings. *Volgens mij* is frequent in Dutch and introduces an epistemic uncertainty that allows material in the question to be repeated. Since *volgens mij* inverts subject and verb positions in Dutch (*volgens mij*-verb-subject), targets in the present study were clearly not in the vicinity of the sentence initial boundary that may elicit early sensory effects and modify the neural response to accentuation (Heim & Alter, 2006). Importantly, *volgens mij* does not introduce an adjacent prosodic boundary itself[19] that may have independent effects on ERP components to information processing, such as the CPS (Steinhauer & Friederici, 2001). This is supported by the stimulus recordings that did not provide evidence for a phrase boundary after *volgens mij*. The accent on the subject *TARA* is thus the only cue that disambiguates corrective and non-corrective readings of the target sentences.

Special care was taken to match sentences with corrective and non-corrective prosody on the following parameters: sentence length (in words), target word frequency, and syntactic structure. Experimental stimuli were designed to account for the fact that semantic and prosodic processing may interfere, since Wang et al. (2011) have shown that accented focus triggers the deepest semantic processing and elicits the largest neural response to incongruity (underlined), cf. *What kind of vegetable did mum buy for a dinner today? – Today mum bought EGGPLANT/ <u>BEEF</u> for dinner*. To minimize elaborative semantic processing of targets that may affect prosody processing, targets in the present study were always semantically shallow proper names like *TARA*. All targets had lexical stress on the initial syllable that always contained a long vowel in order to avoid variation in accent identification

[19] Unlike "volgens mij", the English translation "in my opinion" strongly suggests a phrase-final comma intonation.

points (Ladd et al., 2000). These strict stimulus matching procedures allow for an unequivocal interpretation of the neural mechanisms engaged in natural prosody processing.

Table 11. Experimental conditions

In experiment 1 only the answers were presented as single isolated sentences, whereas in experiment 2 questions and answers were presented together as a dialogue. Pitch contours corresponding to experimental conditions are displayed in Figure 21a and 21b and are annotated according to ToDI (Gussenhoven, 2005).

Question **Non-corrective context (wh-question)**	**Answer** **Non-corrective prosody**	**Corrective prosody**
Wie heeft de bloemen gekocht? *Who bought the flowers?*	Volgens mij heeft TARA de bloemen gekocht. *I think TARA bought the flowers.*	
ToDI	%L **H*L** L%[20]	%L **L*H** L%

Question **Corrective context (yes/no question)**	**Answer** **Non-corrective prosody**	**Corrective prosody**
Wist jij dat Maria de bloemen heeft gekocht? *Did you know that Maria bought the flowers?*	Volgens mij heeft TARA de bloemen gekocht. *I think TARA bought the flowers.*	
ToDI	%L **H*L** L%	%L **L*H** L%

4.1.2 Offline tests

The purpose of the offline tests was to measure how listeners judge the appropriateness of different accent-context combinations (offline test 1) and how they interpret accents when no context is available (offline test 2). In particular, offline test 2 aimed to show whether listeners disambiguate rising L*H accents as corrective and falling H*L accents as non-corrective. A subset of the stimulus material of the two ERP experiments was used.

[20] The initial boundary tone annotated here as %L (Figure 14 a and 14b) can be further differentiated regarding pitch direction: it has level pitch in the non-corrective condition, and a falling pitch in the corrective condition.

4.1.2.1 Offline test 1

Offline test 1 investigated whether listeners perceive the two types of pitch accents used by our speakers as categorically distinct, that is L*H as corrective and H*L as non-corrective, and tested their appropriateness with respect to a preceding question. Seventeen Linguistics students who did not participate in the ERP experiments listened to a subset of the experimental dialogues (for details see Materials section in Experiment 1) and decided if question and answer matched, on a scale from 1 (=very bad match) to 7 (=very good match); no definition of match was provided. To define the ends of the rating scale, we added fillers from the experiment presented in chapter 2 where match came about when focus was accented[21] as in *Did they give a bonus or a fine to the player? – They gave a BONUS to the player* and mismatch when background was accented as in *Did they give a bonus or a fine to the player? – They gave a bonus to the PLAYER*.

Figure 12 shows that unlike incongruous accent placement, the inappropriate use of accent type, i.e., the combination of non-corrective H*L accents and corrective L*H accents with corrective and non-corrective questions respectively, was not considered a mismatch. This suggests that none of the accents was judged as unnatural or mismatching. The results of an ANOVA test showed a significant interaction of *Accent* (corrective L*H vs. non-corrective H*L) and *Context* (corrective yes/no question vs. non-corrective wh-question) ($F(1,16)=39.5$; $p<.001$). Follow-up analyses revealed that the match between non-corrective accents and congruous non-corrective contexts was judged to be significantly higher than the three other conditions, which did not differ significantly. To shed light on how pitch accents are interpreted and whether they carry any semantic meaning, listeners were asked to reconstruct the preceding context of sentences with different prosody in offline test 2.

[21] Accents in filler sentences were always non-corrective H*L accents.

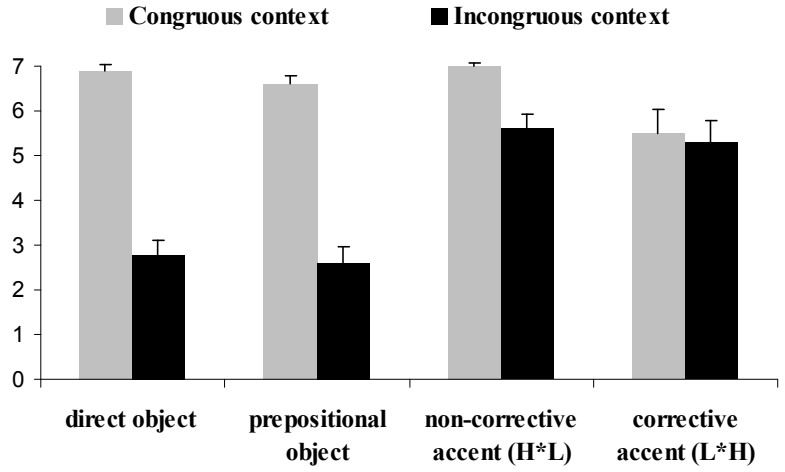


Figure 12: Results offline test 1

In offline test 1, participants listened to dialogues where the focus of the question was (mis)matched in the answer, either by accent placement (left two conditions) or by accent type (right two conditions). In case of accent placement, sentences with accented direct object like *They gave a BONUS to the player* and with accented prepositional object like *They gave a bonus to the PLAYER* were combined with questions with focus on the direct object *Did they give a bonus or a fine to the player?* and with focus on the prepositional object *Did they give a bonus to the player or the trainer?* In case of accent type, sentences like *I think TARA bought the flowers* were presented with a non-corrective H*L accent or a corrective L*H accent on *Tara* and combined with non-corrective wh-questions like *Who bought the flowers?* and corrective yes/no questions like *Did you know that Maria bought the flowers?*. The data show how listeners judged the combination of question and answer: as a match (grey bars) or a mismatch (black bars), on a scale from 1 (very bad fit) to 7 (very good fit).

4.1.2.2 Offline test 2

The goal of offline test 2 was to investigate whether distinct pitch accents evoke different interpretations when no constraining context is present. In Dutch, speakers have been found to produce corrective information with an L*H accent (Krahmer et al., 1999, 2002) or an H*L accent (Hanssen et al., 2008). A good way to test how these accents are perceived is to ask listeners to reconstruct the preceding context of sentences with different accents (Swerts & Krahmer, 2001; Swerts et al., 2002). Using a perceptual paradigm, Swerts and Krahmer found that contrast and non-contrast are discriminated prosodically in Dutch even though

they are both realized with H*L accents. When listeners perceive a phrase like *BLUE square* with contrastive prosody, they reconstruct a contrastive context such as *RED square*. This suggests that the accent on *BLUE* and the deaccentuation of *square* are interpreted as implying contrast on the adjective *BLUE.*

To test whether a similar semantic discrimination exists for the H*L and L*H accents in Dutch, 15 naive first-year Linguistics students were asked to listen to a subset of the experimental sentences in isolation (e.g., *I think TARA bought the flowers*) where the target *TARA* carried an H*L or an L*H accent. Stimuli were counterbalanced with filler sentences that never started with *I think* (Dutch *volgens mij*) and where the target always received H*L accents but varied in accent position (*They gave a BONUS to the player* vs. *They gave a bonus to the PLAYER*). Participants guessed what the preceding context of these sentences might have been (no options were given) and wrote down their response on a blank sheet.

The results of offline test 2 show that listeners varied with respect to their prosodic sensitivity and interpretation, possibly due to differences in introspective ability and general linguistic awareness. After hearing *I think TARA bought the flowers*, 8 out of the 15 participants reconstructed a corrective statement with an alternative to *Tara*, such as *John bought the flowers,* but only when *Tara* carried an L*H accent. This suggests that listeners interpreted L*H accents as implying correction and engaged additional processing costs to construct an imaginative context where this correction can be licensed. When *Tara* carried an H*L accent, a wh-question like *Who bought the flowers?* was reconstructed that did not contain any alternative. The data in Figure 13 show that some participants provided a corrective context also for sentences with H*L accents when they started with *volgens mij*, possibly because the phrase can frame contrast between speaker's and other's views. The remaining participants did not discriminate L*H and H*L accents on *Tara* and always reconstructed wh-questions like *Who bought the flowers?*.

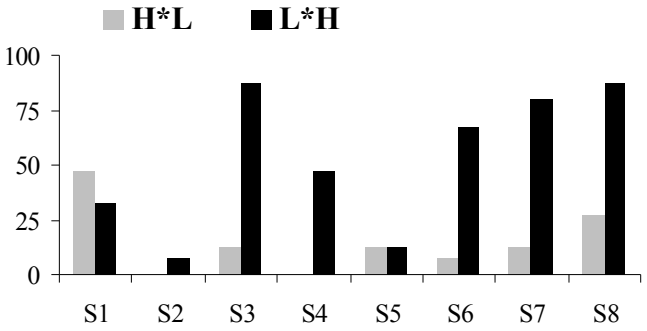


Figure 13. Results offline test 2

Offline test 2 investigated whether corrective L*H accents lead to the reconstruction of a corrective preceding context when participants (n=15) listen to sentences like *I think TARA bought the flowers* where *Tara* carried an L*H or H*L accent. The figure displays only prosody-sensitive subjects (n=8, x-axis) and shows how often they reconstructed a corrective context like *John bought the flowers* (in percentage, y-axis) when *Tara* carried a corrective L*H accent (black bars, congruous) or a non-corrective H*L accent (grey bars; incongruous). The other participants (n=7, not displayed) were not sensitive to prosody and reconstructed a wh-question to all sentences.

In sum, offline tests 1 and 2 have shown that corrective meaning can be perceptually disambiguated by the type of pitch accent in Dutch. Without a preceding context, different accents can trigger different assumptions regarding the preceding discourse context: some listeners assume that L*H accents signal correction, while others never assume correction. When embedded in a discourse context, L*H and H*L accents are considered equally appropriate in corrective and non-corrective contexts.

4.2 Experiment 1: Corrective prosody in isolated sentences

Experiment 1 investigates whether and how the brain responds to different pitch accents in isolated sentences without a preceding context such as corrective L*H or non-corrective H*L accents. To provide evidence for the functionality of prosody in naturalistic paradigms, no prosody judgment task was employed but only an infrequent comprehension task that guaranteed overall awareness and attentive stimulus processing (Dimitrova et al., submitted).

4.2.1 Methods

4.2.1.1 Participants

Thirty-one right-handed Dutch native speakers (19 female, age 18-29, mean 21) with normal or corrected-to-normal vision participated in the experiment after signing an informed written consent in accordance with the Declaration of Helsinki. None of the participants reported any neurological, psychological, language or hearing disabilities or studied Linguistics. Inclusion criterion was set to 60 % valid data on an electrode in any condition, and as a result, four other female participants were discarded due to data loss of more than 40 %.

4.2.1.2 Materials and procedure

Materials were 120 sentence items comparable to *Volgens mij heeft Tara de bloemen gekocht* (English *I think Tara bought the flowers*) that started with *volgens mij* (English *I think*), followed by an auxiliary verb *heeft* and the subject *Tara* that carried an H*L or an L*H accent. Of main interest was whether the fine-grained tonal differences in these two pitch accents would modify their semantic interpretation. To reduce interference between the processing of prosody and the semantic activation of target meanings, only proper names were selected as targets because they are semantically shallow. All proper names were matched for frequency on the basis of number of hits each received in the Dutch part of the

Google website. Variability in accent detection times was avoided by choosing targets with lexical stress on the initial syllable, which also had a long vowel (Ladd et al., 2000).

After constriction of the experimental materials, stimuli were recorded in a natural elicitation paradigm. Target sentences were embedded in short dialogues (see Table 11) and were preceded by two questions types: a yes/no question with an alternative, which provides the corrective context (*Did you know that Maria bought the flowers?*), and a wh-question without an alternative, which provides the non-corrective context (*Who bought the flowers?*). To ensure that stimuli were pronounced naturally, two phonetically naive Dutch native speakers recorded the dialogues at a normal speech rate. Speakers were instructed to distinguish the different contexts in their pronunciation but to avoid a pause after *volgens mij*. This instruction was in line with the naturalness of prosodic phrasing in Dutch, as *volgens mij* does not introduce phrase-final comma intonation. It is possible that the instruction to avoid prosodic boundaries after *volgens mij* may have prevented participants from using phrasing for disambiguation and as a result, participants may have been forced to use pitch accents for disambiguation. However, this instruction did not imply that distinct pitch accent types may be used: participants had the opportunity to strengthen accents phonetically (e.g., higher peaks, larger duration) and to disambiguate a corrective from a non-corrective reading.

After corrective and non-corrective question contexts, the target in the answer was discriminated phonologically by L*H and H*L accents respectively (see *Acoustic analysis*). In the following, L*H accents are referred to as 'corrective accents', and H*L accents as 'non-corrective accents'. Special care was taken to avoid any phrase boundaries or prosodic breaks in the vicinity of targets. All utterances with disruptions and hesitations were repeated at the end of the recording session. From all 240 dialogues (120 items x 2 conditions), in experiment 1 only the answers (n=240) were presented as isolated sentences and were distributed over two lists of 120 sentences using the Latin square format. In each list, half of

the stimuli contained a non-corrective accent on the subject (n=60) and the other half contained a corrective accent on the subject (n=60).

4.2.1.3 Acoustic analysis

Acoustic analysis was performed in PRAAT (Boersma & Weenink, 2010) and included measures of the timing, acoustic duration and fundamental frequency (f0) of targets and their surrounding elements. Table 12 shows that overall sentence length did not vary per condition and targets in corrective and non-corrective sentences had similar acoustic duration. The f0 data in Table 12 show that L*H accents had a higher absolute maximal pitch and a larger pitch slope (difference between f0 max and f0 min) than H*L accents.

Table 12. Acoustic stimulus characteristics

Acoustic data are presented for all segments in target sentences: pre-subject (sentence onset-subject onset), subject (target *TARA*), post-subject (subject offset-verb onset), verb (finite verb at sentence end). Duration is measured in milliseconds (ms), and fundamental frequency (f0) in Hertz (Hz). The difference between maximal and minimal frequency (max f0-min f0) defines the pitch range of the corresponding segment. The position of the pitch peak (H) is measured in milliseconds with respect to its distance from target's onset and irrespective of f0.

	Duration				**Minimal f0**				**Maximal f0**			
	H*L		L*H		H*L		L*H		H*L		L*H	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Pre-subject	372	39	355	46	172	37	138	22	224	17	190	18
Subject	354	53	372	53	167	26	189	39	242	24	288	30
Post-subject	525	168	510	156	141	15	186	27	177	40	250	21
Verb	589	98	563	104	130	26	171	18	177	49	223	57
Distance H - target onset	155	46	233	40								

In a next step, the prosody of all sentences was transcribed according to the ToDI framework (*Transcription of Dutch Intonation*, Gussenhoven, 2005). Figure 14a plots all sentences in the corrective condition that were answers to yes/no questions, and Figure 14b displays all sentences in the non-corrective condition that were answers to wh-questions. The two conditions differ regarding their pitch contours and the type of pitch accents used. Targets in corrective sentences were realized with L*H accents that were part of a pitch contour %L L*H L%[22], also referred to as "delayed fall". Targets in non-corrective sentences were realized with H*L accents that were part of a pitch contour %L H*L L%, called "fall" (Gussenhoven, 2005). The results suggest that speakers signal correction phonologically by pitch accents rather than phonetically by acoustic strengthening of H*L accents. No pauses or phrase breaks occurred after *volgens mij* or anywhere else in the utterance. The plots show pitch differences preceding the critical accents in the two conditions: *volgens mij* has a falling pitch before L*H accents (Figure 14a) and a level pitch before H*L accents (Figure 14b).

[22] In the ToDI framework, % is used to mark a boundary tone, and both initial boundary tones (here %L) and final boundary tones (here L%) are transcribed (Gussenhoven, 2005).

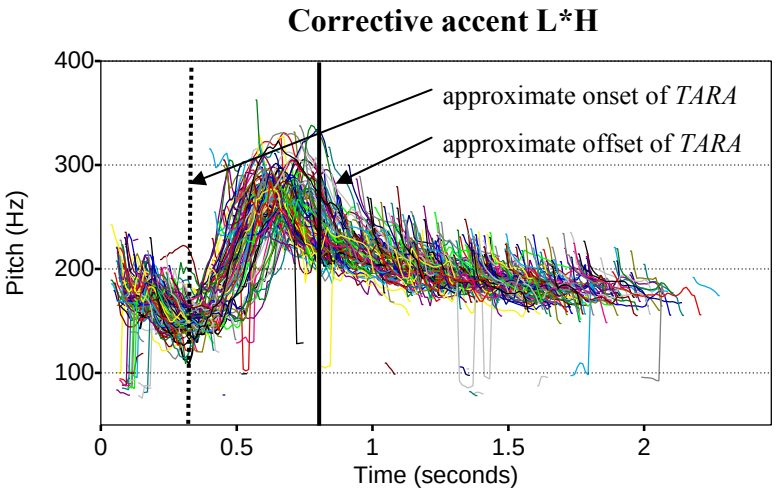


Figure 14a: Pitch contours of target sentences in the corrective condition

The figure displays all instances of target sentences in the corrective condition (after yes/no questions). The target TARA is realized with a rising accent, transcribed here as L*H (ToDI system, Gussenhoven, 2005), showing that the pitch in the target syllable moves from a low pitch target (L) to a high pitch target (H). The pitch valley is realized at the onset of the accented syllable, and the low tone target is marked with an asterisk (*). No silent pauses, boundaries or disruptions were produced and all answers have very consistent contours.

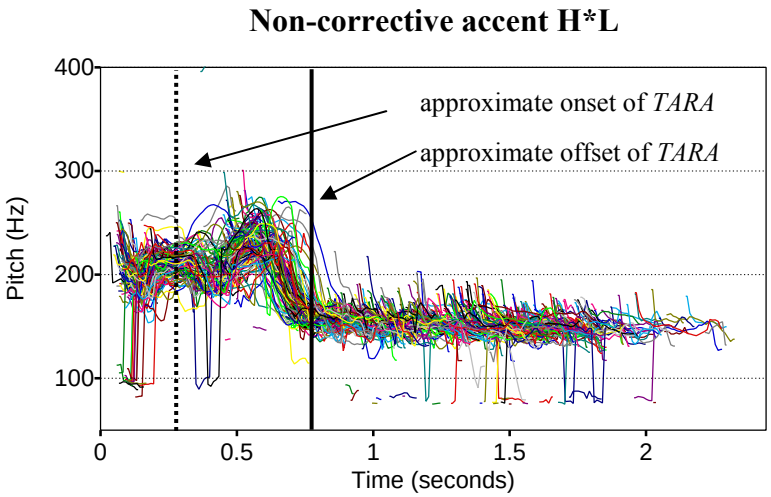


Figure 14b: Pitch contours of target sentences in the non-corrective condition

The figure displays all instances of target sentences in the non-corrective condition (after wh-questions). The target TARA is realized with a falling accent, transcribed here as H*L (ToDI system, Gussenhoven, 2005), showing that the pitch in the target syllable moves from a high pitch target (H) to a low pitch target (L). The pitch peak occurs within the accented syllable and represents a high tone target marked with an asterisk (*), while the pitch valley occurs at it's the syllable offset. No silent pauses, boundaries or pitch disruptions were produced and all answers have very consistent prosodic contours.

4.2.1.4 EEG procedure and recordings

Participants were seated in an electrically shielded room and performed a trial session before the actual experiment that consisted of two experimental blocks. To avoid eye movement artifacts during the auditory stimulus presentation (via loudspeakers), participants fixated a black cross against a grey screen that appeared 100 ms before the start of the sound file and remained there for additional 500 ms after the sentence end. In 25 % of all trials, a probe word appeared on the screen after the last silence period and participants judged whether it was semantically related to the preceding sentence; correct and incorrect responses were counterbalanced. After the response or otherwise after the silence period in trials without a probe word, a blinking period of 2000 ms was initiated.

The EEG was recorded at 250 Hz from 64 Ag/AgCl channels that were placed according to the international extended 10-20 system (Electro Cap International) and amplified against the average of all connected inputs of the amplifier (TMS international). The amplifier measured DC without a highpass filter but with a digital FIR filter (cutoff frequency of 67.5 Hz) to avoid aliasing effects. After recording, electrodes were re-referenced to the algebraic average of left and right mastoid electrodes. Vertical eye movements and blinks were monitored via electrodes below and above the left eye, and horizontal movements from electrodes at the left and right canthus of each eye. Impedances were kept below 5Ω. All data were filtered offline with a band-pass filter of 0.01-30 Hz.

4.2.1.5 EEG analysis

Trials with movement and ocular artifacts or electrode drifts (± 75 μV voltage maximum) were rejected. Number of rejected trials did not differ across conditions. ERPs were time-locked to the acoustic onset of each target, and EEG analysis was performed on 97.5 % data.

Upon visual inspection, two time windows were selected: an *Early P600 time window* 500-700 ms post target onset, and a *Late P600 time window* 700-1000 ms post target onset.

Average ERPs were computed for a number of Regions of Interest (ROI's) as the average over several electrodes. Lateral ROIs included: *left anterior* (FP1, AF3, F3, F5, F7)[23], *right anterior* (FP2, AF4, AF8, F4, F6, F8), *left central* (FC3, FC5, C3, C5, CP3, CP5), *right central* (FC4, FC6, C4, C6, CP4, CP6), *left posterior* (P3, P5, P7, PO3, PO7, O1), and *right posterior* (P4, P6, P8, PO4, PO8, O2). Midline ROIs included: *anterior* (FPz, AFz, Fz), *central* (FCz, Cz, CPz), and *posterior* (Pz, POz, Pz). Repeated measures ANOVAs were conducted separately for the set of lateral ROIs and for the set of midline ROIs. For lateral electrodes, ANOVAs were calculated with three within-subject factors: *Accent* (non-corrective H*L accent vs. corrective L*H accent), *Anteriority* (anterior vs. central vs. posterior region), and *Hemisphere* (left hemisphere vs. right hemisphere). ANOVAs for midline ROIs included only the factors *Accent* and *Anteriority*. Statistical analyses were performed on mean voltage values and adjusted with the Huynh-Feldt correction for nonsphericity where appropriate. We used a 200 ms pre-stimulus baseline correction on segments of 1300 ms length that were time-locked to the acoustic onset of each target.

4.2.2 Results

4.2.2.1 Behavioral results

In 25 percent of all trials participants judged whether a probe word was semantically related to the preceding sentence. The average task performance of 91 % correct responses suggests that participants paid attention to the stimuli. Incorrect responses were distributed equally across experimental conditions.

[23] The AF7 electrode was not included in the left anterior ROI since it produced artifacts in most of the participants.

4.2.2.2 ERP results

Statistical results are presented in Table 13, and ERP data in Figure 15. Effects involving *Hemisphere* and *Anteriority* are discussed only if they interact with the factor *Accent*.

Table 13: Statistical results experiment 1

Table 13 presents the results of ANOVAs for experiment 1**.** Abbreviations: ACC=Accent, ANT=Anteriority, HEM=Hemisphere. Only effects and interactions that were significant in at least one time window are displayed. Marginal effects with .05<p≤.1 are included for future reference and are presented in italics.

		500-700 ms		**700-1000 ms**	
Experiment 1	***df***	F	p	F	p
Lateral					
ACC	*1,30*	12.976	.001	13.313	.001
ACC x ANT	*2,60*	3.940	.046		
ACC x ANT x HEM	*2,60*			2.955	*.076*
Midline					
ACC	*1,30*	13.757	.001	10.138	.003

4.2.2.2.1 Early P600 time window 500-700 ms

There was a main effect of *Accent* on lateral (F(1,30)=12.976, p=.001) and midline electrodes (F(1,30)=13.757, p=.001), showing positive waveforms for corrective accents relative to non corrective accents. This effect was modified by an *Accent* x *Anteriority* interaction on lateral electrodes (F(2,60)=3.940, p<.05), suggesting that the positivity for corrective accents had a central (F(1,30)=11.89, p<.01) and posterior distribution (F(1,30)=15.419, p<.001).

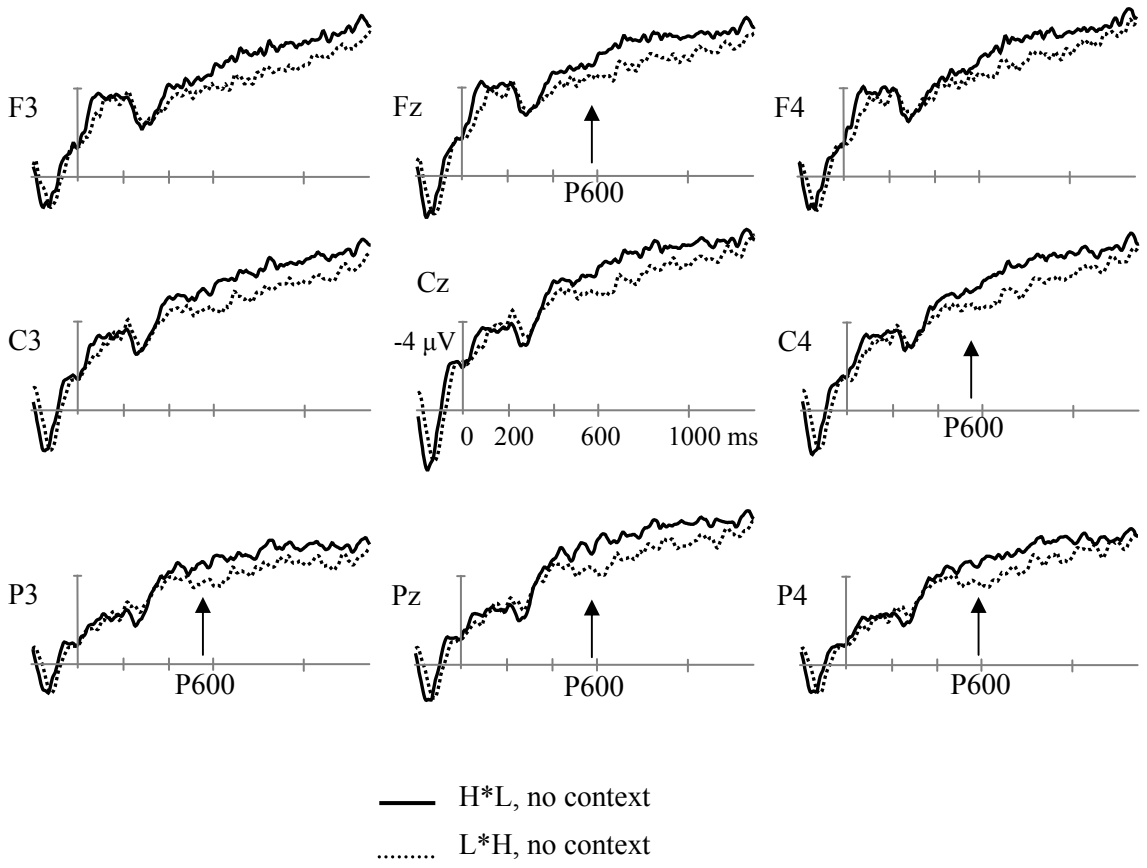


Figure 15. Effect of Accent (H*L vs. L*H) in sentences without context (experiment 1)
ERPs are time locked to the acoustic onset of the target *Tara* in isolated sentences from experiment 1 such as *I think TARA bought the flowers*, where *Tara* received a non-corrective H*L accent (solid lines) or a corrective L*H accent (dotted lines). ERPs display segments of 1300 ms length and show an effect of *Accent* in the form of a P600-like positivity for corrective L*H accents which is significant in the 500-1000 ms time window.

4.2.2.2.2 Late P600 time window 700-1000 ms

There was a main effect of *Accent* on lateral ($F(1,30)=13.313$, $p=.001$)[24] and midline electrodes ($F(1,30)=10.138$, $p<.01$), again due to a positivity for corrective accents relative to non-corrective accents.

[24] There was also a marginal *Accent* x *Anteriority* x *Hemisphere* interaction ($F(2,60)=2.955$, $p=.08$) on lateral electrodes that was due to the posterior and slightly right-lateralized distribution of the positivity.

4.2.3 Discussion

Experiment 1 investigated whether the brain is sensitive to differences in the accent type of accented words in isolated sentences. Corrective L*H accents elicited a centro-posterior positivity between 500-1000 ms after the onset of the critical stimulus. The positivity may be related to the processing of acoustic stimulus characteristics such as the larger pitch slope and the higher pitch of L*H accents as compared to H*L accents. However, this interpretation appears implausible since the discrimination of the acoustic signal occurs immediately when a stimulus comes in. Generally speaking, physical stimulus differences elicit early neural responses in the form of early *negativities* such as the *Mismatch Negativity* (MMN, for a review, see Näätänen, 1995) or early *positivities* such as the P200 for the processing of falling pitch (Friedrich et al., 2001) or accentuation (Heim & Alter, 2006). Although the pitch accents used in the current study have distinct pitch direction, i.e., corrective accents had a rising pitch, and non-corrective accents had a falling pitch, the positivity for corrective L*H accents is unlikely to belong to the P200 due to its late onset around 500 ms that implies a cognitive processing of the stimulus.

The late positivity for corrective accents likely reflects their functional semantic interpretation and belongs to the family of P600 components for making sense of an utterance (e.g., Hoeks et al., 2004; Kaan et al., 2000), here the making sense of corrective emphasis by constructing a hypothetical discourse with an alternative. This interpretation is supported by the results of offline test 2 which show that listeners interpret L*H accents as corrective and come up with explicit alternatives in a hypothetical context. Alternatively, the late positivities might reflect revision processes if listeners disprefer corrective accents in isolated sentences due to the absence of context where correction can be licensed. Similar late positive effects have been reported for the integration of incongruous non-corrective prosody in the discourse (Dimitrova et al., submitted; Schumacher & Baumann, 2010). Understanding the neural source of this late positivity requires further investigation, since experiment 1 does allow any

conclusions about how discourse may impact prosody interpretation. If corrective accents were incongruous due to the lack of a context in isolated sentences, their inappropriateness should disappear as soon as they are embedded in a biasing context.

4.3 Experiment 2: Corrective prosody in sentences with context

To test whether discourse context affects the processing of corrective accents, sentences from experiment 1 were embedded in congruous and incongruous dialogues in experiment 2. Of main interest was the underlying source of the late positivity for corrective accents that was found in experiment 1. If the effect was due to the infelicity of corrective accents in isolated sentences, it should disappear as soon as they are embedded in constraining contexts. If the positivity was due to the interpretation of L*H accents as corrective, similar effects were expected to occur in context. As in experiment 1, no prosodic task was used.

4.3.1 Methods

4.3.1.1 Participants

Twenty-eight right-handed Dutch native speakers (9 male, age 18-29, mean 21), none of whom were Linguistics students, were paid for participation after signing an informed written consent according to the Declaration of Helsinki. Participants had normal or corrected-to-normal vision. None reported any neurological, psychological, language or hearing disabilities. Inclusion criterion was set to 60 % valid data on any electrode in any condition, and additional seven participants (five male) were excluded due to artifacts of more than 40 %. No participant took part in experiment 1 or the offline studies.

4.3.1.2 Materials and procedure

120 sentence items used in experiment 1 (*I think TARA bought the flowers*, see Table 11) were embedded in short dialogues that projected two different focus readings. In the corrective focus condition, target sentences were preceded by yes/no questions like *Did you know that Maria bought the flowers?* that contained an alternative, i.e., *Maria*, to the target *Tara* in the answer. In the non-corrective focus condition, target sentences were preceded by wh-questions like *Who bought the flowers?* where no alternative was present. In addition to the different contexts, targets varied also with respect to their accentuation and carried either a non-corrective H*L accent or a corrective L*H accent.

All 240 congruous dialogues recorded for experiment 1 (120 items x 2 conditions) were re-used in the congruous conditions and duplicated and recombined to generate the incongruous conditions. Incongruity refers to the inappropriate combination of corrective contexts (yes/no questions) and answers with non-corrective prosody and *vice versa*. A total of 480 stimuli (120 items x 2 context types x 2 accent types) were assigned to four experimental lists with 120 dialogues each using the Latin square format. Each dialogue was presented in all four conditions, and no participant listened more than once to any dialogue across all conditions. Target sentences in experiment 1 and 2 were physically identical.

4.3.1.3 Acoustic analysis

The acoustic characteristics of target stimuli were identical to experiment 1.

4.3.1.4 EEG procedure and recordings

EEG procedure was similar to experiment 1. Stimuli were presented auditorily via loudspeakers. After a 100 ms delay, a question was presented (average duration of wh-questions = 2000 ms, yes/no-questions = 2700 ms), followed by silence (500 ms), the answer (average duration of 2000 ms), and silence again (1500 ms). In 25 % of all trials, after the last

silence period a probe word was displayed on the screen and listeners judged whether it was semantically related to the preceding dialogue. After the response or otherwise after the last silence period in trials without a task, a blinking phase was initiated (2000 ms). The recording of the EEG signal was identical to experiment 1.

4.3.1.5 EEG analysis

EEG analysis was performed on 98.3 percent valid data. The amount of excluded data did not differ across conditions. Data analysis and ROI selection was as described in experiment 1. In addition to the *Early P600 time window* (500-700 ms) and the *Late P600 time window* (700-1000 ms) in experiment 1, two further time windows were analyzed: *Early time window* (100-300 ms) and *N400 time window* (300-500 ms) post target onset. Repeated measures ANOVAs were conducted with the factors *Accent* (non-corrective H*L vs. corrective L*H accent), *Congruity* (congruous vs. incongruous context), *Anteriority* (anterior vs. central vs. posterior regions), and *Hemisphere* (left vs. right hemisphere). In congruous contexts, accent type and context type match, and in incongruous contexts, the combination of accent and context represents a mismatch (e.g., non-corrective H*L accents in corrective contexts, and corrective L*H accents in non-corrective contexts). ERPs were time locked to the acoustic onset of each target using a 200 ms pre-stimulus baseline on segments of 1300 ms length.

4.3.2 Results

4.3.2.1 Behavioral results

In 25 % of all trials, participants judged the semantic relatedness of a probe word to the preceding dialogue and gave on average 93 % correct responses, which shows that they attended to the stimuli. Incorrect responses did not differ between experimental conditions.

4.3.2.2 ERP results

Statistical results are displayed in Table 14 and ERP data in Figures 16, 17 and 18. Effects of *Hemisphere* and *Anteriority* are discussed only if they interact with the cognitive factors.

Table 14: Statistical results experiment 2

Table 14 presents statistical data for experiment 2. Abbreviations: ACC=Accent, ANT=Anteriority, CONG=Congruity, HEM=Hemisphere. Only effects and interactions that were significant in at least one time window are presented. F values with $p \geq .1$ are not included, and all marginal results with $.5<p\leq 1$ are included for future reference. Marginal p-values are presented in italics.

Experiment 2		**100-300 ms**		**300-500 ms**		**500-700 ms**		**700-1000 ms**	
	df	F	p	F	p	F	p	F	p
Lateral									
ACC	*1,27*	3.068	*.091*	4.013	*.055*	9.167	.005	8.440	.007
ACC x ANT	*1,27*					5.083	.027		
ACC x CONG x ANT	*2,54*	5.225	.015						
ACC x HEM	*1,27*			3.310	*.08*	3.638	*.067*		
ACC x ANT x HEM	*2,54*							3.212	*.056*
CONG x ANT x HEM	*2,54*			2.745	*.091*	4.346	.033		
ACC x CONG x ANT x HEM	*2,54*					3.024	*.060*		
Midline									
ACC	*1,27*	3.182	*.086*	5.349	.029	11.613	.002	10.273	.003
CONG	*1,27*					3.844	*.060*		
ACC x CONG x ANT	*2,54*	2.724	*.076*						

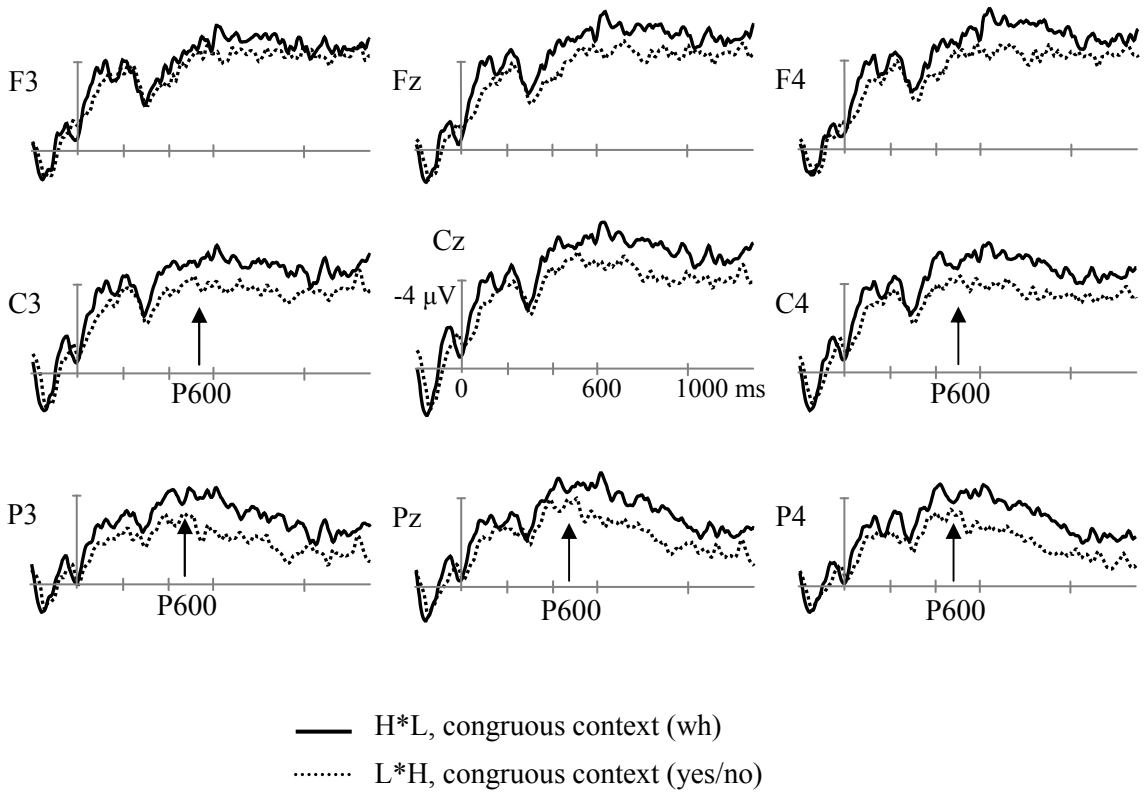


Figure 16. Effect of Accent (H*L vs. L*H) in congruous contexts (experiment 2)
ERPs display congruous target sentences like *I think TARA bought the flowers* from experiment 2 where *TARA* carries a non-corrective H*L accent (black solid lines) after a wh-question (*Who bought the flowers*), or a corrective L*H accent (black dotted lines) after a yes/no question (*Did you know that Maria bought the flowers?*). ERPs are time locked to the acoustic onset of *TARA* and display segments of 1300 ms length. The *Accent* effect is significant between 300-500 ms (midline sites), 500-700 ms (centro-parietal), and 700-1000 ms (broadly distributed) and represents a P600-like positivity for congruous corrective L*H accents.

4.3.2.2.1 Early time window 100-300 ms

There was a significant interaction of *Accent* x *Congruity* x *Anteriority* ($F(2,54)=5.225$, $p<.05$) that was followed up with *Accent* as the split variable. For non-corrective accents, the interaction of *Congruity* x *Anteriority* was significant ($F(2,54)=4.391$, $p<.05$) and revealed a positive effect of *Congruity* on posterior regions ($F(1,27)=4.178$, $p=.05$). Thus, non-corrective accents triggered posterior positivities in incongruous corrective contexts relative to congruous non-corrective contexts. For corrective accents, there was neither an interaction

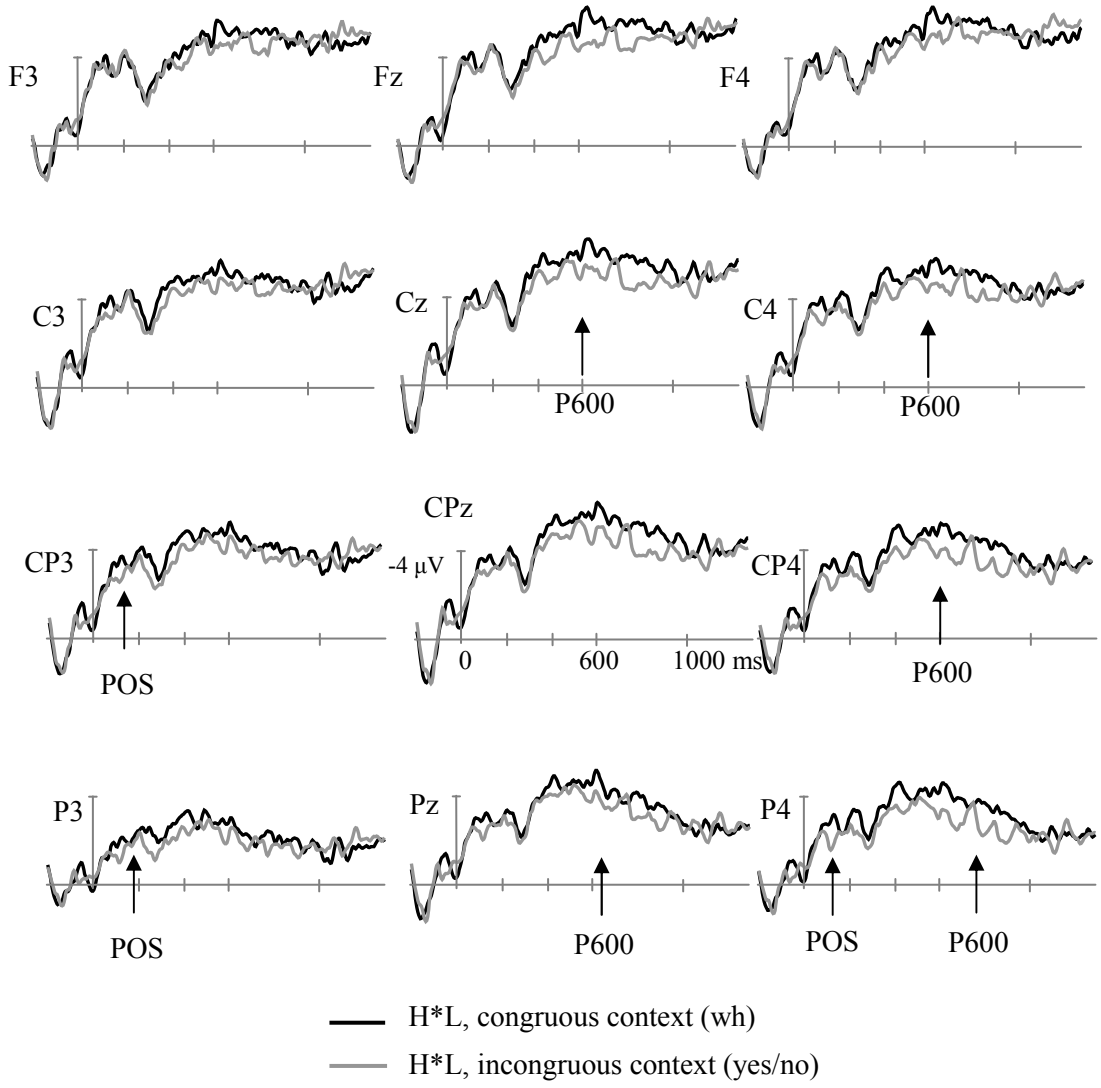


Figure 17: Effect of Congruity for H*L accents in context (experiment 2)
ERPs display the effect of *Congruity* for non-corrective H*L accents in context-embedded sentences like *I think TARA bought the flowers*. The target *TARA* always carried a non-corrective H*L accent that was either congruous (after wh-questions, black lines) or incongruous (after yes/no questions, grey lines). ERPs are time locked to the acoustic onset of *TARA* and display segments of 1300 ms length. H*L accents in incongruous contexts elicited an early posterior positivity (100-300 ms) and a late P600-like positivity (500-700 ms).

of *Congruity* and *Anteriority* (F(2,54)=.897, p=.38) nor a main effect of *Congruity* (F(1,27)=1.369, p=.25).[25]

[25] There was a marginal effect of *Accent* on lateral (F(1,27)=3.068, p=.09) and midline electrodes (F(1,27)=3.182, p=.09) due to positivities for corrective L*H accents. A marginal interaction of *Accent* x

4.3.2.2.2 N400 time window 300-500 ms

On midline electrodes the main effect of *Accent* was significant ($F(1,27)=5.349$, $p<.05$) and was due to positivities for corrective accents relative to non-corrective accents; the positive effect did not reach significance on lateral electrodes ($F(1,27)=4.013$, $p=.055$).[26]

4.3.2.2.3 Early P600 time window 500-700 ms

There was a main effect of *Accent* on lateral ($F(1,27)=9.167$, $p<.01$) and midline electrodes ($F(1,27)=11.613$, $p<.01$) that was due to positivities for corrective accents relative to non-corrective accents. The *Accent* effect was qualified by an *Accent* x *Anteriority* interaction on lateral electrodes ($F(2,54)=5.083$, $p<.05$), showing a distribution of the positivity over central ($F(1,27)=10.758$, $p<.01$) and posterior sites ($F(1,27)=11.973$, $p<.01$) but not over anterior sites ($F(1,27)=1.572$, $p=.221$). The positive effect for corrective accents was found for both context types and is presented in Figure 16. The interaction of *Congruity* x *Anteriority* x *Hemisphere* was significant on lateral electrodes ($F(2,54)=4.346$, $p<.05$) but follow-up interactions were not statistically reliable. The mean voltage values suggest that accents in incongruous contexts triggered positivities relative to accents in congruous contexts which were most pronounced over right central and right posterior regions.[27]

Congruity x *Anteriority* on midline electrodes ($F(2,54)=2.724$, $p=.08$) was due to posterior positivities for non-corrective H*L accents in incongruous contexts.

[26] On lateral electrodes there were further marginal interactions of *Accent* x *Hemisphere* ($F(1,27)=3.310$, $p=.08$) showing right lateralized positivities for corrective accents, and *Congruity* x *Anteriority* x *Hemisphere* ($F(2,54)=2.745$, $p=.091$) due to positivities for all accents in incongruous contexts relative to congruous contexts that were largest on right central sites.

[27] In addition, there was a marginal interaction of *Accent* x *Hemisphere* on lateral electrodes ($F(1,27)=3.638$, $p=.07$) and a marginal main effect of *Congruity* on midline electrodes ($F(1,27)=3.844$, $p=.06$), showing a positivity for all incongruous accents. A marginal interaction of *Accent* x *Congruity* x *Anteriority* x *Hemisphere* ($F(2,54)=3.024$, $p=.06$) was found on lateral electrodes. Follow-up analyses revealed that there were only effects for corrective accents (incongruous L*H accents more positive than congruous L*H accents), especially at left anterior electrodes; there were no effects involving congruity for non-corrective accents.

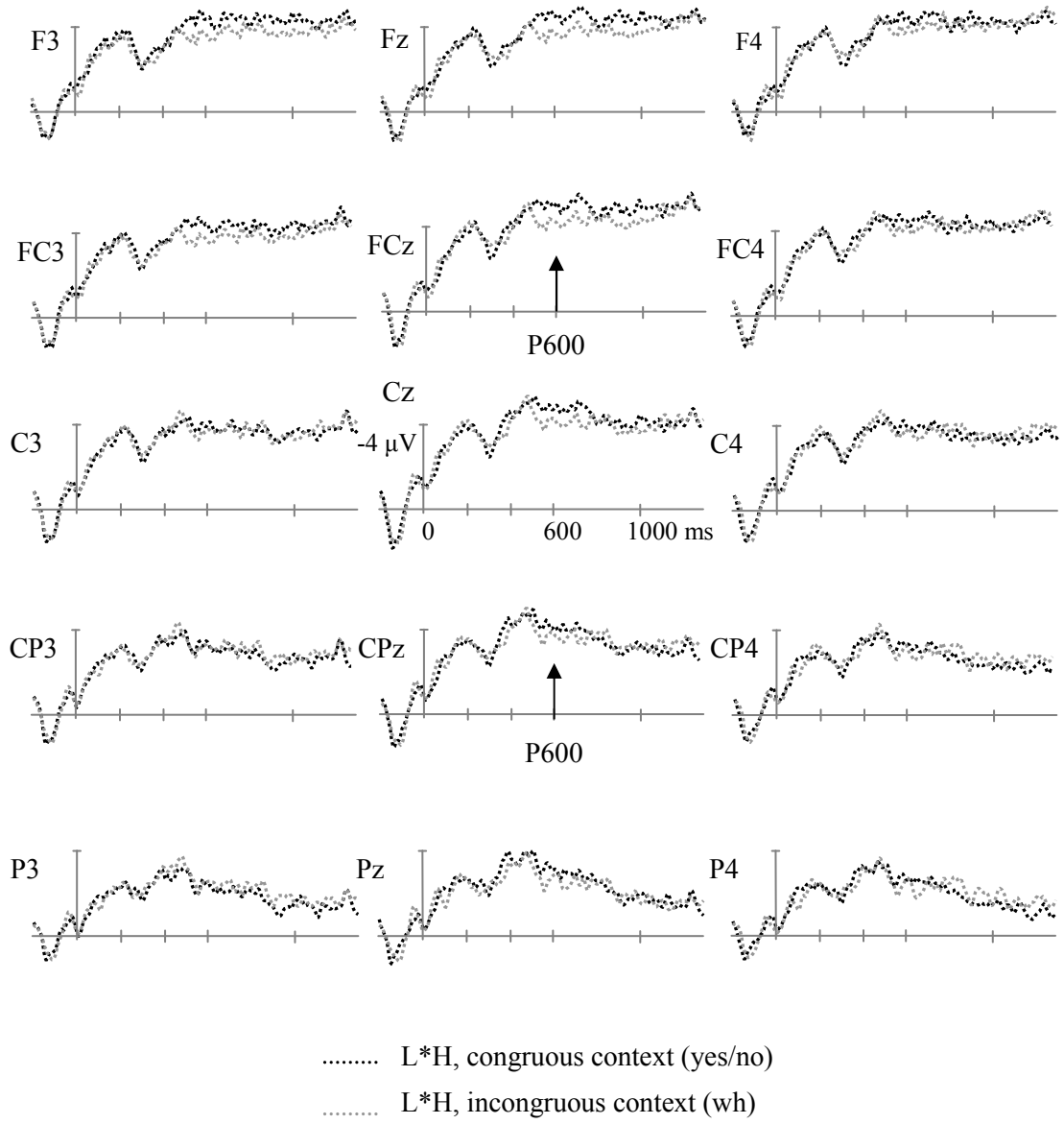


Figure 18: Effect of Congruity for L*H accents in context (experiment 2)

ERPs display the effect of *Congruity* for corrective L*H accents in context-embedded sentences like *I think TARA bought the flowers*. The figure compares corrective L*H accents in congruous contexts (yes/no questions, black dotted lines) *versus* in incongruous contexts (wh-questions, grey dotted lines). ERPs are time locked to the acoustic onset of *TARA* and have a 1300 ms length. Corrective L*H accents in incongruous contexts elicited a late P600-like positivity (500-700 ms). The left anterior positivity for incongruous L*H accents did not reach significance.

4.3.2.2.4 Late P600 time window 700-1000 ms

There was a main effect of *Accent* on lateral ($F(1,27)=8.440$, $p<.01$) and midline electrodes ($F(1,27)=10.273$, $p<.01$) that was due to positive effects for corrective accents relative to non-corrective accents. There were no effects or interactions involving the factor *Congruity*.[28]

4.3.2.3 Summary of results

In experiment 2, there were main effects of *Accent* and *Congruity* and a significant interaction of the factors in the earliest time window. Already 100 ms post stimulus onset, targets with non-corrective H*L accents in incongruous corrective contexts elicited an early posterior positivity that was not present for targets with corrective L*H accents in incongruous non-corrective contexts. In the N400 time window, corrective accents elicited a positivity on midline electrodes. Between 500-700 ms, there was a *Congruity* effect in the form of a centro-posterior positivity for all incongruous accent-context combinations which seemed to differ slightly between the two accent types. Corrective accents triggered centro-posterior positivities due to a main effect of *Accent* that was extended over the 500-1000 ms time window.

4.3.3 Discussion

The goal of experiment 2 was to examine the impact of discourse context on the processing of corrective prosody when words with corrective L*H and non-corrective H*L accents are embedded in contexts that either support their interpretation (congruous) or do not support it (incongruous). Differences in accent type gave rise to late positivities for corrective accents, while differences in contextual congruity were reflected in early and late positivities for

[28] A marginal interaction of *Accent* x *Anteriority* x *Hemisphere* ($F(2,54)=3.212$, $p=.06$) was due to right anterior positivities for corrective L*H accents.

accents in incongruous contexts. The present results show that discourse context and the tonal specifications of accents have an effect on the processing of prosody in Dutch.

4.3.3.1 Effects of corrective and non-corrective accentuation

Experiment 2 replicated the main effect of *Accent* that was found in experiment 1: corrective L*H accents elicited a centro-posterior positivity between 500-1000 ms post target onset. There was no interaction with context in this time window, suggesting that the processing of corrective accents is independent from the presence of a biasing context or its congruity.

This finding allows us to discard one of the possible interpretations of the accent positivity discussed in experiment 1: the positivity for corrective accents cannot be due to their infelicity in isolated sentences where the missing context was assumed to impede the interpretation of correction. Rather, the processing of corrective prosody appears to activate an additional mechanism that is inactive in the processing of non-corrective prosody. The mechanism may be related to the assignment of a corrective meaning to a word that carries an L*H accent when listeners generate or identify an alternative, suggesting a semantic source of the late positivity for corrective prosody. The results of offline study 2 support this interpretation: listeners assumed that an alternative must be present in the hypothetical context when they perceived words with a corrective L*H accent.

One could also hypothesize that yes/no questions in experiment 2 (*Did you know that Maria bought the flowers?*) did not trigger the expectation of corrective focus because *Maria* did not bear an emphatic accent. As a result, listeners might have identified correction later, when they perceived *Tara* in the answer (*I think TARA bought the flowers*).[29] The mechanism underlying the interpretation of corrective prosody may be thus pragmatic in nature: corrective accents may violate the Gricean Maxim of Quantity (Grice, 1975), postulating that

[29] This suggests that with wh-questions, listeners can assume correction only on the basis of accentuation.

the speaker should not give more information with respect to what is required. Since elements with corrective accents are realized in a more prominent way than is expected, speakers may well signal special meaning by giving extra information. Thus, listeners may well be spurred to create a coherent representation of the utterance, and the positivity would then reflect the search for a relevant alternative entity to the accented element and the making sense of corrective prosody as reflected in the P600 component (Kaan et al., 2000; Hoeks et al., 2004; Schumacher & Baumann, 2010; Dimitrova et al., submitted). This pragmatic explanation can also account for the processing of the congruity of corrective and non-corrective accents in the discourse context.

4.3.3.2 Early effects of contextual congruity

Non-corrective accents in incongruous corrective contexts elicited an early posterior positivity already 100 ms post target onset; no such effect was found for corrective accents in incongruous non-corrective contexts. This result is in line with Toepel's (2005) findings of an early, though negative, effect in the same condition that she attributed to the processing of pre-focal accentual cues prior to the target's onset.

One could argue that in the current study too, the distinct prosodic contours of *volgens mij* prior to the target may have had a similar disambiguating effect, as *volgens mij* had a high level pitch prior to non-corrective accents but a falling pitch prior to corrective accents (cf. Figures 14a, 14b). Interpreting the positivity as related to the mere processing of pre-focal accentual cues in the phrase *volgens mij* is problematical since the effect occurs after the target's onset. Furthermore, the early positivity is elicited only in one specific condition, the incongruous combination of corrective context and non-corrective accent in the answer, which implies that the effect is related to the processing of incongruity in the context. It appears plausible to assume that the different contexts in the present study may have had different effects on the processing of prosody: corrective contexts may have projected very

strong expectations for corrective accents, and hence listeners attended to pre-focal prosody, whereas non-corrective contexts may have not projected specific prosodic expectations and as a result, listeners paid less attention to prosody.

The neural system underlying the early positive effect might thus reflect the expectation-based processing of prosody in the discourse context. Similar early posterior positivities for incongruous accents on background elements in context have been reported in our previous study (Dimitrova et al., submitted) and are consistent with the results of the current offline test 1. Toepels's (2005) behavioral findings also show a reduced offline preference for non-corrective H*L accents in corrective contexts, suggesting that corrective contexts behave differently. In pragmatic terms, H*L accents are underspecified in corrective contexts and violate the Griecean Maxim of Quantity as speakers provide too little information by using a non-corrective accent type.

There is, however, an alternative explanation of the early positivity. As suggested above, no element in the present yes/no-questions was overly emphatic and hence, listeners may not have anticipated that the subject *Maria* will be corrected in the answer, cf. *Did you know that Maria bought the flowers? – I think TARA bought the flowers*. Since answers started with *I think*, listeners might have expected additional information about *Maria* or *the flowers*. This is in line with previous studies which report a high preference for continuing what the sentence is about, that is, its topic (Hoeks et al., 2002). As a result of the expected topic continuation, the initial phonemes of *Tara* may mismatch the expected topic *Maria*, and the early posterior positivity may reflect phonetic mismatch processing. However, this interpretation is inconsistent with the fact that the positivity depends on the accent type of *Tara* and is only elicited by non-corrective accents in incongruous corrective contexts; it is not present when *Tara* carries a corrective accent, even though its onset still mismatches *Maria*. Therefore, the underlying source of the early posterior positivity is most likely related

to the incongruity and low emphasis of the non-corrective H*L accent. The current data are suggestive of a general expectation of correction to be marked by corrective L*H accents.

4.3.3.3 Late effects of contextual congruity

The processing of incongruous prosody-context combinations gave rise also to late effects. Corrective and non-corrective accents in incongruous contexts elicited right-lateralized centro-posterior positivities in the time window of 500-700 ms post stimulus onset. Two components, the *Closure Positive Shift* (CPS) and the P600, can serve as the underlying neural mechanism for the contextual incongruity of prosody.

The late positivity for incongruous prosody may well belong to the CPS, a late centro-posterior positivity around 500 ms that is initiated by the processing of prosodic breaks irrespective of syntactic phrasing (Steinhauer & Friederici, 2001; Pannenkamp et al., 2005). Since prosodic parsing activates independent processing mechanisms, in the present study stimuli were explicitly controlled for the lack of prosodic boundaries in the vicinity of targets. Figures 14a and 14b show that no silent pauses or pitch changes indicative of a boundary occurred anywhere in the target sentences that could have elicited a CPS response.

Others have proposed that the CPS is not limited to the processing of a phrase boundary per se but rather represents a general mechanism for focus processing in context irrespective of prosody (Hruska & Alter, 2004; Toepel & Alter, 2004; Toepel, 2005). For instance, incongruously accented background information has been shown to elicit late positivities similar to accented focus, and multiple focus elements each elicit a positivity. Thus, since all targets in the present study were in focus, the late positivity may indeed reflect focus processing. In contrast to previous studies, the positivity does not occur in all conditions (e.g., Toepel & Alter, 2004), but only as a response to identically accented targets in incongruous contexts. The positive effect is thus likely to be related to the processing of incongruous prosody in the discourse context irrespective of the type of the pitch accent used.

It is therefore suggested that the late positivity in experiment 2 represents a incongruity response reminiscent of the P600, showing the listener's effort to make sense of the inappropriate combination of context and accentuation. The P600 component represents a late posterior positivity and has been previously reported for the re-interpretation of incongruous information (Kaan et al., 2000; Hoeks et al., 2004) or for information integration into the discourse (Burkhardt, 2007). The present findings suggest that listeners are sensitive to prosody-context mismatches when the interpretation of accents is in conflict with the semantics of context.

4.4 General discussion

Two ERP studies investigated the processing of corrective and non-corrective prosody in sentences with and without discourse context. Using a naturalistic paradigm with strictly controlled stimuli and without a prosodic judgment task, the present studies provide evidence that the brain is sensitive to the type of accents and their congruity in the discourse context. Corrective accents elicit late centro-posterior positivities irrespective of the presence and type of discourse context. In incongruous contexts, corrective and non-corrective accents give rise to late centro-posterior positivities, in addition to early posterior positivities for non-corrective accents in corrective contexts. The current neurological data are consistent with the results of two additional offline tests, but challenge previous findings in the ERP literature.

4.4.1 Underlying sources of the P600 for corrective accents

In context-embedded as well as in isolated sentences, corrective L*H accents activated neural systems that were not active for the processing of non-corrective H*L accents. The effect was a late posterior positivity that started earlier in context (around 300 ms) than in isolated

sentences (around 500 ms post target). The neural source underlying the accent positivity was attributed to the P600 effect for the semantic interpretation and making sense of corrective accentuation that requires the generation (experiment 1) or identification of an alternative in the discourse context (experiment 2).

The present findings suggest a semantic interpretation source of the P600 where L*H accents in Dutch are interpreted as signaling a corrective meaning themselves, similarly to languages like Greek and German (Stavropoulou et al., 2010; Toepel, 2005). This assumption is in line with a number of behavioral studies. Offline task 2 in the current experiment provides evidence that corrective accents may trigger semantic interpretation processes: listeners generated hypothetical contexts and constructed an alternative to elements that carried an L*H accent in order to license the correction. The present results are consistent with Krahmer et al. (1999, 2002) who have also reported that Dutch speakers use L*H accents for correction. Without instruction, the naïve speakers in the present study produced L*H accents in the corrective condition to discriminate them from H*L accents in the non-corrective condition. It can be concluded that at least some speakers use L*H accents to signal correction, and at least some listeners interpret L*H accents as implying correction.

Alternatively, the underlying neural source of the P600 effect may be pragmatic in nature, related to the processing of "too much" emphasis in L*H accents (Gussenhoven, 2005), given previous empirical evidence that no distinct accents are used if correction is expressed by lexical markers such as "no" (Hanssen et al., 2008). It is thus possible that L*H accents may not carry a specific semantic meaning per se but rather just be more emphatic than default non-corrective H*L accents. As suggested above, excessive emphasis violates general communication principles that require speakers to provide no more and no less information than is necessary (Grice, 1975). Interpreting the P600 as making sense of overspecified emphatic L*H accents is consistent with the fact that the effect does not disappear in corrective contexts where an alternative is already present in the yes/no question.

The process of interpreting corrective prosody may thus engage semantic mechanisms for the construction of alternatives in isolated sentences (offline task 2, experiment 1) and pragmatic mechanisms when a preceding context is available. Whether the brain interprets emphasis and correction as the two sides of the same coin should be addressed in future research.

4.4.2 Processing corrective prosody: new insights

Late positive effects starting around 500 ms post stimulus onset were triggered by the processing of incongruous accent-context combinations, in addition to early positive effects for non-corrective accents in incongruous corrective contexts. The present findings are in line with previously reported early and late positivities for incongruous accent-focus combinations in context (Schumacher & Baumann, 2010; Dimitrova et al., submitted) and provide new insights into the mechanisms that underlie prosody processing in the brain.

First, the current study is the first to report a very early positive effect of incongruity for less specified non-corrective accents in corrective contexts. These effects suggest that listeners expect corrective information to be realized with a more emphatic corrective L*H accent. Due to the very early onset of the positivity (100 ms post stimulus onset), the expectation of corrective accentuation must have arisen due to the preceding yes/no question. It is unlikely that the early positivity is triggered by the phonetic mismatch of the targets *Maria* and *Tara* (e.g., *Did you know that Maria […] – I think Tara […]*); if this were the case, the early positivity would have been a main effect of yes/no contexts. The early positivity most likely reflects that listeners do not expect non-corrective H*L accents to be associated with corrective information. This is in line with the high preference for H*L accents in non-corrective contexts that was found in offline task 1. The identification of early differences between the conditions was possible due to the strict time-locking procedures in the present study which have not been applied previously.

Second, the current findings demonstrate that the underlying neural source of late positivities for incongruous corrective prosody reported in the literature (Toepel, 2005) is independent from the judgment of prosodic congruity they applied. Even without a prosodic task in the present study, the brain is still sensitive to incongruous prosody-context combinations, although attention is not explicitly shifted towards prosodic congruity. This finding does not suggest that prosodic task does not affect speech processing. On the contrary, previous studies directly comparing prosody processing in different task conditions have shown that neural responses to prosody disappear (late positivities, Astesano et al., 2004) or change (N400 effects, Toepel & Alter, 2004; Dimitrova et al., submitted) when listeners do not judge the prosodic wellformedness of the utterance. Furthermore, the main effect for corrective accents in the current study has not been reported by Toepel (2005) who used the same set of accent types in a prosodic task paradigm (for similar results, see Magne et al., 2005). In appears that when cognitive resources are engaged in the conscious evaluation of the stimulus, the brain may not be able to discriminate different accent types.

The results of the present studies without a prosodic judgment task provide neurological evidence for the pragmatic view of prosody suggested by Wharton and Watson (2006): during natural speech processing, attention is allocated to accented words because they are prominent and most informative. The current study has shown that listeners are not only sensitive to the presence of prosodic prominence but also to the type of accents speakers use. The findings show that emphasis is necessary for the processing of correction in speech, and that the brain engages additional mechanisms to make sense of emphatic accents that do not fit in the discourse context.

5

Mind the gap

Prosody, discourse and thematic fit interact in the disambiguation of "gapping" sentences

Abstract

Two event-related brain potential (ERP) studies investigated how prosody, discourse context, and thematic fit impact the processing of ambiguous clauses in Dutch. In sentences such as *John invited Peter on Monday and Martin on Tuesday*, the underlined clause is ambiguous between a highly preferred verb phrase reading with Martin as object (i.e., "nongapping"), and a dispreferred clause reading with Martin as subject (i.e., "gapping"). In sentences where the ambiguous NP (Martin) does not fit as a grammatical object, such as *John peeled the orange with his knife and Martin with his hands*, gapping readings are enforced, as nongapping readings are semantically anomalous. Sentences were presented in isolation (experiment 1) or with a biasing discourse context (experiment 2) and combined with different prosodic realizations that biased towards gapping or nongapping readings. In experiment 1 (no context), gapping prosody elicited a negativity on Martin (similar to an N400), reflecting the construction of a gapping representation, which was found when gapping was enforced (poor thematic fit) or when it was the dispreferred reading (good thematic fit). In good thematic fit, dispreferred gapping prosody elicited a positivity (P600) which signifies the more complex processing of such sentences. In poor thematic fit, nongapping prosody evoked an anomalous reading (John peeled … Martin with his hands) which listeners revised as reflected in a late P600; additional late negativities were triggered, presumably related to the N400. In experiment 2 (with context), the same N400 component was found for constructing a gapping representation, regardless of thematic fit. Responses in the late time windows differed from those found for sentences presented in isolation: a dispreferred gapping bias in good thematic fit elicited anterior P600-like positivities and posterior negativities (both 700-1300 ms post target) that we attribute to the increased effort in establishing dispreferred readings in the discourse context. A nongapping bias brought about by context and prosody contributed to a semantically anomalous reading, leading to late posterior positivities (P600) for the making sense of the anomaly.

5.1 Introduction

In speech communication, speakers may sometimes omit linguistic elements - a phenomenon called ellipsis - in order to be maximally informative (cf. Grice, 1975). However, ellipsis often introduces ambiguity in a message, which listeners then have to resolve. For instance, a verb phrase may be elided, such that the second of two conjoined clauses is ambiguous as in *John invited Peter on Monday and Martin on Tuesday*. On the one hand, the second clause may be interpreted as a conjoined verb phrase (VP) assuming subject+verb ellipsis (elided elements underlined) as in *John invited* Martin on Tuesday, which in the following is referred to as the ***nongapping*** reading. On the other hand, the second clause may be analyzed as a conjoined clause (S) assuming verb+object ellipsis as in *Martin invited Peter on Tuesday*, which is referred to as the ***gapping*** reading. Disambiguation preferences for such clauses are affected by a number of linguistic factors, including prosody, thematic fit, and information structure (Carlson, 2001; Carlson et al., 2005; Hoeks et al., 2006, 2007, 2009). The current study examines the effects and interaction of these three factors during the on-line processing of sentences containing this sort of ambiguity.

5.1.1 Information structure and the nongapping preference

One of the factors that may determine whether listeners interpret ambiguous clauses as gapping or nongapping is information structure. Generally speaking, information structure refers to what the message is about, i.e., *topic*, and what makes the message informative, i.e., *focus* (Lambrecht, 1994). The exact components of information structure are highly controversial (Erteschik-Shir, 2007 for a review) and allow other views as well, for instance the differentiation of 'focus-background' with *focus* being the more informative information, highlighted by accent, and *background* the less informative information that is usually unaccented (e.g., Halliday, 1967). In the above-mentioned ambiguous sentences, when no

other prosodic or contextual cues available, listeners favor the simplest information structure, which is the "minimal topic structure" (Hoeks et al., 2002). As a result, the ambiguous sentence *John invited Peter on Monday and Martin on Tuesday*, if presented without context, is preferably analyzed as having one single topic (i.e., *John*) and two contrastive focus constituents (i.e., *Peter on Monday*, *Martin on Tuesday*), which corresponds to the nongapping reading. An analysis assuming two topics (*John*, *Martin*) violates the principle of minimal topic structure, which may be one of the reasons why gapping is dispreferred.

The high preference for nongapping interpretations can also be due to their simpler syntactic structure that is closely related to information structure. Reading preferences for sentences with ellipsis are then determined by how easily the listener can construct a syntactic representation and which element is most likely to be elided. First, VP-coordination of the ambiguous NP represents a simpler syntactic analysis where *Martin* is added as a second argument to the verb (i.e., *X invited A and Martin*). By contrast, S-coordination is syntactically more complex and requires the opening of a new slot in the syntactic tree that has to be filled in by *Martin* (i.e., *X invited A, Martin invited A*) (Carlson, 2001). Second, from a typological perspective, subjects are most likely to become discourse topics and to be empty across languages (Falk, 2006; Comrie, 1981), which suggests that an analysis with subject drop (nongapping) is more natural than an analysis with object drop (gapping). A strong favorization of simple universal structures has been attested in behavioral studies showing a high preference for nongapping analysis (96 %) and no preference for gapping analysis of ambiguous conjoined clauses (4 %) (Carlson, 2001; Carlson et al., 2005).

5.1.2 Thematic fit modifies the nongapping preference

Irrespective of the language modality, the preference for nongapping can be modified by changes in the *thematic fit* of sentences that are related to the selectional restrictions of verbs. Each verb has a number of arguments, called thematic roles: the thematic role “agent”

indicates the referent performing the action denoted by the verb and is mostly realized as a syntactic subject, while the thematic role "patient" denotes the referent that undergoes the action and is mostly realized as a syntactic object. Semantic restrictions on thematic roles can account for the ambiguity of sentences like *John invited Peter on Monday and Martin on Tuesday* where the verb "invite" requires a human agent and a human patient, and hence, *Martin* can be interpreted both as a syntactic object to the verb (VP-coordination) and as a syntactic subject of a new clause (S-coordination). In contrast, verbs like "peel" have distinct semantic restrictions and require a nonhuman patient, which is why the interpretation of *Martin* as an object is ungrammatical in *John peeled the orange with his knife and Martin with his hands*. Such sentences are less ambiguous due to the poor thematic fit between the verb and the object interpretation of *Martin* and differ from sentences with good thematic fit where the ambiguous referent represents a plausible object and a plausible subject.

Behavioral studies suggest that a simple manipulation of the thematic role restrictions of verbs can change the nongapping preference from 96% in sentences with good thematic fit to 19 % in sentences with poor thematic fit (Carlson, 2001). Thus, the preference for a simple structure may be overruled by semantic plausibility and congruity in written language.

5.1.3 Prosody in speech: a disambiguating factor

In spoken language, ambiguity resolution can be facilitated by prosody, the melody and rhythm of speech, which provides additional information about the syntactic phrasing and information structure of a sentence. Simply presenting this sort of sentence auditorily, *John invited Peter on Monday and Martin on Tuesday*, even if the prosody does not strongly support either syntactic structure, increases the instances of gapping readings in ambiguous clauses from 4 % in written language to 38 % in spoken language (Carlson, 2001).

Prosody can support a specific—gapping or nongapping—interpretation through the impression of prosodic similarity between elements in conjoined clauses, referred to as

prosodic parallelism. Elements are linked together when they are considered parallel due to their similar accentuation or pitch range. Parallelism represents a crucial cue in sentences with good thematic fit where the ambiguity cannot be resolved by the thematic restrictions of verbs. With 'gapping prosody', the accent on the ambiguous element *Martin* is parallel with the accent on the subject in the main clause *John* as in *JOHN invited Peter on Monday and MARTIN on Tuesday* and as a result, both elements are considered syntactically similar. Gapping prosody increases gapping readings from 38 % with neutral prosody to 44 % with gapping prosody. Thus, although prosodic parallelism is likely to be interpreted as syntactic parallelism, gapping prosody does not reverse the nongapping preference which remains above 50 % (Carlson, 2001; Hoeks et al., 2006, 2007, 2009). With 'nongapping prosody', the accent on the ambiguous *Martin* is parallel with the accent on the object in the main clause *Peter* as in *John invited PETER on Monday and MARTIN on Tuesday*. Nongapping prosody decreases gapping readings from 38 % preference with neutral prosody to 28 % preference with nongapping prosody (Carlson, 2001).

Parallelism in pitch range and pitch peak height has a similar effect as accentual parallelism and can disambiguate sentence interpretation, even when accent type and position are held constant (Bartels & Kingston, 1994; Rump & Collier, 1996). Prosodic boundaries represent another good cue for parsing syntactic structure and tend to occur at the position of the elided element; a prosodic "gap" seems to be related to a syntactic "gap". However, the presence of a prosodic boundary is not sufficient for ambiguity resolution, since prosodic breaks are equally acceptable with VP- and S-coordination structures (Carlson, 2001; Selkirk, 1997, 1999). To increase the bias towards gapping readings, previous behavioral studies have used prosodic breaks in sentences with gapping prosody, usually after the position of the ambiguous element (Carlson, 2001; Hoeks et al., 2007). All these prosody bias aspects have been applied in combination with further disambiguating factors in the present study.

The interaction of various biasing cues, such as prosody and thematic fit, allows the prediction of which analysis will be favored on-line. When both prosody and thematic fit support the same reading, speech comprehension should be facilitated, as in good thematic fit sentences with nongapping prosody and in poor thematic fit sentences with gapping prosody. When prosody and thematic fit are in conflict, processing is expected to be more effortful, as in good thematic fit sentences with gapping prosody and in poor thematic fit sentences with nongapping prosody. Hoeks et al. (2009) have shown that inappropriate readings of sentences with poor thematic fit are more often evoked by nongapping prosody (32 %) than by gapping prosody (23 %).

5.1.4 Discourse context as a disambiguating factor

Discourse context is another factor that may aid disambiguation, as it promotes the information structure of the upcoming sentence which is either gapping or nongapping. In contexts with a gapping bias, a question like *When did the boys invite Peter?* leads to the anticipation of a sentence with multiple topics, to be realized as multiple subjects, at least when the answer starts out with one of these boys. The ambiguity in *John invited Peter on Monday and Martin on Tuesday* can thus be resolved easily after the first subject has been identified as *John* and the only candidate available for another subject is *Martin*. Nongapping contexts like *When did John meet the boys?* have the opposite effect and lead to the anticipation of an answer with a single topic *John* and multiple objects (*Peter*, *Martin*).

Discourse context interacts with thematic fit in a similar way as prosody does. Behavioral studies show that the anomalous reading of sentences with poor thematic fit (*John peeled ... Martin*) is evoked more often with biasing nongapping context (34 %) as compared to a biasing gapping context (22 %). Together with gapping prosody, gapping discourse context can reverse the strong nongapping preference of sentences with good thematic fit: gapping becomes the preferred interpretation in 60 % of all cases (Hoeks et al., 2006, 2007,

2009). Hoeks et al. (2009) have shown that in case of conflicting bias (e.g., discourse promotes gapping, prosody promotes nongapping), listeners consider discourse context more reliable than prosody and choose a gapping reading in 37 % if only discourse favors gapping and in 17 % if only prosody favors gapping.

5.1.5 Neural correlates of gapping and nongapping

Until now, almost all data on the processing of gapping was gathered using off-line methods. Neuroimaging evidence on the interpretation of sentences that are ambiguous between gapping and nongapping is missing in the literature, which makes it difficult to understand how elided information is reconstructed and how various cues such as prosody, discourse context and thematic fit are integrated during the on-line disambiguation process. For instance, discourse context may diminish the effortful processing of dispreferred structures and affect interpretations evoked by prosody. The present study applied the event-related potentials technique (ERP) to measure changes in brain activity that occur during the processing of ambiguous sentences with verb ellipsis.

One of the current research questions is thus whether nongapping prosody activates semantically incongruous analyses in poor thematic fit sentences when they are presented with and without discourse context. If implausible readings such as *John peeled ... Martin with his hands* are activated, they are expected to activate a centro-posterior negativity around 400 ms after the onset of the target *Martin*, the N400 component (Kutas & Hillyard, 1981). The N400 is not restricted to the processing of semantic anomaly, but represents a general process of lexical retrieval (Federmeier & Kutas, 2011 for a review) and is elicited when semantic meaning is constructed from memory.

Prosodic functions can also activate the N400, mostly when prosody is in conflict with information structure principles, such as the principle stating that focus bears an accent and background remains unaccented. In a recent study on prosody processing in the discourse

context (Dimitrova et al., submitted), we found an N400 effect for incongruous accents on background information (for a similar result, see Wang et al., 2011; Toepel & Alter, 2004), though other studies report N400 effects for unaccented focus (Hruska & Alter, 2004; Toepel & Alter, 2004). In the context of the present study, it was hypothesized that the N400 may be evoked when prosody is in conflict with the preferred reading (dispreferred gapping prosody in sentences with good thematic fit), when prosody promotes semantically implausible readings (nongapping prosody in sentences with poor thematic fit), or when there are differences in the resources needed to access the meaning of or a concept from memory.

Evidence for neural processes related to the reconstruction of elided information and their consequence for semantic processing comes from the only previous ERP study on gapping in written language (Kaan et al., 2004). Kaan et al. used unambiguous gapping sentences like *Ron took/ sanded the planks, and Bill Ø the hammer* where the semantic plausibility of the target *hammer* varied depending on the elided verb from the first clause (e.g., *sanded/ took*, marked by *Ø* in the second clause).[30] No effects were reported for *Bill* (that was temporary ambiguous between VP- and S-coordination) but only for the processing of the determiner *the* after it, which triggered an early centro-posterior negativity between 100-300 ms. Kaan et al. related the negativity to the processing of a word category violation, suggesting that listeners initially assumed S-coordination without ellipsis and expected a verb instead of a determiner. The authors suggest that the restoration of the elided verb from memory evokes late fronto-central positivities (300-500 ms post onset of *the*) that have not been reported previously in the literature. The study provides important insights in the impact of ellipsis on semantic processing, but does not address the neural mechanisms engaged in the disambiguation of the NP *Bill*. Most importantly, Kaan et al.'s findings do not address ambiguity processing spoken language where a number of factors such as prosody, discourse

[30] Note that the nongapping reading (e.g., where Ron sanded Bill) is still not completely ruled out.

context and thematic fit are expected to modify or revise reading preferences.

In addition to the ellipsis reconstruction processes discussed by Kaan et al. (2004), sentences with ellipsis activate various other processes related to the resolution of the ambiguity between VP- and S-coordination and the generation of a coherent discourse representation. In the ERP literature, discourse update processes have been related to late positive waveforms around 500 ms post stimulus with a centro-posterior distribution, the P600 component (Kaan et al., 2000; Hoeks et al., 2004). The P600 is evoked by the revision and repair of incongruous syntactic structure (Friederici, 2002) or by the integration of new referents in the discourse (Burkhardt, 2007). P600 effects with frontal distribution have been reported for complex sentences, for instance when two NPs lead to an ambiguity as in *I cut the cake beside the pizzas that <u>were</u> brought by Jill* (P600 for underlined word), as compared to unambiguous sentences with only one NP such as *The man in the restaurant doesn't like the hamburgers that <u>are</u> on his plate* (Kaan & Swaab, 2003). Kaan & Swaab (2003) clearly differentiate late frontal positivities triggered by the processing of what they call 'discourse complexity' from posterior positivities related to the repair of ungrammatical structure.

5.1.6 The present study

Two ERP studies were designed to test how linguistic factors such as prosody, context and thematic fit interact and affect the processing of gapping structures. Stimuli were presented in isolation: sentences with good thematic fit were compared to sentences with poor thematic fit to see whether interpretative preferences depend on the thematic role restrictions of the verbs in the stimuli. Sentences with good thematic fit were hypothesized to favor nongapping readings with VP-coordination of the ambiguous element, whereas sentences with poor thematic fit were expected to favor gapping readings with S-coordination.

The present study also tested how distinct prosodic realizations, gapping and nongapping prosody, interact with the interpretation preferences projected by thematic fit.

The effect of prosody was expected to depend on thematic fit: gapping prosody should facilitate processing in sentences with poor thematic fit because it corresponds to their preferred reading (as compared to sentences with good thematic fit where it supports the less preferred reading). Nongapping prosody should facilitate processing in sentences with good thematic fit because it is in line with their highly preferred reading as compared to sentences with poor thematic fit where it suggests an anomalous reading.

In the second experiment, discourse context was included as an additional factor, to see whether it would bias the interpretation of ambiguous gapping sentences. Discourse was hypothesized to additionally facilitate processing when it is consistent with biasing prosody but to increase processing demands when it is in conflict with prosody. Interpretational preferences were collected at the end of each trial where a rephrasing statement provided a gapping or a nongapping interpretation of the second clause.

5.2 Experiment 1: Gapping in isolated sentences

In experiment 1, sentences that are ambiguous between a gapping and a nongapping reading were presented without a preceding discourse context, leaving only prosody and thematic fit as factors that can influence processing. Thematic fit was expected to affect the choice between a gapping and a nongapping reading as suggested by previous behavioral studies (Carlson, 2001; Hoeks et al., 2006, 2007, 2009) that report a high preference for nongapping readings in sentences with good thematic fit (vs. very low preference of gapping readings), and a preference for gapping readings in sentences with poor thematic fit (vs. no preference for anomalous nongapping readings). Due to the interaction of prosody and thematic fit, gapping prosody was expected to increase processing costs in sentences with good fit and to facilitate the processing of sentences with poor fit. Nongapping prosody was hypothesized to

facilitate processing in sentences with good thematic fit but to impede processing in sentences with poor thematic fit where it introduces a semantically anomalous reading.

5.2.1 Methods

5.2.1.1 Participants

Twenty-seven right-handed students (11 male, age 18-25 years, mean 21), none studied Linguistics, with normal or corrected-to-normal vision and without any neurological, psychological, language or hearing impairment were paid for participation after signing an informed written consent in accordance with the Declaration of Helsinki. Inclusion criterion was set to 60 % valid data on any analyzed electrode in any condition, which resulted in the exclusion of another seven participants (2 male) that had data loss of more than 40 %.

5.2.1.2 Stimuli

Experimental stimuli were ambiguous conjoined clauses like *John invited Peter on Monday and Martin on Tuesday* with verb ellipsis in the second clause that were presented without a preceding discourse context (see Table 15, no questions were used). As a result, the NP *Martin* in the second clause was ambiguous, as it could either be the subject of a new clause (S-coordination with gapping reading), or the object of the verb in the main clause (VP-coordination with nongapping reading). Two factors biased the resolution of the ambiguity: the between-items factor *thematic fit* (sentences with good thematic fit vs. sentences with poor thematic fit) and the within-items factor *prosody* (gapping vs. nongapping prosody).

Depending on the thematic role restrictions of the verb in the main clause, stimuli either had a good or a poor thematic fit (presented in Table 15). In sentences with good thematic fit, the ambiguous target *Martin* could be resolved as subject or as object because the verb (e.g., “invite”) allowed for human patient. In contrast, in sentences with poor

thematic fit, *Martin* could only be resolved as subject because the verb (e.g., "peel") did not allow for a human patient and hence, *Martin* was an implausible object.

All stimuli varied also with respect to their prosody that supported either the gapping or the nongapping reading of each sentence. In case of gapping prosody, the accent on *Martin* was parallel to the accent on the subject in the first clause as in *JOHN invited Peter on Monday and MARTIN on Tuesday*. In case of nongapping prosody, the accent on *Martin* was parallel to the accent on the object in the first clause as in *John invited PETER on Monday and MARTIN on Tuesday;* the subject of the first clause, *John*, was not prominent. Prosodic parallelism promoted either the preferred reading (good fit=nongapping, poor fit=gapping) or the dispreferred/ ungrammatical reading (good fit=gapping, poor fit=nongapping).

Participants were asked to agree or disagree with a statement after each stimulus which disambiguated the second clause as gapping or nongapping. The task aimed to enhance the naturalness of the stimuli, similarly to natural speech where the listener usually makes sure that she understood the speaker, especially if ambiguity is present as in the current stimuli. Statements in the good thematic fit condition presented a nongapping rephrasing like *Okay, so John invited Martin on Tuesday*, or a gapping rephrasing like *Okay, so Martin invited Peter on Tuesday* (see Table 15). Statements in the poor thematic fit condition always confirmed the gapping reading *Okay, Peter peeled the orange with his knife* because a nongapping analysis would have resulted in semantic anomaly like **Okay, Peter peeled Martin with his hands*. Half of the statements were correct, half incorrect, due to the appropriateness of the prepositional phrase that varied between correct "… with a knife …" or incorrect "… with this hands …" for sentences with poor thematic fit.

By presenting only (correct vs. incorrect) gapping statements in the poor thematic fit condition, a misbalance may have been introduced in the stimuli: gapping statements occurred more often than nongapping statements. This choice was motivated by the intention to avoid the expectation of semantic anomaly that had arisen if the actual nongapping

Table 15. Experimental conditions

Table 15 displays the interaction of the three experimental factors: *Thematic Fit* (good fit vs. poor fit), *Prosody* (gapping prosody vs. nongapping prosody), and *Discourse Context* (gapping context vs. nongapping context). Predictions of the interpretive preferences based on the interaction of these factors are presented in the column "preference". Examples (presented here in English translation) correspond to the experimental conditions. In experiment 1, no questions were presented.

Preference	Thematic Fit	Prosody	Discourse Context	Example
Highly preferred	Good thematic fit	Nongapping	Nongapping	*When did John invite the boys?* John invited PETER on Monday and MARTIN on Tuesday.
Dispreferred	Good thematic fit	Gapping	Gapping	*When did the boys invite Peter?* JOHN invited Peter on Monday and MARTIN on Tuesday.
Enforced	Poor thematic fit	Gapping	Gapping	*How did the farmers peel the orange?* JOHN peeled the orange with his knife and MARTIN with his hands.
Anomalous	Poor thematic fit	Nongapping	Nongapping	*What did John peel?* John peeled the ORANGE with his knife and MARTIN with his hands.
	Statement Good Thematic Fit		Nongapping	*OK, so John invited Martin on Tuesday.*
			Gapping	*OK, so Martin invited Peter on Monday.*
	Statement Poor Thematic Fit		Correct	*OK, so John peeled the orange with his knife.*
			Incorrect	*OK, so John peeled the orange with his hands.*

statement was used (i.e., *Okay, so Peter peeled Martin with his hands*), which violates the state of affairs and can hardly be agreed with, even if it corresponds to the nongapping reading promoted by prosody. Since the study focuses on neural responses to target sentences prior to the statements, the misbalance was not expected to interfere with the on-line processing of the ambiguous sentence.

Table 16a. Acoustic stimulus characteristics in sentences with good thematic fit

The table presents means (M) and standard deviations (SD) to measured acoustic parameters of targets (in bold) and their surrounding elements (subject, verb, object, prepositional phrases) in sentences with good thematic fit. Measurements include acoustic duration (in ms), fundamental frequency (f0, in Hz) and pitch range (in Hz). Acoustic data are presented for sentences with gapping prosody (GAP) and sentences with nongapping prosody (NONGAP). Abbreviations: PrepPhr1 = prepositional phrase prior to target in the first clause, PrepPhr2 = prepositional phrase after the target in the second clause.

Good Thematic Fit												
	Subject		**Verb**		**Object**		**PrepPhr1**		**Target**		**PrepPhr2**	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Duration												
GAP	392	69	373	88	293	63	461	128	**458**	61	527	116
NONGAP	276	64	369	91	367	86	447	118	**385**	53	525	122
F0 (min)												
GAP	141	23	132	11	128	13	112	21	**125**	17	105	13
NONGAP	137	23	114	16	120	22	118	21	**117**	13	93	19
F0 (max)												
GAP	234	16	175	29	162	48	210	26	**216**	19	166	60
NONGAP	173	15	162	42	202	15	214	34	**180**	41	156	72
Pitch range												
GAP	93		43		34		98		**91**		61	
NONGAP	36		48		82		96		**63**		63	

The goal of the current study was to account specifically for the role of prosody and thematic fit on interpretation. For this reason, other sources of semantic processing costs were minimized and targets were selected to be proper names which are semantically shallow, instead of common nouns which are semantically rich (e.g., *Martin* instead of *the man*). Targets were matched for length and lemma frequency (Dutch Google website) and always had a lexical stress on the initial syllable (Ladd et al., 2000). This guaranteed identical accent identification points, which is crucial for determining the exact timing of the effects.

Table 16b. Acoustic stimulus characteristics in sentences with poor thematic fit

The table presents means (M) and standard deviations (SD) to the acoustic parameters of targets (in bold) and their surrounding elements (subject, verb, object, prepositional phrases) in sentences with poor thematic fit. Measurements include acoustic duration (in ms), fundamental frequency (f0, in Hz) and pitch range (in Hz). Acoustic data are presented for sentences with gapping prosody (GAP) and sentences with nongapping prosody (NONGAP). Abbreviations: PrepPhr1 = prepositional phrase prior to target in the first clause, PrepPhr2 = prepositional phrase after the target in the second clause.

Poor Thematic Fit												
	Subject		**Verb**		**Object**		**PrepPhr1**		**Target**		**PrepPhr2**	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Duration												
GAP	374	74	356	89	328	90	477	102	**448**	70	515	121
NONGAP	271	59	336	80	398	91	446	104	**375**	57	511	128
F0 (min)												
GAP	142	32	126	18	123	8	115	21	**119**	11	102	15
NONGAP	140	13	119	15	119	18	118	18	**115**	13	100	11
F0 (max)												
GAP	231	27	168	27	150	37	227	55	**194**	18	163	71
NONGAP	168	16	159	37	201	15	209	16	**172**	11	159	67
Pitch range												
GAP	89		42		27		112		**75**		61	
NONGAP	28		40		82		91		**57**		59	

To ensure natural pronunciation, two phonetically naive Dutch native speakers recorded the stimuli as short dialogues with a question preceding the target sentence; the female speaker produced the questions and the statements, and the male speaker produced the answers that correspond to the target sentences. The male speaker was instructed to disambiguate the two readings by accent placement and by producing a short break after *Martin* in the gapping condition. Stimuli with disruptions and hesitations were re-recorded at the end of the session. In experiment 1, questions were cut out of the recorded dialogues and the actual stimuli consisted of a single target sentence followed by a statement.

Table 16c. Acoustic duration of segments and pauses in each condition

The table displays the acoustic duration (in ms) of segments and pauses across experimental conditions, in poor thematic fit and good thematic fit sentences with gapping prosody (GAP) and nongapping prosody (NONGAP). Means (M) and standard deviations (SD) are presented. Abbreviations based on the example *John invited Peter on Monday and Martin on Tuesday*: PrepPhr1 = prepositional phrase in first clause (*Monday*), Pre-PrepPhr1 = elements between Object and PrepPhr1 (*on*); PrepPhr2 = prepositional phrase in second clause (*Tuesday*), Pre-PrepPhr2 = elements between *Martin* and Prep Phrase2 *Tuesday* (*on*), Total = total sentence duration.

Thematic Fit	**Good Thematic Fit**				**Poor Thematic Fit**			
Prosody	**GAP**		**NONGAP**		**GAP**		**NONGAP**	
	M	SD	M	SD	M	SD	M	SD
Subject	329	69	276	64	374	74	271	59
Pause	60	21	0	0	70	23	0	0
Verb	373	88	369	91	356	89	336	80
Pause	0	0	0	0	92	28	95	28
Object	293	63	367	86	328	90	398	91
Pause	0	0	40	9	0	0	67	0
Pre-PrepPhr1	209	49	234	67	183	56	204	57
PrepPhr 1	461	128	447	118	477	102	446	104
Pause	107	47	86	30	111	37	88	30
“and”	118	36	122	30	106	29	121	31
TARGET	**458**	**61**	**385**	**53**	**448**	**70**	**375**	**57**
Pause	97	39	0	0	94	43	0	0
Pre-PrepPhr2	213	48	234	48	199	58	210	53
PrepPhr 2	527	116	525	122	515	121	511	128
Total	**3085**		**3122**		**3353**		**3308**	

Experimental items were 80 good thematic fit sentences and 80 poor thematic fit sentences that were each recorded with gapping and nongapping prosody and with a gapping or nongapping statement (160 items x 2 prosodies x 2 statements = 640 in total). All 640 stimuli were distributed over four lists of 160 sentences each using a Latin square format where half of the sentences were sentences with good thematic fit (n=80) and the other half were sentences with poor thematic fit (n=80). In each of these groups, half of the stimuli had gapping prosody (n=40) and half of the stimuli had nongapping prosody (n=40). Each gapping and nongapping prosodic realization was followed by a gapping statement (n=20) or by a nongapping statement (n=20). There were no more than two successive presentations of the same condition per list. No participant heard more than one version of any sentence.

5.2.1.3 Acoustic analysis

Acoustic analysis was performed in *Praat* (Boersma & Weening, 2010). Table 16 displays the duration, minimal and maximal fundamental frequency (f0), and pitch range of the target *Martin* and its surrounding elements in sentences with good thematic fit (Table 16a) and sentences with poor thematic fit (Table 16b), both realized with gapping and nongapping prosody. Table 16c displays the acoustic duration of each segment across conditions.

Although targets were accented in all conditions, their duration was longer (by 73 ms) in sentences with gapping prosody than in sentences with nongapping prosody. Thematic fit had no effect on acoustic lengthening. The acoustic data for the subject and the object in the main clause provide evidence that accentuation increases acoustic duration irrespective of prosody type (gapping vs. nongapping) and thematic fit (poor fit vs. good fit): accented subject and object NPs were longer by more than 100 ms than their unaccented counterparts.

As Table 16c shows, conditions differed also with respect to the presence of a prosodic break after the target *Martin*. In sentences with gapping prosody, a pause was produced after the target (100 ms on average); no such pause occurred in sentences with nongapping prosody. Any other pauses in the signal had a very short duration (<50 ms) and did not occur in the vicinity of targets. Stimuli prior to the ambiguous target *Martin* did not vary in duration across experimental conditions.

Accentuation triggered changes in pitch height (f0 max) and pitch range (differences between f0 max and f0 min). Table 16a and 16b show that accented elements had higher pitch and larger pitch range than unaccented elements. Furthermore, prosodically parallel elements that were accented in the first and the second clause had similar pitch range.

Table 17a. Phonological variation in sentences with gapping prosody

The table presents the distribution of pitch accents and prosodic boundaries in sentences with gapping prosody and compares sentences with poor thematic fit and sentences with good thematic fit. The distribution is based on 80 experimental stimuli per condition. Pitch accents are annotated according to ToDI (Gussenhoven, 2005) where L denotes low pitch, H high pitch, an asterisk (*) the tone in the accented syllable, and "%" the prosodic boundary. The following accents were found: LH* (low rising), H* (high level), H*L (high falling), L* (low level), deaccented (no accent), and the boundaries H% (high pitch), and L% (low pitch). Abbreviations: Subj = subject, Obj = object, PrepPhr = prepositional phrase.

Gapping Prosody	**Good Thematic Fit**					**Poor Thematic Fit**				
N=80	Subj	Obj	Prep Phr1	Target	Prep Phr2	Subj	Obj	Prep Phr1	Target	Prep Phr2
LH*	50		61	75		54		77	79	
H*						10		3	1	
H*L	30		12	5	73	16				61
L*			7		7					19
deaccented		80	0				80			
H%	48		51	79		48		76	80	
L%	32		29	1		31		4		

Pitch range differed across conditions and was higher in sentences with gapping prosody than in sentences with nongapping prosody, regardless of the fact that all words were accented.

The prosodic contour of each recorded sentence was transcribed in accordance with the Transcription of Dutch Intonation system (ToDI, Gussenhoven, 2005), such that the phonological type of accents and the present prosodic breaks were annotated. In ToDI, pitch accents are described as movements from high pitch (H) to low pitch (L), that is HL, or *vice versa*, whereas level pitch is presented as either H or L. An asterisk (*) is used to indicate the pitch in the accented syllable, differentiating the tonal target of high rising LH* and low rising L*H accents. Phrase boundaries are annotated by "%" together with their pitch: high (H%) and low (L%) boundaries.

Table 17b. Phonological variation in sentences with nongapping prosody

The table presents the distribution of pitch accents and prosodic boundaries in sentences with nongapping prosody and compares sentences with poor thematic fit and sentences with good thematic fit. The distribution is based on 80 experimental stimuli per condition. Pitch accents are annotated according to ToDI (Gussenhoven, 2005) where L denotes low pitch, H high pitch, an asterisk (*) the tone in the accented syllable, and "%" the prosodic boundary. The following accents are displayed: LH* (low rising), H* (high level), H*L (high falling), L* (low level), deaccented (no accent), and the boundaries H% (high pitch), and L% (low pitch).

Nongapping Prosody	**Good Thematic Fit**					**Poor Thematic Fit**				
N=80	Subj	Obj	Prep Phr1	Target	Prep Phr2	Subj	Obj	Prep Phr1	Target	Prep Phr2
LH*		38	69	70			34	73	75	
H*		1	6	9			2	7	5	
H*L		41	5	1	70		44			67
L*					10					13
deaccented	80					80				
H%			65					75		
L%			15					5		

Representative examples of prosodic contours across conditions are displayed in Figure 19a-d. In sentences with gapping prosody (Figure 19b, 19d) such as *JOHN invited Peter on Monday and MARTIN on Tuesday*, the accented subject in the first clause carried mostly a rising LH* accent, followed by a high boundary tone H%; in some cases, the accent was realized as H*L or H* (see Table 17a, 17b for the distribution of accent types). The direct object of the first clause in the same condition was deaccented, and the first prepositional phrase carried an LH* accent, followed by a high boundary tone H%. The target *Martin* in the second clause was always accented with an LH* accent which is phonologically parallel to the accent on the subject, and is followed by a high boundary tone H%. Lastly, the second prepositional phrase had mostly an H*L accent (or an L* accent).

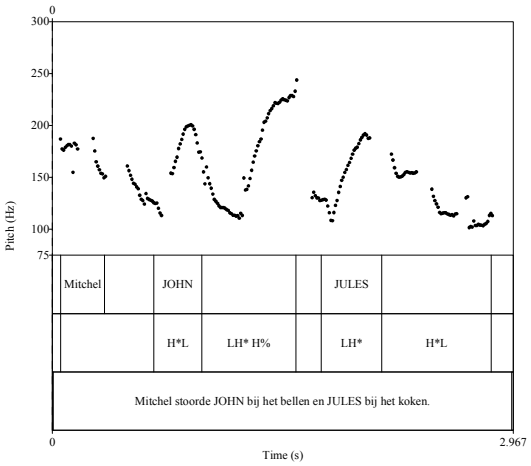


Figure 19a. Good Thematic Fit # Nongapping Prosody

Dutch: *Mitchel stoorde JOHN bij het bellen en JULES bij het koken.*

English: *Mitchel disturbed JOHN during the call and JULES during the cooking.*

There is a prosodic parallelism between the object in the first clause *JOHN* and the ambiguous target in the second clause *JULES*, which receive an H*L and LH* accent respectively (accent in capitals). Prosodic parallelism leads to a nongapping reading of the second clause with *Jules* as an object to the verb "disturb". The prosodic contour in this condition was mostly realized as:

Subject	**Object**	**PrepPhrase1**	**TARGET**	**PrepPhrase2**
deaccented	H*L	LH* H%	LH*	H*L

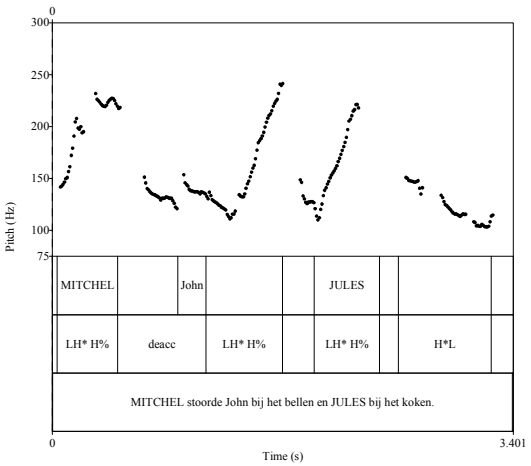


Figure 19b. Good Thematic Fit # Gapping Prosody

Dutch: *MITCHEL stoorde John bij het bellen en JULES bij het koken.*

English: *MITCHEL disturbed John during the call and JULES during the cooking.*

A prosodic parallelism is present between the accent on the subject in the first clause *MITCHEL* and the accent on the target *JULES* in the second clause which both receive an LH* accent (accent in capitals). Due to the prosodic parallelism, the sentence receives a gapping reading with *Jules* as the subject of a conjoined clause. The prosodic contour in this condition was most often realized as:

Subject	**Object**	**PrepPhrase1**	**TARGET**	**PrepPhrase2**
LH* H%	deaccented	LH* H%	LH* H%	H*L

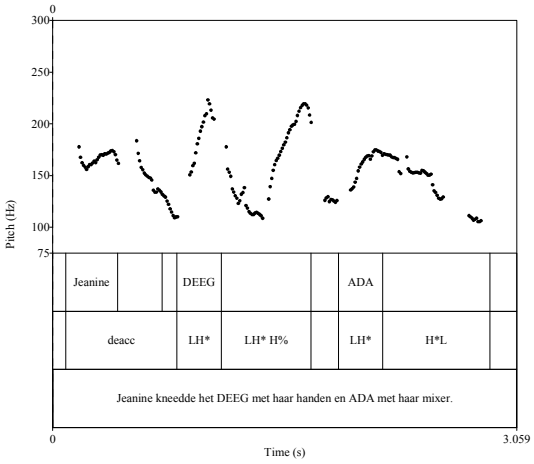


Figure 19c. Poor Thematic Fit # Nongapping Prosody

Dutch: *Jeanine kneedde het DEEG met haar handen en ADA met haar mixer.*

English: *Jeanine kneaded the DOUGH with her hands and ADA with her mixer.*

The object in the first clause *DOUGH* and the target in the second clause *ADA* are prosodically parallel and receive an L*H accent (in capitals). Prosodic parallelism promotes a nongapping reading with an implausible interpretation of *Ada* as object. Due to the poor thematic fit, this reading of *Ada* is anomalous and a gapping reading is enforced. The prosodic contour was mostly realized as:

Subject	**Object**	**PrepPhrase1**	**TARGET**	**PrepPhrase2**
deaccented	H*L	LH* H%	LH*	H*L

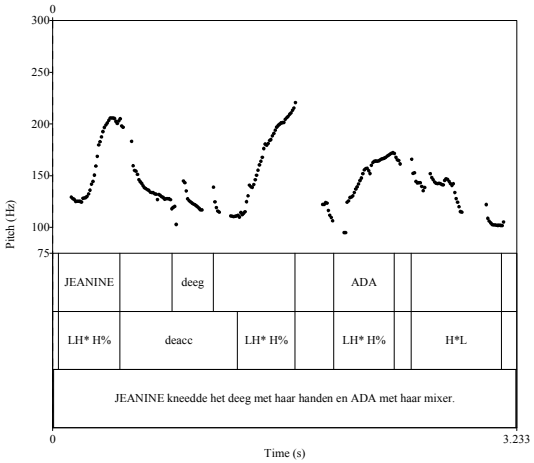


Figure 19d. Poor Thematic Fit # Gapping Prosody

Dutch: *JEANINE kneedde het deeg met haar handen en ADA met haar mixer.*

English: *JEANINE kneaded the dough with her hands and ADA with her mixer.*

The subject in the first clause *JEANINE* and the target in the second clause *ADA* are prosodically parallel and receive an LH* accent (accent in capitals). Based on prosodic parallelism, the second clause receives a gapping reading and the target is interpreted as a subject. The prosodic contour was mostly realized as:

Subject	**Object**	**PrepPhrase1**	**TARGET**	**PrepPhrase2**
LH* H%	deaccented	LH* H%	LH* H%	H*L

In sentences with nongapping prosody (Figure 19a, 19c) such as *John invited PETER on Monday and MARTIN on Tuesday*, the subject in the first clause was deaccented. The following object carried either an H*L or an LH* accent, and the prepositional phrase was mostly realized with a rising LH* accent, followed by a high boundary tone H%. The target *MARTIN* carried a rising LH* accent and was not followed by a boundary. The final prepositional phrase had a falling H*L accent. Table 17a and 17b display the distribution of accents and phrase boundaries across all conditions.

5.2.1.4 EEG methods and procedure

A cap with 64 Ag/AgCl electrodes was used in accordance with the extended international 10-20 system (Electro Cap International). The EEG signal was sampled at 250 Hz and amplified on-line against the average of all connected inputs of the amplifier (TMS international). The amplifier measured DC with a digital FIR filter (cutoff frequency of 67.5 Hz) to avoid aliasing. Electrodes were re-referenced offline to the algebraic average of left and right mastoid electrodes. Vertical eye movements and blinks were recorded via electrodes below and above the left eye, and horizontal eye movements via electrodes at the left and right canthus of each eye. Impedances were kept below 5Ω. All data were filtered offline with a band-pass filter of 0.01-30 Hz.

After electrode application, participants completed a trial session and listened to auditorily presented (via loudspeakers) target sentences and rephrasing statements. The actual experiment consisted of four blocks of 40 sentence pairs each; stimuli in the good thematic fit condition were presented as the first two blocks. In the good thematic fit condition the majority of sentences would be given a nongapping reading, which could influence the processing of the poor thematic fit condition (where the large majority of sentences would receive a gapping reading). Correspondingly, the poor thematic fit condition would draw attention to the semantic plausibility of sentences, which would shift the focus of attention to

an unnatural aspect of the stimuli (plausible vs. implausible); this was avoided by presenting sentences with poor thematic fit as the last two experimental blocks.

To minimize eye movement artifacts, participants fixated a black cross against a grey computer screen during stimulus presentation. Each trial started with a delay (100 ms), followed by the target sentence (3400 ms on average), silence (500 ms), and a rephrasing statement (2700 ms on average). After the rephrasing statement, a question "does it match?" was displayed on the screen and participants indicated with a button press whether or not the statement matched with the preceding sentence. Participants were instructed to rely on their first impression; it was stressed that there are no correct or incorrect responses. Matching and mismatching rephrasing statements were counterbalanced. After the response was given, a blinking period (3000 ms) was initiated.

5.2.1.5 EEG analysis

Trials with movement artifacts, ocular artifacts and electrode drifts (± 75 μV) were rejected. Only participants with a minimum of 60 % valid data on any analyzed electrode in each condition were included, leading to the exclusion of seven other participants. Number of rejected trials did not vary per condition. ERPs were time locked to the acoustically determined onset of the target NP *Martin* (e.g., good thematic fit: *John invited Peter on Monday and Martin on Tuesday*; poor thematic fit: *John peeled the orange with a knife and Martin with his hands*) that represented the first point at which disambiguation between a clause coordination and VP coordination reading could occur.

Three time windows were selected for further analysis: *N400 time window* 400-700 ms, *P600 time window* 700-1000 ms, and *Late time window* 1000-1300 ms post target onset. Average ERPs were computed for groups of electrodes according to pre-defined lateral and midline Regions Of Interest (ROI) separately. Lateral ROIs included *left anterior* (FP1, AF3, AF7, F3, F5, F7), *right anterior* (FP2, AF4, AF8, F4, F6, F8), *left central* (FC3, FC5, C3, C5,

CP3, CP5), *right central* (FC4, FC6, C4, C6, CP4, CP6), *left posterior* (P3, P5, P7, PO3, PO7, O1), *right posterior* (P4, P6, P8, PO4, PO8, O2). Midline ROIs included *anterior* (FPz, AFz, Fz), *central* (FCz, Cz, CPz), and *posterior* electrodes (Pz, POz, Pz).

Two pairwise comparisons using repeated measures ANOVAs were performed. First, sentences with good thematic fit were compared to sentences with poor thematic fit to test the effect of *Prosody* (gapping prosody vs. nongapping prosody). Second, sentences with gapping prosody were compared to sentences with nongapping prosody to examine the effect of *Thematic Fit* (sentences with good thematic fit vs. sentences with poor thematic fit). In each of these pairwise comparisons, two further factors were included: *Anteriority* (anterior vs. central vs. posterior region), and *Hemisphere* (left hemisphere vs. right hemisphere). ANOVAs for midline electrodes included all factors except for *Hemisphere*. Statistical analyses were performed on mean voltage data and were adjusted with the Huynh-Feldt correction for nonsphericity where appropriate. To eliminate potential ERP differences that might have arisen prior to the processing of the target, e.g., due to differences in the prosodic contour across conditions, a within-stimulus baseline correction was calculated between 0-100 ms post target onset (for a similar procedure, see Philips et al., 2005; Mueller, 2009). Average waveforms are computed to segments of 1300 ms duration from target onset.

5.2.2 Results

5.2.2.1 Behavioral results

After the presentation of an ambiguous sentence and a rephrasing statement, listeners judged whether the statement (gapping vs. nongapping rephrasing) corresponded to the meaning of the sentence. With gapping prosody, participants agreed with a gapping rephrasing statement in 75 % of all sentences, and with nongapping prosody, they agreed with a nongapping rephrasing statement in 75 %; the data did not vary depending on thematic fit. Due to the

almost identical distribution of responses across conditions, the results are considered unreliable. Since a technical error cannot be excluded, e.g., in the coding of the recorded response, we refrain from further analysis and discussion of the behavioral results.

5.2.2.2 ERP results: Prosody effect

Statistical results are shown in Table 18: Table 18a presents the pairwise comparison of sentences with good thematic fit vs. poor thematic fit (*Prosody* effect), and Table 18b presents the pairwise comparison of sentences with gapping prosody vs. nongapping prosody (*Thematic Fit* effect). ERP data are displayed in Figure 20 and 21a. Effects due to *Anteriority* and *Hemisphere* are reported only if they interact with the cognitive factors *Prosody* and *Thematic Fit*. Low order interactions are not discussed if included in higher order interactions. Marginal effects and interactions (.05<p≤.1) are presented in footnotes for future reference and are not included in the discussion.

Table 18a. Statistical results for experiment 1 (no context): Effect of Prosody

Statistical data are based on pairwise comparisons of gapping prosody and nongapping prosody, separately for sentences with good thematic fit and sentences with poor thematic fit. Marginal results (.05<p≤.1) are given in italics. Abbreviations: PROS=Prosody, ANT=Anteriority, HEM=Hemisphere.

Experiment 1			**400-700 ms**		**700-1000 ms**		**1000-1300 ms**	
		df	F	p	F	p	F	p
Good Thematic Fit	***Lateral***							
	PROS	*1,26*			7.633	.010		
	PROS x HEM	*1,26*	3.165	*.087*				
	Midline							
	PROS	*1,26*			8.568	.007		
Poor Thematic Fit	***Lateral***							
	PROS	*1,26*	10.450	.003			3.894	*.059*
	PROS x ANT	*2,52*			4.592	.030	9.075	.003
	Midline							
	PROS	*1,26*	8.481	.007	2.764	*.079*	4.407	.046
	PROS x ANT	*2,52*					6.882	.005

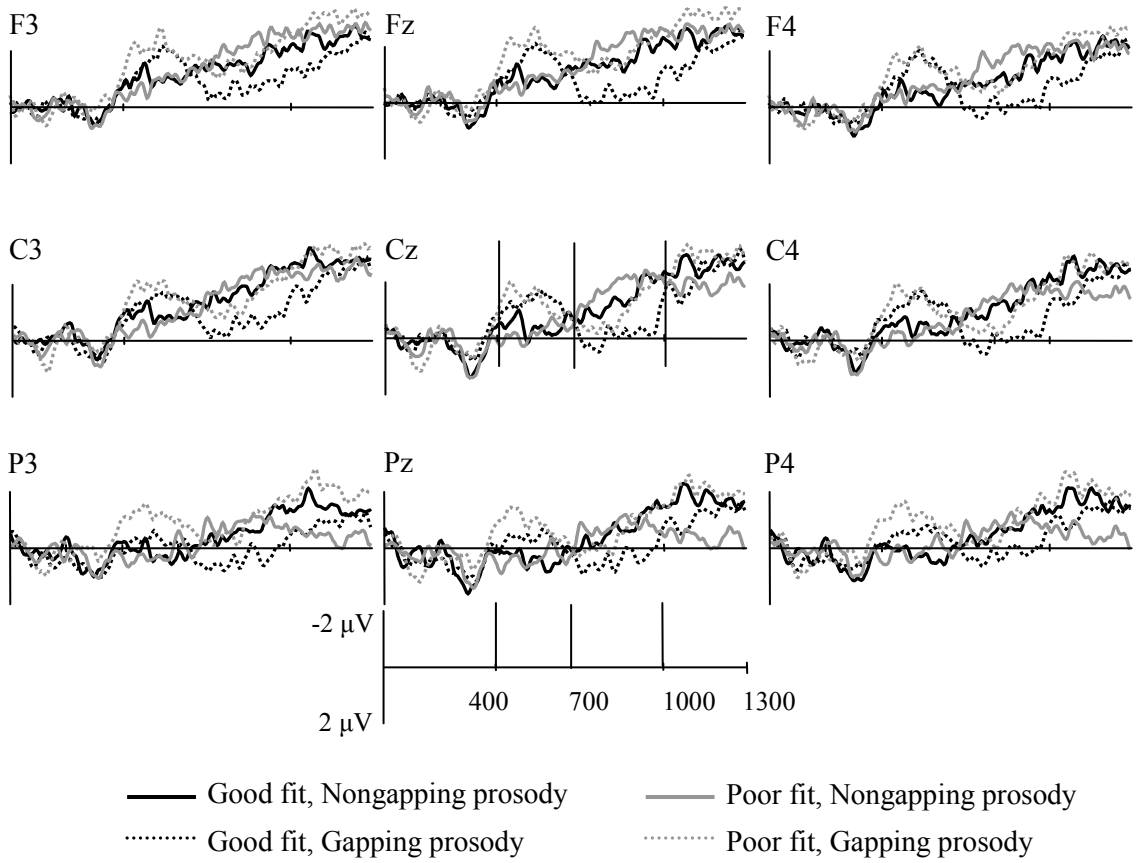


Figure 20. Interaction plot for the effects of prosody and thematic fit in experiment 1

The figure presents interaction plots across all conditions in experiment 1 where sentences were presented without a discourse context. Gapping prosody is displayed in dotted lines, nongapping prosody in solid lines; sentences with good thematic fit are presented in black and sentences with poor thematic fit in grey. Three time windows which were statistically analyzed are separated by vertical lines (400-700, 700-1000, 1000-1300 ms).

5.2.2.2.1 N400 time window 400-700 ms

Good Thematic Fit. No significant effects were found on lateral or midline electrodes in sentences with good thematic fit.[31]

Poor Thematic Fit. On lateral electrodes, there was a main effect of *Prosody* ($F(1,26)=10.450$, $p<.01$) due to a negativity for gapping prosody relative to nongapping

[31] There was a marginal interaction of *Prosody* x *Hemisphere* ($F(1,26)=3.165$, $p=.09$) on lateral electrodes, due to a negativity for gapping prosody in the right hemisphere ($F(1,26)=3.501$, $p=.07$) vs. no effect in the left hemisphere ($F(1,26)=.620$, $p=.44$).

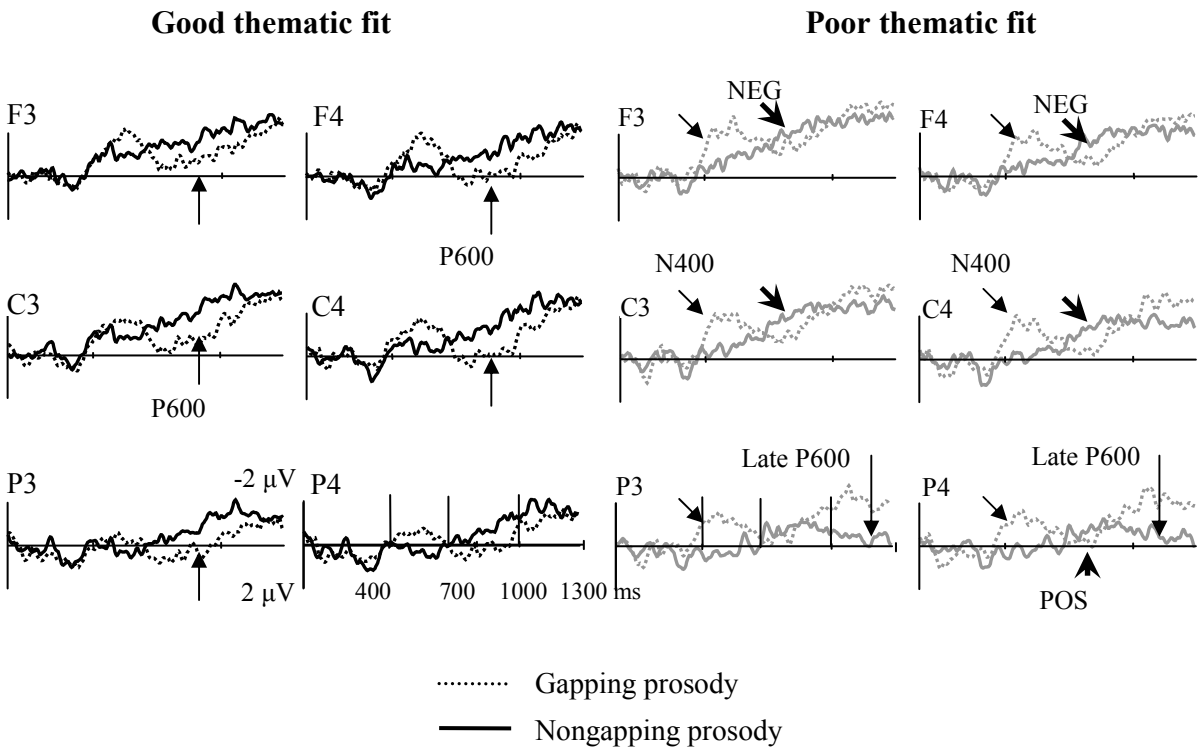


Figure 21a. Experiment 1: Prosody effects in sentences with poor vs. good thematic fit
ERPs to gapping prosody (dotted lines) and nongapping prosody (solid lines) are compared in sentences with good thematic fit (left panel, black lines) vs. sentences with poor thematic fit (right panel, grey lines). The figure shows a negativity (400-700 ms) for gapping prosody in sentences with poor fit (N400); the negativity in good fit was marginally significant and was right-lateralized. In good thematic fit sentences there was a positivity (P600) for gapping prosody (700-1000 ms). In poor thematic fit sentences, nongapping prosody elicits an anterior negativity (700-1000 ms) and a posterior positivity (700-1300 ms).

prosody. The *Prosody* main effect was also significant on midline electrodes ($F(1,26)=8.481$, $p<.01$), due to negative fluctuations for sentences with gapping prosody.

5.2.2.2.2 P600 time window 700-1000 ms

Good Thematic Fit. There was a main effect of *Prosody* on lateral electrodes ($F(1,26)=7.633$, $p=.01$), due to a positivity for gapping prosody relative to nongapping prosody; the effect was also significant on midline electrodes ($F(1,26)=8.568$, $p<.01$).

Poor Thematic Fit. On lateral electrodes, the *Prosody* x *Anteriority* interaction was significant (F(2,52)=4.592, p<.05), but follow-ups did not reveal a statistically reliable difference in the *Prosody* effect at anterior, central or at posterior sites (all *p*'s>.15). The means show that the interaction must have been due to an anterior-central negativity and posterior positivity for nongapping prosody.

5.2.2.2.3 Late time window 1000-1300 ms

Good Thematic Fit. No effects or interactions were significant on lateral or midline electrodes.

Poor Thematic Fit. On lateral electrodes[32], there was an interaction of *Prosody* x *Anteriority* (F(2,52)=9.075, p<.01). Follow-ups revealed a significant *Prosody* effect on posterior regions (F(1,26)=20.174, p<.000) and a marginal one on central regions (F(1,26)=3.390, p=.077), both due to a positivity for nongapping prosody; the *Prosody* effect was not significant at anterior sites (F(1,26)=.120, p=.73).

On midline electrodes, the main effect of *Prosody* was significant (F(1,26)=4.407, p<.05) and represented a positivity for nongapping prosody. The effect was licensed by a *Prosody* x *Anteriority* interaction (F(2,52)=6.882, p<.01). Post-hocs examined that the *Prosody* effect was significant at posterior sites (F(1,26)=16.102, p<.000), marginal at central sites (F(1,26)=4.031, p=.055) and not significant at anterior sites (F(1,26)=.009, p=.925). The means show that nongapping prosody triggered a posterior positivity.

[32] *Prosody* had a marginal main effect on lateral sites (F(1,26)=3.894, p=.059), due to a positivity for nongapping prosody.

5.2.2.3 ERP results: Thematic fit effect

Statistical results are displayed in Table 18b, and ERP data in Figure 21b.

Table 18b. Statistical results for experiment 1 (no context): Effect of Thematic Fit

The Table presents statistical data for experiment 1, based on pairwise comparisons of sentences with good thematic fit and sentences with poor thematic fit, separately for gapping prosody and nongapping prosody. Marginal results (.05<p≤.1) are presented in italics for future reference. Abbreviations: FIT=Thematic Fit, ANT=Anteriority, HEM=Hemisphere.

Experiment 1			**400-700 ms**		**700-1000 ms**		**1000-1300 ms**	
		df	F	p	F	p	F	p
Gapping Prosody	***Lateral***							
	FIT	*1,26*			9.532	.005	5.353	.029
	FIT x ANT	*2,52*	3.540	*.054*				
	FIT x HEM	*1,26*	3.158	*.087*				
	Midline							
	FIT	*1,26*			8.057	.009	4.728	.039
Nongapping Prosody	***Lateral***							
	FIT x ANT	*2,52*					7.280	.009
	FIT x ANT x HEM	*2,52*					4.006	*.056*
	Midline							
	FIT x ANT	*2,52*					7.879	.005

5.2.2.3.1 N400 time window 400-700 ms

Gapping prosody. No effects or interactions were significant on lateral or midline electrodes.[33]

Nongapping prosody. No significant effects or interactions were found.

[33] There were two marginal interactions on lateral electrodes in sentences with gapping prosody (400-700 ms). First, there was a *Thematic Fit* x *Anteriority* interaction (F(2,52)=3.540, p=.054), due to a *Thematic Fit* effect on posterior regions (F(1,26)=9.338, p<.01). That is, sentences with good thematic fit elicited a posterior positivity; no such effect was found on anterior (F(1,26)=.012, p=.915) and central regions (F(1,26)=1.673, p=.207). Second, there was a marginal interaction of *Thematic Fit* x *Hemisphere* (F(2,52)=3.158, p=.087), due to a *Thematic Fit* effect in the left hemisphere (F(1,26)=4.298, p<.05) in the form of a left lateralized positivity for good thematic fit; no such effect was found in the right hemisphere (F(1,26)=.868, p=.360).

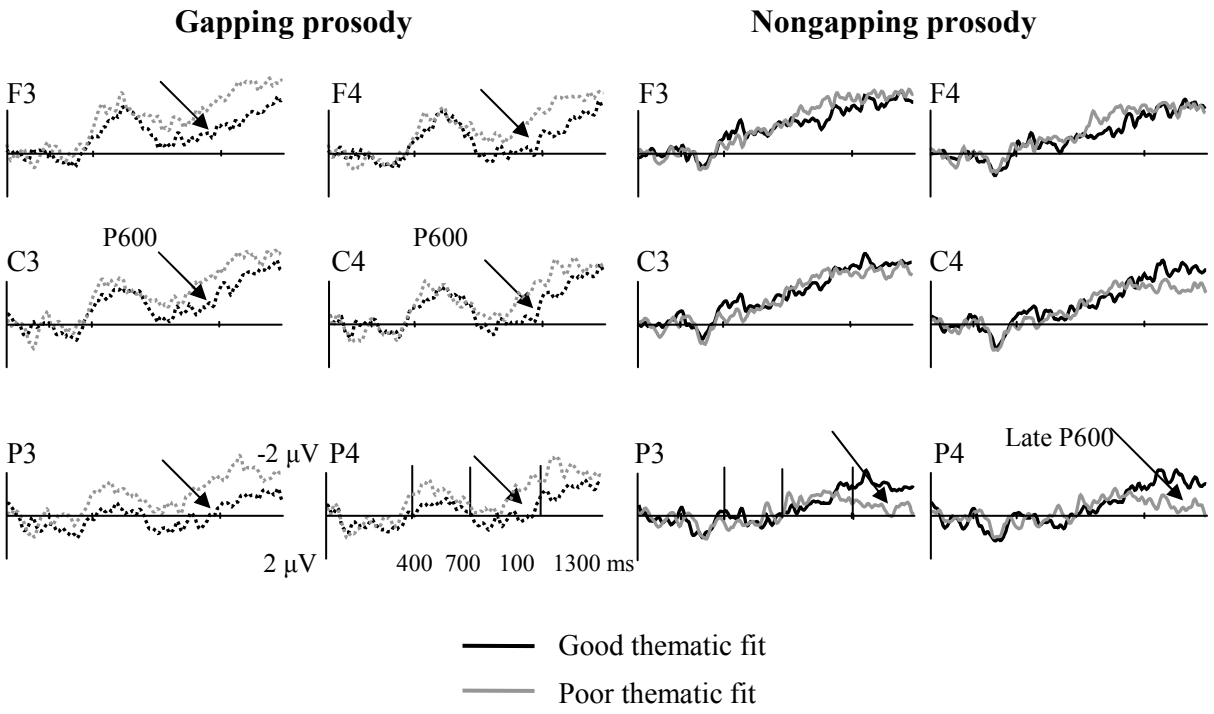


Figure 21b. Experiment 1: Thematic Fit effects in sentences with gapping vs. nongapping prosody

ERPs compare the effect of thematic fit in sentences with gapping prosody (left panel, dotted lines) and nongapping prosody (right panel, solid lines). Sentences with good thematic fit are presented in black color, and sentences with poor thematic fit in grey color. In sentences with gapping prosody, there was a marginal left posterior positive effect for good thematic fit (400-700 ms) that was significant and broadly distributed between 700-1300 ms. In sentences with nongapping prosody, poor thematic fit elicited late posterior positivities (1000-1300 ms).

5.2.2.3.2 P600 time window 700-1000 ms

Gapping prosody. On lateral electrodes, there was a main effect of *Thematic Fit* ($F(1,26)=9.532$, $p<.01$) due to a positivity for good thematic fit vs. poor thematic fit. On midline electrodes, the same positive effect was found for sentences with good thematic fit ($F(1,26)=8.057$, $p<.01$).

Nongapping prosody. No significant results were found on lateral and midline electrodes.

5.2.2.3.3 Late time window 1000-1300 ms

Gapping prosody. On lateral electrodes, the effect of *Thematic Fit* was significant ($F(1,26)=5.353$, $p<.05$) and was due to a positivity for sentences with good thematic fit. On midline electrodes, *Thematic Fit* had the same effect ($F(1,26)=4.728$, $p<.05$).

Nongapping prosody. On lateral electrodes, the interaction of *Thematic Fit* x *Anteriority* was significant ($F(2,52)=7.280$, $p<.01$). Follow-up analyses showed a *Thematic Fit* effect on posterior regions ($F(1,26)=6.553$, $p<.05$), but no effect on anterior ($F(1,26)=1.369$, $p=.253$) or central regions ($F(1,26)=1.299$, $p=.265$). The means reveal that sentences with poor thematic fit elicited a posterior positive effect relative to sentences with good thematic fit.[34] On midline electrodes, the *Thematic Fit* x *Anteriority* was significant ($F(2,52)=7.879$, $p<.01$) and pointed in the same direction.

5.2.2.4 Summary of results

Prosody affected neural processing in both types of sentences. In sentences with good thematic fit, gapping prosody (dispreferred) triggered a marginal right-lateralized negativity (400-700 ms), followed by a positivity (700-1000 ms) relative to nongapping prosody (highly preferred). In sentences with poor thematic fit, gapping prosody (preferred) elicited a broadly distributed negativity (400-700 ms). Nongapping prosody in poor thematic fit (anomalous) triggered an anterior-central negativity (700-1000) and a posterior positivity (700-1300 ms) as compared to gapping prosody (preferred).

[34] There was also a marginal interaction of *Thematic Fit* x *Hemisphere* ($F(1,26)=4.006$, $p=.056$), but the *Thematic Fit* effect was not statistically reliable. The means show that the interaction was due to a positivity for poor thematic fit relative to good thematic fit in the right hemisphere and no such difference in the left hemisphere.

When looking at the data from the perspective of *Thematic Fit*, this factor affected the processing of sentences with different prosodies. With gapping prosody, sentences with good thematic fit (dispreferred) elicited a positivity relative to sentences with poor thematic fit (preferred), which was marginal and left-posterior in the 400-700 ms time window, and broadly distributed after that (700-1300 ms). With nongapping prosody, sentences with poor thematic fit (ungrammatical) elicited a positivity in the late time window (1000-1300 ms) relative to sentences with good thematic fit (highly preferred).

5.2.3 Discussion

The present study investigated the neural mechanisms engaged in the processing of sentences containing a special kind of ellipsis, namely gapping, without discourse context. Two factors were expected to play a role in this process: prosody and thematic fit. Due to offline preferences for a simple topic structure and due to the semantics of elided verbs, sentences with good thematic fit are preferably interpreted as 'nongapping', that is, as VP coordination of the ambiguous (underlined) target as in *John invited Peter on Monday and Martin on Tuesday* (*Martin*=object). In contrast, sentences with poor thematic fit favor a 'gapping' reading of the ambiguous clause, that is, an S-coordination as in *John peeled the orange with a knife and Martin with his hands* (*Martin*=subject). These offline preferences interact with the prosody of each sentence that also favors a gapping or a nongapping reading.

5.2.3.1 Effects of prosody

Differences in prosody elicited two effects: (i) a *negativity* (400-700 ms) when prosody was in favor of gapping, which was preferred in poor thematic fit sentences and dispreferred in sentences with good thematic fit, and (ii) a *positivity* when prosody favored the dispreferred gapping reading in sentences with good thematic fit (700-1000 ms) and the anomalous

nongapping reading in sentences with poor thematic fit (1000-1300 ms). A bipolar effect (700-1000 ms), an anterior-central negativity together with a posterior positivity, was elicited when prosody supported the anomalous nongapping reading in poor thematic fit sentences.

The negativity for gapping prosody (400-700 ms) could belong to the family of N400 components. Due to its occurrence in good fit sentences (though only marginally significant) and poor fit sentences, it probably reflects the construction of a gapping reading of the ambiguous sentence. Creating this gapping representation involves the assignment of a subject role to the ambiguous NP, thus interpreting *Martin* as a new subject in an S-coordinated clause, and the re-activation of the elided verb once the listener notices the ellipsis. The gapping analysis is enhanced in sentences with poor thematic fit (significant N400) where gapping represents the only valid interpretation (see Table 1). In sentences with good thematic fit (marginal N400), the computation of a gapping reading represents a dispreferred though still valid analysis that, given previous evidence, is biased by prosody.

The negativity may be alternatively analyzed as an N400 effect for mismatch processing: gapping prosody represents a mismatch to the preference for nongapping prosody. However, this interpretation cannot account for the fact that the N400 is present and even stronger in sentences with poor thematic fit where gapping prosody is in line with reading preferences. It is furthermore unlikely that the negativity reflects pure acoustic processing of the accented elements in sentences with gapping prosody that are acoustically enhanced as compared to their corresponding counterparts in sentences with nongapping prosody (i.e., longer duration, higher peaks, larger pitch range, see Table 16a, 16b). Previous evidence suggests that acoustic differences between accented and unaccented elements elicit an early positive response, the P200 component (Friedrich et al., 2001; Heim & Alter, 2006; Dimitrova et al., submitted), whereas tonal differences between corrective and non-corrective accents trigger late P600-like responses (see chapter 4). By contrast, N400-like negativities tend to indicate that accentuation is unusual (e.g., when the verb is accented; Heim & Alter,

2006) or incongruous in the context (e.g., when background is accented; Dimitrova et al., submitted; Toepel & Alter, 2004), which does not apply to the current stimuli.

A positivity was found for gapping prosody in good thematic fit sentences (700-1000 ms) that seems to be related to the 'making sense' of their dispreferred though semantically plausible reading. Late positivities are usually attributed to the P600 component for the revision of difficult structures (Hagoort et al., 2003; Hoeks et al., 2004; Kaan et al., 2000) or for the discourse integration of new referents (e.g., Burkhardt, 2007). As discussed in the introduction, a gapping reading in good thematic fit sentences represents the more complex structure with two topics that requires the assumption of an object drop. The P600 in this condition may thus reflect the processing of structural complexity as suggested by Kaan & Swaab (2003) who found an anterior P600 effect for the processing of complex ambiguous sentences like *I cut the cake beside the pizzas that were brought by Jill*.

A similar posterior positivity was evoked by nongapping prosody in sentences with poor thematic fit (700-1300 ms) which misleads the interpretation of the sentence towards anomaly. The late positivity seems to reflect the process of revision of the semantically implausible reading evoked by the prosodic parallelism of *Martin* and the *orange*, cf. *John peeled the ORANGE with a knife and MARTIN with his hands*. The revision of an anomalous reading is in line with previous studies of the P600 (e.g., Hagoort et al., 1999, 2003; Kaan et al., 2000) and suggests that listeners attempt to arrive at a coherent discourse interpretation.

Other interpretations of these late positivities seem less plausible. For instance, late centro-posterior positivities (500-800 ms) have been reported for prosodic parsing at pauses and boundaries in the signal, called the *Closure Positive Shift* (CPS, Steinhauer et al., 1999; Steinhauer & Friederici, 2001). In the present study a silent pause which may have elicited a CPS response occurred only after targets in the gapping prosody condition. Given the temporal dynamics of the stimuli (target duration: 450 ms, pause: 100 ms), the onset of the positivity (700 ms after target onset) starts around 150 ms after the onset of the silent pause,

whereas a CPS should start significantly later, around 500 ms after the onset of the boundary. It seems more likely that the effect, if related to prosodic phrasing, belongs to the P200 which has been reported for boundary processing (Li et al., 2010). This interpretation suggests that the P600-like positivity for gapping prosody in good thematic sentences might actually represent a P200 response elicited by the silent pause after the target *Martin*. Future studies without a silent pause after the target in sentences with gapping prosody are necessary to shed more light on the exact neural source of the late positive effect.

Yet another interpretation of the late positivities is related to the processing of a prosodic boundary between the two conjoined clauses, especially if one interprets the effects in the poor thematic fit condition in the opposite direction, i.e., as a fronto-central positivity for gapping prosody (their preferred reading) rather than as a fronto-central negativity for nongapping prosody (their anomalous reading). The late positivity for gapping prosody in the poor and good fit conditions might thus represent a CPS response to the boundary between the two conjoined clauses (indicated by ||) in *John invited Peter on Monday || and Martin on Tuesday*, given also the temporal dynamics of the elements. Although such view is possible and implies that prosody is the only factor that modulates neural responses irrespective of thematic fit restrictions and sentence plausibility, it seems very unlikely that the positivities represent a CPS response related to the prosodic parsing in sentences with gapping prosody.

Alternatively, the effect in poor thematic fit sentences may represent an anterior-central negativity for nongapping prosody (700-1000 ms), due to the anomalous reading elicited by prosody in this condition; no such negativity was found in sentences with good thematic fit that were semantically plausible. An implausible object interpretation of *Martin* evoked by nongapping prosody (i.e., *John peeled Martin with his hands*) may elicit an N400 response for semantic anomaly. Although it is difficult to account for the relatively late timing of this effect, similar N400 responses have been previously reported in sentences that were semantically anomalous like *He spread his bread with socks* (Kutas & Hillyard, 1980).

The current results suggest that N400-like responses are elicited by reconstruction processes due to ellipsis, and that P600 effects reflect the more effortful processing of dispreferred and anomalous sentence readings. Alternatively, prosodic boundaries in sentences with gapping prosody appear to trigger P200 or CPS responses irrespective of thematic fit. The late negativity following poor thematic fit sentences where nongapping prosody emphasizes the semantic anomaly could be interpreted as ongoing semantic processing due to implausibility.

5.2.3.2 Effects of thematic fit

After discussing the effects of prosody, it may also be informative to look at the data from the point of view of the thematic fit manipulation. Sentences realized with gapping prosody gave rise to a positivity in the good thematic fit condition (where gapping is dispreferred) as compared to the poor thematic fit condition (where gapping is preferred). On the other hand, in sentences with nongapping prosody, the thematic poor fit condition (where nongapping leads to anomaly) was more positive than the good thematic fit condition (where nongapping prosody coincides with the preferred reading). Thus, the positivities for thematic fit may reflect the processing of a conflict between interpretative preferences projected by thematic fit and prosody. As discussed above, the positivity is in line with previous findings of P600 effects for information integration in the discourse (Burkhardt, 2007), the processing of dispreferred structures (Kaan & Swaab, 2003), the integration of incongruous prosody in the discourse (Dimitrova et al., submitted; Schumacher & Baumann, 2010) and in isolated sentences (chapter 3 in this dissertation). The positivity is interpreted as a general process of making sense of what is a less preferred or incongruous reading, signifying the effort to construct a coherent discourse representation in sentences with good and poor thematic fit.

Summarizing, in the present experiment we may have identified the neural correlate of instantiating a gapping interpretation, which is associated with a negative component that

occurs a little bit later than the standard N400. In addition, it has been shown that adding nongapping prosody affects the processing of sentences with poor thematic fit, where it leads to a late anterior negativity and a late positivity that may reflect the effortful processing of a semantically anomalous sentence. The following study investigates whether the effects of gapping and thematic fit change when sentences are embedded in a biasing discourse context.

5.3 Experiment 2: Gapping sentences in discourse context

In experiment 2, ambiguous clauses from experiment 1 were presented after a question context that strongly suggested a particular topic structure in the answer, which was either conducive to a gapping reading (with two contrastive topics) or to a nongapping reading (with only one topic). Of main interest was how readings promoted by discourse context interact with the course of processing suggested by prosody and thematic fit. Discourse information, thematic fit, and prosody were in unison, except for one of the four conditions, where sentences with poor thematic fit (pro-gapping) were coupled with nongapping prosody, and a nongapping context, which favored a semantically anomalous interpretation.

5.3.1 Methods

5.3.1.1 Participants

Twenty-eight right-handed students (9 male, age 18-29 years, mean 21), none of whom had studied Linguistics, with normal or corrected-to-normal vision were paid for participation after signing a written informed consent according to the Declaration of Helsinki. None of the participants reported any neurological, psychological, hearing or language impairment. Inclusion criterion was set to 60 % valid data on any electrode in any condition, which

resulted in the exclusion of seven other female participants due to data loss of more than 40 %. Rejected trials did not differ per condition. No student had participated in experiment 1.

5.3.1.2 Stimuli

Stimuli were identical to the target sentences and rephrasing statements used in experiment 1, but here questions were added prior to the target sentences as an additional disambiguation factor (Table 1). Questions preceding sentences with good thematic fit were strongly predictive of the information structure in the upcoming answers and were in line with the reading projected by prosody. In the nongapping condition, questions projected a structure with one subject (*John*) and two contrastive objects (*the boys*): *When did John see the boys? – John saw PETER on Monday and MARTIN on Tuesday* (contrasted elements underlined, capitals for accent). In the gapping condition, questions projected a structure with two contrastive subjects (*the boys*) and one object (*Peter*): *When did the boys see Peter? – JOHN saw Peter on Monday and MARTIN on Tuesday*. The target *Martin* was intended as contrastive topic, while contrastive foci were realized in the prepositional phrases "on Monday … on Tuesday". In the questions, full NPs (e.g., *the boys*) were used to avoid repetition of the proper names in the answers.

Questions in sentences with poor thematic fit were slightly different. In the gapping condition, questions contained a plural subject, suggesting two contrastive subjects in the answer as in *How did the farmers peel the orange? – JOHN peeled the orange with a knife and MARTIN with his hands*. In the nongapping condition, questions did not introduce two contrastive objects (e.g., something like "How did the farmer peel the fruit and the human/ the two objects?"), which would have implied that *Martin* is an anomalous object of John's peeling action. Rather, nongapping questions suggested a single non-contrastive subject and a single non-contrastive object like *How did the farmer peel the orange?*, whereas nongapping prosody promoted a semantically anomalous reading with two prosodically parallel objects as

in *John peeled the ORANGE with a knife and MARTIN with his hands*. Thus, nongapping contexts avoided the anticipation of semantic anomaly, whereas the nongapping prosody in the answer promoted it. Arguably, this condition could be, to some extent at least, *pragmatically* infelicitous, as the question asks about how one person did something, but the answer is more elaborate and gives extra information about an additional event, involving an unintroduced person (*Martin*). This may lead to additional processing difficulty in poor fit sentences with nongapping prosody. Rephrasing statements are identical to experiment 1.

A total of 640 dialogues were created (160 dialogue items (80 good thematic fit, 80 poor thematic fit) x 2 prosody+context realizations x 2 statements). Using the Latin square format, stimuli were distributed to four lists of 160 sentences each where half of the dialogues were good thematic fit sentences (n=80) and the other half were poor thematic fit sentences (n=80). In each of these groups, half of the dialogues had gapping context and prosody (n=40) and half of the dialogues had nongapping context and prosody (n=40). Each of these subgroups was combined either with a gapping statement (n=20) or with a nongapping statement (n=20). Each participant listened to all experimental items with no more than two successive repetitions of each condition and no participant listened to more than one version of each sentence.

5.3.1.3 Acoustic analysis

The acoustic characteristics of the target sentences are identical to the data in experiment 1.

5.3.1.4 EEG methods and procedure

The EEG signal was recorded as described in experiment 1. Stimulus presentation proceeded as follows: Each trial started with a delay (100 ms), followed by the question (2100 ms on average, nongapping questions in poor thematic fit: 1440 ms on average), silence (500 ms), the target sentence (3400 ms on average), silence (500 ms), and the rephrasing statement

(2700 ms). After the last silence, a question "does it match?" was displayed on the screen and participants judged, relying on their first impression, whether the statement and the dialogue matched by pressing a button; no definition of match was provided. After the response, a blinking period (3000 ms) was initiated. Gapping and nongapping statements (good thematic fit) and correct and incorrect statements (poor thematic fit) were counterbalanced.

5.3.1.5 EEG analysis

EEG analysis was identical to experiment 1. Since the additional factor "discourse context" always promoted the same reading as the factor "prosody", we used the factor *Bias* (favoring gapping vs. favoring nongapping) to refer to the joint effect of prosody and context on sentence interpretation. All other factors and time windows are identical to experiment 1.

5.3.2 Results

5.3.2.1 Behavioral results

As in experiment 1, behavioral results will not be presented as we assume that a technical error may have occurred in the coding of responses.

5.3.2.2 ERP results: Prosody and Context bias effect

As in experiment 1, a repeated measures ANOVAs were performed on pairwise comparisons of sentences with different thematic fit (Table 19a) and sentences with different prosody-context bias (Table 19b). ERP data are presented in Figure 22 (interaction plot) and 23a (effect of prosody-context bias).

Table 19a. Statistical results for experiment 2 (with context): Effect of Prosody

The table presents pairwise comparisons of gapping prosody and nongapping prosody (experiment 2) where stimuli were embedded in a biasing discourse context. Data are presented separately for sentences with good thematic fit and with poor thematic fit. Marginal results (.05<p≤.1) are displayed in italics for future reference. Abbreviations: BIAS=Combinatory bias of Prosody and Context, ANT=Anteriority, HEM=Hemisphere.

Experiment 2			**400-700 ms**		**700-1000 ms**		**1000-1300 ms**	
		df	F	p	F	p	F	p
Good Thematic Fit	***Lateral***							
	BIAS	*1,27*	5.036	.033				
	BIAS x ANT	*2,54*	8.118	.006	11.726	.001	5.121	.027
	Midline							
	BIAS	*1,27*	4.317	.047				
	BIAS x ANT	*2,54*	7.008	.007	11.262	.001	5.362	.019
Poor Thematic Fit	***Lateral***							
	BIAS	*1,27*	10.062	.004				
	BIAS x ANT	*2,54*			3.340	*.071*	5.754	.018
	BIAS x ANT x HEM	*2,54*	5.399	.012	5.624	.014	3.264	*.062*
	Midline							
	BIAS	*1,27*	8.177	.008				

5.3.2.2.1 N400 time window 400-700 ms

Good Thematic Fit. On lateral electrodes, there was a main effect of *Bias* (F(1,27)=5.036, p<.05), due to a negativity for sentences where prosody and context biased towards a gapping interpretation relative to a nongapping interpretation. The effect was licensed by a *Gapping* x *Anteriority* interaction (F(2,54)=8.118, p<.01), showing that the *Bias* effect was significant on central (F(1,27)=5.971, p<.05) and posterior regions (F(1,27)=12.832, p=.001), but not on anterior regions (F(1,27)=.036, p=.851): a gapping bias elicited a centro-posterior negativity.

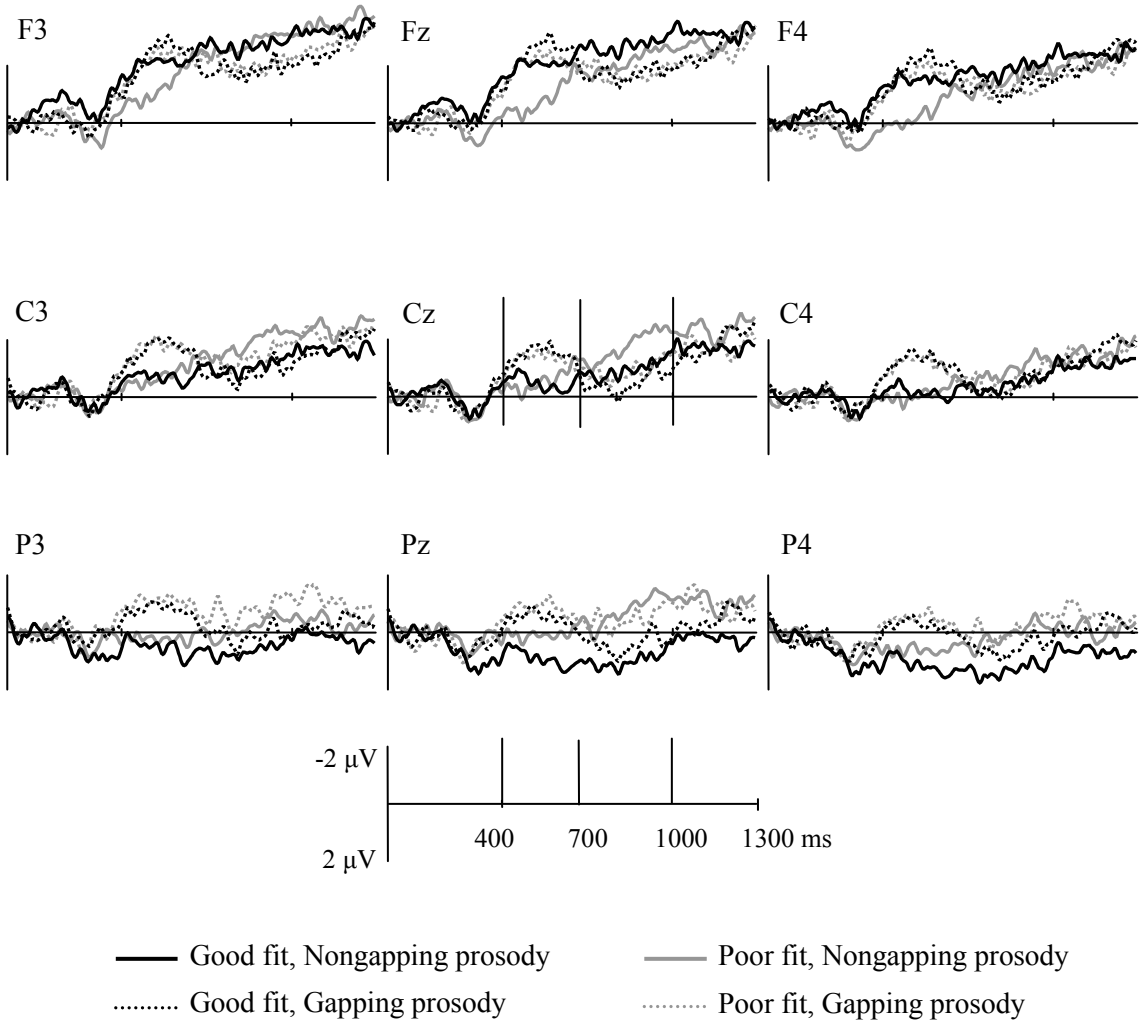


Figure 22. Interaction plot for the effects of prosody and thematic fit in experiment 2
ERPs compare processing in context-embedded sentences with good thematic fit (black lines) to sentences with poor thematic fit (grey lines), which were realized with gapping prosody (dotted lines) or nongapping prosody (solid lines). The three analyzed intervals are separated by vertical lines (400-700, 700-1000, 1000-1300 ms).

On midline electrodes, there was a main effect of *Bias* ($F(1,27)=4.317$, $p<.05$), also due to a negativity for a gapping bias by context and prosody. The effect was licensed in a *Bias* x *Anteriority* interaction ($F(2,54)=7.008$, $p<.01$) that show that the negativity was distributed over central ($F(1,27)=4.250$, $p<.05$) and posterior sites ($F(1,27)=10.916$, $p<.01$), but not over anterior sites ($F(1,27)=.007$, $p=.935$). The means show that a gapping bias elicited a centro-posterior negativity.

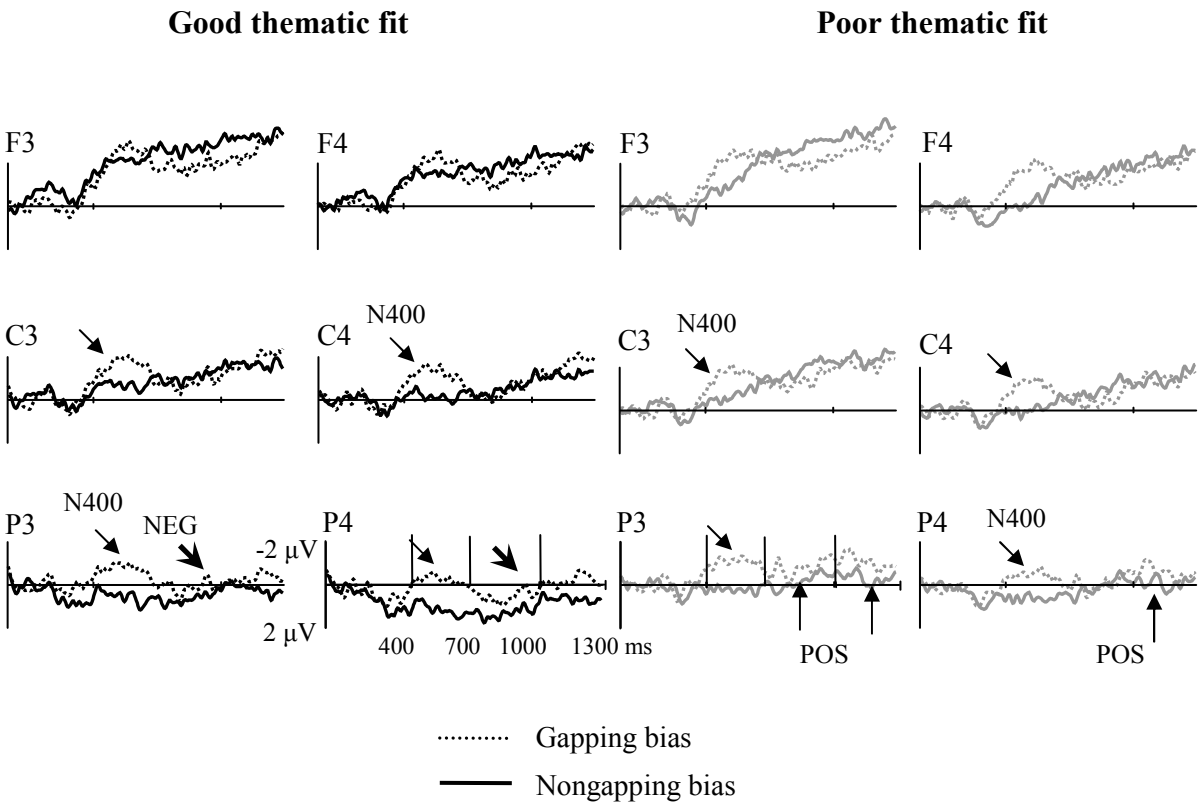


Figure 23a. Experiment 2: Prosody-context bias effects in sentences with good vs. poor thematic fit

ERPs compare the effect of gapping bias (dotted lines) and nongapping bias (solid lines) in sentences with good thematic fit (left panel, black lines) and with poor thematic fit (right panel, grey lines). Gapping bias triggered a centro-posterior negativity in both conditions (N400, 400-700 ms). In sentences with good thematic fit, the gapping bias elicited also an anterior positivity on midline electrodes and a posterior negativity on lateral electrodes (700-1300 ms). In sentences with poor thematic fit, the nongapping bias elicited a posterior positivity (700-1300 ms).

Poor Thematic Fit. On lateral electrodes, there was a main effect of *Bias* ($F(1,27)=10.062$, $p<.01$), due to a negativity for sentences with a gapping bias. There was also a *Bias* x *Anteriority* x *Hemisphere* interaction ($F(2,54)=5.399$, $p<.05$) that revealed a significant *Bias* x *Anteriority* interaction in the left hemisphere ($F(2,54)=3.721$, $p<.05$). Follow-ups in the left hemisphere revealed a significant *Bias* effect at central ($F(1,27)=7.823$, $p<.01$) and posterior sites ($F(1,27)=23.620$, $p<.000$), but not at anterior sites ($F(1,27)=.739$, $p=.398$), showing that a gapping bias elicited a centro-posterior negativity in the left hemisphere. In the right hemisphere, the *Bias* x *Anteriority* interaction was not significant ($F(2,54)=.907$, $p=.365$), but

there was a low order main effect of *Bias* (F(1,27)=8.324, p<.01), due to a negativity in the right hemisphere for sentences with a gapping bias.

On midline electrodes, there was a main effect of *Bias* (F(1,27)=8.177, p<.01), also due to negative effects triggered by sentences with a gapping bias.

5.3.2.2.2 P600 time window 700-1000 ms

Good Thematic Fit. On lateral electrodes, the *Bias* x *Anteriority* interaction (F(2,54)=11.726, p=.001) was due to a *Bias* effect at posterior sites (F(1,27)=4.821, p<.05), showing a posterior negativity for sentences with a gapping bias. This effect was marginal at anterior sites (F(1,27)=3.268, p=.082) and was due to a positivity for sentences with a gapping bias; the effect was not significant at central sites (F(1,27)=,227, p=.638).

On midline electrodes, the *Bias* x *Anteriority* interaction was also significant (F(2,54)=.001), due to a *Bias* effect on anterior regions (F(1,27)=4.418, p<.05) where sentences with a gapping bias elicited anterior positivities. The *Bias* effect was marginal at posterior sites (F(1,27)=3.130, p=.088) and was in the form of a posterior negativity for a gapping bias. There was no significant *Bias* effect at central sites (F(1,27)=1.373, p=.252).

Poor Thematic Fit. On lateral electrodes, the *Bias* x *Anteriority* x *Hemisphere* interaction was significant (F(2,54)=5.624, p<.05). Post-hocs split by *Hemisphere* revealed a significant interaction of *Bias* x *Anteriority* in the left hemisphere (F(2,54)=6.049, p<.05). Follow-up analyses showed that the *Bias* effect was significant on posterior regions (F(1,27)=5.151, p<.05), but not on anterior (F(1,27)=1.756, p<.196) or central regions (F(1,27)=.446, p=.510). The means suggest that when context and prosody biased towards an anomalous nongapping interpretation, a left posterior positivity was elicited. In the right hemisphere, the

Gapping x *Anteriority* interaction was not significant (F(2,54)=1.189, p=.291) and there was no *Gapping* effect (F(1,27)=.347, p=.561).

No effects or interactions were significant on midline electrodes.

5.3.2.2.3 Late time window 1000-1300 ms

Good Thematic Fit. On lateral electrodes, there was a *Bias* x *Anteriority* interaction (F(2,54)=5.754, p<.05), due to a marginal *Bias* effect at posterior sites (F(1,27)=3.867, p=.06), but not at anterior ((F(1,27)=1.338, p=.258) or central sites (F(1,27)=.306, p=.585). The gapping bias in good thematic fit sentences evoked a posterior negativity.

On midline electrodes, there was a *Bias* x *Anteriority* interaction (F(2,54)=5.362, p<.05), but the effect of *Bias* was not statistically reliable at anterior, central or posterior sites (all *p*'s>.1). The mean voltage values suggest that the interaction must have been caused by the distinct polarity of the *Bias* effect: at anterior sites, the gapping bias elicited a positivity, whereas at posterior sites, the gapping bias elicited a negativity.

Poor Thematic Fit. On lateral electrodes[35], there was a *Bias* x *Anteriority* interaction (F(2,54)=5.754, p<.05), due to a marginal *Bias* effect at posterior sites (F(1,27)=2.984, p=.096), but not at anterior (F(1,27)=2.209, p=.149) and at central sites (F(1,27)=.001, p=.969). The means show that a nongapping bias elicited a posterior positivity.

On midline electrodes, no effects or interactions were significant in this time window.

[35] On lateral electrodes, there was a marginal interaction of *Bias* x *Anteriority* x *Hemisphere* (F(2,54)=3.264, p=.062), due to an interaction of *Bias* x *Anteriority* in the left hemisphere (F(2,54)=8.673, p<.05), but not in the right hemisphere (F(2,54)=2.872, p=.094). Follow-ups in the left hemisphere showed a marginal *Bias* effect on posterior regions (F(1,27)=3.458, p=.074), in the form of a left posterior positivity for a nongapping bias.

5.3.2.3 ERP results: Thematic fit effect

Statistical results are displayed in Table 19b, and ERP data in Figure 23b.

Table 23b. Statistical results for experiment 2 (with context): Effect of Thematic Fit
The table presents pairwise comparisons of sentences with good thematic fit and sentences with poor thematic fit in experiment 2, separately for sentences with a gapping bias by discourse and prosody, and a nongapping bias by discourse and prosody. Marginal results (.05<p≤.1) are presented in italics for future reference. Abbreviations: FIT=Thematic Fit, ANT=Anteriority, HEM=Hemisphere.

Experiment 2			**400-700 ms**		**700-1000 ms**		**1000-1300 ms**	
		df	F	*p*	F	*p*	F	*p*
Gapping Bias	***Lateral***							
	FIT x ANT	*2,54*	2.822	*.097*				
	Midline							
	FIT x ANT	*2,54*	2.872	*.09*	3.208	*.076*		
Nongapping Bias	***Lateral***							
	FIT x ANT	*2,54*	14.450	.000	7.089	.007		
	FIT x ANT x HEM	*2,54*			4.506	.033	2.829	*.079*
	Midline							
	FIT x ANT	*2,54*			16.963	.000	6.494	.009

5.3.2.3.1 N400 time window 400-700 ms

Gapping Bias. There were no significant (only a few marginal) effects due to *Thematic Fit* in sentences with a gapping bias.[36]

Nongapping Bias. On lateral electrodes, the interaction of *Thematic Fit* x *Anteriority* was significant (F(2,54)=14.450, p<.000), due to a *Thematic Fit* effect at anterior sites (F(1,27)=4.277, p<.05) and at posterior sites (F(1,27)=5.110, p<.05), but not at central sites

[36] On lateral electrodes in sentences with a gapping bias (400-700 ms), a marginal interaction of *Thematic Fit* x *Anteriority* (F(2,54)=2.822, p=.097) was due to an anterior negativity and posterior positivity for good thematic fit sentences; the interaction was also present on midline electrodes (F(2,54)=2.872, p=.09).

(F(1,27)=.497, p=.487). The means suggest that when sentences with poor thematic fit were biased towards an anomalous nongapping interpretation, anterior positivities and posterior negativities were triggered.

On midline electrodes, the *Thematic Fit* x *Anteriority* interaction was also significant (F(2,54)=23.298, p<.000) and was due to a *Thematic Fit* effect on anterior regions (F(1,27)=7.819, p<.01) and on posterior regions (F(1,27)=11.178, p<.05), but not on central regions (F(1,27)=.019, p=.890). The means revealed that when context and prosody biased towards an anomalous nongapping reading, sentences with poor thematic fit triggered anterior positive and posterior negative effects relative to sentences with good thematic fit.

5.3.2.3.2 P600 time window 700-1000 ms

Gapping Bias. On lateral electrodes, no effects or interactions were significant. There were only marginal interactions on midline electrodes.[37]

Nongapping Bias. On lateral electrodes, there was a *Thematic Fit* x *Anteriority* x *Hemisphere* interaction (F(2,54)=5.013, p<.05) that was split by *Hemisphere*. In the left hemisphere, the interaction of *Thematic Fit* x *Anteriority* was not significant (F(2,54)=2.619, p=.107) and the effect of *Thematic Fit* was also not significant (F(1,27)=1.163, p=.290). In the right hemisphere, the interaction of *Thematic Fit* x *Anteriority* was significant (F(2,54)=11.198, p=.001). Post hocs revealed that the *Thematic Fit* effect was significant at right posterior sites (F(1,27)=13.433, p=.001), but not at right anterior (F(1,27)=.509, p=.482)

[37] On midline electrodes in sentences with a gapping bias, the interaction of *Thematic Fit* x *Anteriority* was marginal (F(2,54)=3.208, p=.076), due to a *Thematic Fit* effect at posterior sites (F(1,27)=7.621, p<.010), but not at anterior (F(1,27)=.010, p=.923) or at central sites (F(1,27)=1.200, p=.283). With a gapping bias, sentences with good thematic fit elicited posterior positivities relative to sentences with poor thematic fit.

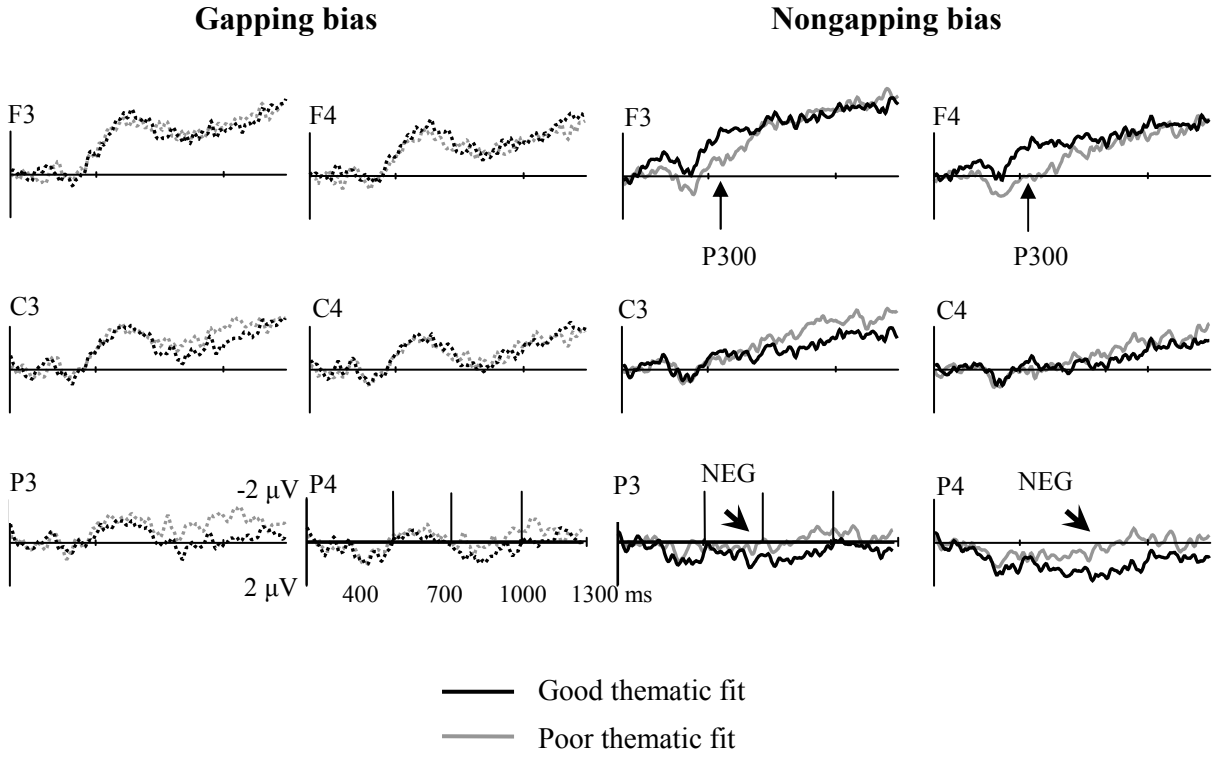


Figure 23b. Experiment 2: Thematic Fit effects in sentences with gapping vs. nongapping bias in context

ERPs compare effects to gapping prosody and bias (left panel, dotted lines) vs. nongapping prosody and bias (right panel, solid lines) in sentences with good thematic fit (black lines) and sentences with poor thematic fit (grey lines). With a gapping prosody bias, no effects of thematic fit were significant. With a nongapping bias, sentences with poor thematic fit elicit an anterior positivity (400-700 ms) and a posterior negativity on lateral (400-1000 ms) and midline electrodes (400-1300 ms).

or right central sites ($F(1,27)=.719$, $p=.404$). That is, a nongapping bias triggered right posterior negativities in sentences with poor thematic fit.

On midline electrodes, there was a *Thematic Fit* x *Anteriority* interaction ($F(2,54)=16.963$, $p<.000$) that was due to a significant *Thematic Fit* effect on posterior regions ($F(1,27)=18.349$, $p<.000$), in the form of a negativity for sentences with poor thematic fit relative to sentences with good thematic fit. The *Thematic Fit* effect was not significant at anterior ($F(1,27)=2.093$, $p=.159$) or at central sites (($F(1,27)=2.236$, $p=.146$).

5.3.2.3.3 Late time window 1000-1300 ms

Gapping Bias. No effects or interactions were significant on lateral or midline electrodes in this time window.

Nongapping Bias. On lateral electrodes, no effects or interaction reached significance.[38]

On midline electrodes, there was a significant interaction of *Thematic Fit* x *Anteriority* ($F(2,54)=6.494$, $p<.01$). Post-hocs revealed that the interaction was due to a significant effect of *Thematic Fit* on posterior regions ($F(1,27)=10.732$, $p<.01$), showing posterior negativities for sentences with poor thematic fit. No effects of *Thematic Fit* were found on anterior ($F(1,27)=.405$, $p=.530$) or central regions ($F(1,27)=1.031$, $p=.319$).

5.3.2.4 Summary of results

Additional bias by discourse context changed the neural pattern underlying the effects of *Prosody* and *Thematic Fit* on disambiguation. When discourse and prosody biased towards gapping, a centro-posterior negativity (400-700 ms) was elicited irrespective of thematic fit. In good thematic fit sentences, the gapping bias (dispreferred interpretation) lead to an anterior positivity[39] and posterior negativity in two subsequent time windows: 700-1000 and 1000-1300 ms. In sentences with poor thematic fit, a nongapping bias (anomalous

[38] On lateral electrodes in sentences with a nongapping bias, there was a *Thematic Fit* x *Anteriority* x *Hemisphere* interaction ($F(2,54)=2.829$, $p=.079$), due to a marginal interaction of *Thematic Fit* x *Anteriority* in the right hemisphere ($F(2,54)=2.815$, $p=.094$). Post-hocs showed a *Thematic Fit* effect on right posterior regions ($F(1,27)=7.226$, $p=.012$), due to a right posterior negativity for sentences with poor thematic fit; there was no effect on anterior ($F(1,27)=.001$, $p=.973$) or central regions ($F(1,27)=.148$, $p=.703$) or in the left hemisphere.

[39] In good thematic fit sentences with a gapping bias, the anterior positivity was marginal on lateral but significant on midline electrodes (700-1000 ms, 1000-1300 ms).

interpretation) triggered a posterior positivity between 700-1000 ms (left lateralized) and 1000-1300 ms.

The effect of *Thematic Fit* also changed but only in the nongapping bias condition; no effects were significant with a gapping bias. In contrast, with a nongapping bias by prosody and context, sentences with poor thematic fit (anomalous reading) triggered an anterior positivity (400-700 ms) and a sustained posterior negativity (400-1000 ms on lateral, 400-1300 ms on midline electrodes) that was right lateralized in the 700-1300 ms time window.

5.3.3 Discussion

Experiment 2 investigated whether discourse context impacts the disambiguation of sentences that can be interpreted as gapping or nongapping, while listeners integrate information coming from three sources: discourse, prosody, and thematic fit. Sentences with good and poor thematic fit appeared in two conditions each. In the nongapping bias condition of good thematic fit sentences, all factors favored the preferred nongapping reading of the ambiguous conjoined clause, which should be the easiest condition of all four. In the gapping bias condition of good fit sentences, prosody and context were in favor of gapping and worked against the offline preference for nongapping, suggesting that this condition would be dispreferred. In sentences with poor thematic fit, the gapping bias condition enforced the assumption of a gapping reading and may have made this condition easy as well, or at least the easiest one of all sentences with an intended gapping reading. In the nongapping bias condition in poor thematic fit sentences, a nongapping prosody promoting an implausible reading is combined with a context promoting a nongapping reading. This condition is ungrammatical and pragmatically less felicitous, as it only asks about the subject in the first clause without mentioning that another human referent may be present in the second clause.

It was hypothesized that sentences where all factors favor nongapping would be easiest, followed by sentences where all factors favored gapping, followed by the other conditions where an inappropriate combination of factors was expected to elicit the most effortful processing, with semantically anomalous readings being the most difficult to process (Hoeks et al., 2006, 2007, 2009).

5.3.4 Effects of the prosody-context bias

In experiment 2, discourse context allowed listeners to anticipate the information structure of the upcoming message and to anticipate answers with two subjects (*When did the boys invite Peter?*) or two objects (*When did John invite the boys?*). The current results show that discourse context did not affect the early stages (400-700 ms) of processing the ambiguous target in the answer: when factors biased towards gapping, a negativity was elicited irrespective of thematic fit, which was practically identical to the negativity in experiment 1. The presence of a discourse context influenced the late stages of processing (700-1300 ms) and evoked anterior positivities and posterior negativities in good fit sentences with a gapping bias, as well as posterior positivities in poor fit sentences with a nongapping bias.

In both experiments, a centro-posterior negativity (400-700 ms) was triggered when context and prosody (experiment 2) or prosody alone (experiment 1) promoted a gapping reading. The negative response appears related to the generation of a gapping representation and is consistent with an interpretation as an N400 component. Although a gapping context leads to the anticipation of an upcoming answer with two subjects, it does not have the effect of removing or attenuating the negativity in the N400 time window. This might mean that, regardless of the bias by context and prosody, the construction of gapping inherently involves more effortful processing. This is especially clear if one considers the poor thematic fit sentences in the gapping bias condition. Here, three factors are in favor of gapping: thematic fit, prosody, and context. Nonetheless, an N400 is triggered, suggesting that all support for

the gapping reading does not eliminate the need for some kind of a basic process for the generation of a gapping representation. This may mean that the re-activation of elided verb-phrase information in case of gapping ("X invited Peter") is qualitatively different from the re-activation of elided verb-phrase information in case of nongapping ("John invited X"), which may have been highly active all along.

Contexts with a gapping bias affected the late processing stages of sentences with good thematic fit and triggered anterior positive and posterior negative effects (7000-1300 ms). This pattern of results is distinct from the positivity (700-1000 ms) that was found in the same condition in isolated sentences in experiment 1 and cannot be accounted for by the assumption of a CPS reflecting the prosodic phrasing in sentences with gapping prosody, as the CPS has a centro-posterior distribution.

The exact underlying mechanism of the late anterior positivities and posterior negativities is less clear. At first sight, the additional processing in context appears in conflict with behavioral findings that context actually diminishes difficulties with gapping readings of ambiguous sentences (e.g., Hoeks et al., 2007, 2009). The anterior positivity may well be related to previously reported frontal P600 effects (Kaan & Swaab, 2003) that are evoked by discourse complexity in ambiguous though fully appropriate sentences (in contrast to posterior P600 effects for ungrammatical sentences). Listeners in the present study seem to have had more difficulties with the interpretation of dispreferred structures such as the gapping reading of good thematic fit sentences. Instead of diminishing the effortful processing in this dispreferred condition, discourse context seems to increase processing costs. The effortful processing may also be related to additional computations needed to link *Martin* in the answer to *the boys* in the preceding question. The disambiguation of the ambiguous NP and its establishment in the discourse may be also responsible for the posterior negativity in this condition. Similar, though anterior negativities have been found

for the establishment of ambiguous referents in the discourse context which triggers referential negativities (Nieuwland et al., 2007).

Nongapping bias leading to a semantically anomalous reading in poor thematic fit sentences triggered a sustained posterior positivity (700-1300 ms). This condition was ungrammatical in two ways: nongapping prosody suggested an implausible reading (*John peeled … MARTIN with his hands*), and context was also misleading (*What did John peel?*), as it did not suggest two subjects or objects in the upcoming answer. As discussed in the introduction, questions in this condition were pragmatically incongruous because we wanted to avoid the anticipation of anomaly (**How did John peel the two fruits/ objects?*). Thus, prosody promoting anomaly together with a misleading discourse context gave rise to a posterior positivity which replicates the P600 for nongapping prosody in poor thematic fit sentences in experiment 1.

Similarly to experiment 1, the effect of nongapping prosody and bias in poor thematic fit sentences could be interpreted in the opposite direction as a negativity for a gapping bias rather than as a positivity for a nongapping bias. If the effect were due to prosodic parsing elicited by gapping prosody, a CPS-like positivity should be elicited in the gapping bias condition. Given that this is not the case in experiment 2, it appears unlikely that the effects are related to phrasing in sentences with gapping prosody.

Thus, in both experiments nongapping bias in poor thematic fit sentences gave rise to late positive responses related to the processing of the implausible interpretation in these sentences. This finding implies that the revision of an anomalous interpretation is independent of the presence of discourse context (Hagoort et al., 1999; Kaan & Swaab, 2003; Kaan, 2000). The missing effect of context may be attributed to the fact that in experiment 2, the ambiguous second clause, and hence the target too, still had no real biasing context because questions only referred to the first clause. Changes in neural processing due to the presence of a discourse context were evident in the effect of thematic fit.

5.3.5 Effects of thematic fit in context

Just as in experiment 1, here the perspective is changed which allows us to look at the effect of thematic fit. When discourse context and prosody biased towards a gapping reading, sentences with good thematic fit (where gapping is dispreferred) elicited a sustained posterior positivity (400-1300 ms) which was also found in experiment 1 for sentences without context. As noted in the discussion of experiment 1, the posterior positivity most likely belongs to the P600 family reflecting the listeners' efforts to process complex structures that involve ambiguity. The effect of context on the processing of dispreferred structures leads to a more specific posterior distribution of the P600 but does not remove it. Thus, even when a gapping reading can be anticipated in discourse, it still requires complex computations.

A nongapping bias brought about by discourse context and prosody resulted in anomalous readings in sentences with poor thematic fit and gave rise to an anterior positivity (400-700 ms) and a sustained posterior negativity (400-1300 ms, right lateralized between 700-1000 ms). This effect of poor thematic fit differs from the results in experiment 1 where there was only a posterior positivity in the same condition which occurred later (1000-1300 ms) and was attributed to the revision of the anomalous reading due to nongapping prosody.

To account for the change of neural response in experiment 2, one has to consider the role of contextual anticipation processes. First, questions with a nongapping bias in sentences with poor thematic fit were pragmatically incongruous: *What did John peel? John peeled the orange with a knife and Martin with his hands*. In this condition, the second clause represented an unexpected continuation, which may well have given rise to expectancy-related effects. The processing of novel unexpected information has been previously shown to trigger an anterior positivity around 300 ms, the P3a component (Picton, 1982; Donchin & Cowles, 1988; Polich, 2007). Second, not only was the second clause unexpected, it also did not fit semantically to the first clause, especially when combined with nongapping prosody that promoted a semantically anomalous interpretation. The revision of an anomalous reading

seems a good candidate for the sustained posterior negativity in this condition. The negativity may be related to the processing of a semantic mismatch (some kind of a late N400) or to the efforts needed to establish an ambiguous referent in the discourse (referential negativity, Nieuwland et al., 2007). The late negativity is inconsistent with previous findings of *positive* effects for the integration of semantically *plausible* new referents in the discourse (Burkhardt, 2007). More research is necessary to shed light on end-of-sentence processing mechanisms that sometimes give rise to negativities, and more often to positivities.

In conclusion, the present study identified at least three distinct neural mechanisms for the processing of sentences with verb ellipsis. Gapping prosody initiated the generation of a gapping representation irrespective of whether a biasing discourse context was present and whether sentences had good or poor thematic fit, which was reflected in an N400-like negative component. In addition, late posterior negative effects were found, for instance when poor fit sentences were presented with incongruous context and prosody, presumably due to semantic and pragmatic interpretation problems. Furthermore, we found late positivities for different types of mismatches, which are most likely related to effortful processing aimed at making sense of sub-optimal combinations of prosody, context, and thematic fit. The present findings provide evidence that listeners link upcoming information to the preceding discourse when context is available and try to make sense of upcoming anomalous information irrespective of the presence of a discourse context. But whatever the support for gapping, it always seems to require a specific kind of process, possibly related to syntactic and semantic processes needed for the assignment of a syntactic role to the ambiguous element and the re-activation of elided verb-phrase information.

6
Conclusion

6.1 Conclusions of the dissertation

The present dissertation investigated the neural systems that are activated during the processing of spoken language, focusing on a number of linguistic functions of prosody in speech. Three general aspects of prosody were addressed: the use of prosodic prominence for signaling information structure (focus vs. background), the function of prosody to express semantic meaning such as correction, and the role of prosody and pitch accent placement as disambiguation cues in ambiguous clauses with verb phrase ellipsis. These functions of prosody were examined in a series of event-related brain potentials experiments that compared spoken language processing in sentences in isolation vs. in sentences in a discourse context (congruous vs. incongruous context), to investigate how contextual information may affect the nature of speech processing. All experiments applied naturalistic auditory paradigms and refrained from the use of a meta-linguistic prosodic judgment task, as previous studies have found that the judgment of prosodic congruity can modify on-line processing.

Chapter 2 aimed at disentangling the neural mechanisms that underlie the processing of information structural categories, i.e., focus and background, with respect to their prosodic marking in the discourse context (congruous vs. incongruous context). Irrespective of whether focus or background were accented, the processing of a pitch accent triggered an early positivity (200-500 ms), which may be an instance of the P200 component for sensory processing of enhanced acoustic features, or, as suggested here, a cognitive response reflecting the conscious interpretation of prosodic prominence, labeled an “accent positivity”. Incongruous accents on background information mismatched the information structural principle that background should remain unaccented and triggered an early positivity (100-200 ms) and an N400 effect, most likely due to difficulties with the integration of its incongruous prosody. No N400 was found for focus elements that did not receive an accent,

which has been considered a considerable mismatch in previous studies that, unlike the current study, used a prosodic task. All types of inappropriate prosody gave rise to late positive effects reminiscent of the P600 component for making sense of an utterance with incongruous prosodic realizations of information structural categories.

Chapter 3 addressed the processing of pitch accents in isolated sentences with and without the focus particle *alleen* in Dutch (English *only*), which had a preferred adjacent scope (accented focus after the particle) or a dispreferred nonadjacent scope (accented focus displaced from the particle). Similar to the findings in chapter 2, accented elements elicited an anterior right-lateralized positivity (200-500 ms) irrespective of whether the isolated sentence contained a focus particle. As in chapter 2, the positivity was interpreted as "accent positivity" for the processing of prosodic prominence. Interestingly, when the particle *alleen* occurred prior to the accented word (adjacent scope), the positivity had a delayed onset (350-500 ms) as compared to the other conditions, possibly due to the processing of the focus particle itself, which also triggered sustained positive shifts. In dispreferred sentences with *alleen* having a nonadjacent scope, accented focus occurred towards the sentence end and elicited an early negativity (100-200 ms) related to expectation and working memory processes. An additional left anterior P600 effect was found in these sentences and was attributed to the effortful processing of their dispreferred and complex information structure.

Chapter 4 focused on the neural mechanisms engaged in the processing of distinct pitch accent types, corrective L*H accents (rising pitch from low to high, see Pierrehumbert, 1980; Gussenhoven, 2005) and neutral H*L accents (falling pitch from high to low), as distinguishing between corrective and non-corrective focus in isolated sentences and in sentences with congruous and incongruous discourse contexts. Irrespective of the presence of discourse context, corrective accents (L*H) elicited a posterior P600 relative to neutral accents (H*L), which was interpreted as an indication that listeners assign a corrective interpretation to the element carrying a corrective accent. Incongruous accent-context

combinations gave rise to P600 effects that reflected the effortful integration of incongruous prosody in the discourse. There was also evidence for context-based anticipatory processes: corrective contexts seem to have projected the expectation of corrective accents. When neutral accents occurred in these contexts instead, an early posterior positivity was found, similar to the one that was reported for incongruous accents in context in chapter 2.

Chapter 5 investigated the neural processes related to the interpretation of structurally ambiguous sentences and the impact of prosody and discourse context on their disambiguation. In the second of two conjoined clauses, the verb was omitted and the clause was ambiguous between verb phrase coordination (nongapping reading) and clause coordination (gapping reading). Due to the thematic restrictions of verbs, nongapping readings were preferred in good thematic fit sentences (the ambiguous element fits as a theme argument of the matrix verb) but semantically anomalous in poor thematic fit sentences (the ambiguous element does not fit as a theme). In contrast, gapping readings were preferred in poor thematic fit and dispreferred in good thematic fit sentences. Irrespective of thematic fit and discourse context, gapping prosody that promoted a gapping reading elicited a negativity reminiscent of the N400 component, presumably reflecting memory processes involved in the construction of a gapping representation. Dispreferred and anomalous readings evoked by prosody in isolated sentences, including semantically implausible interpretations, gave rise to late positive effects reminiscent of the P600. The P600 was seen as reflecting the processing of structural complexity and the revision of implausible interpretations, in addition to late negative fluctuations elicited by anomalous readings in context. Discourse context impacted the processing of poor thematic fit: when the second ambiguous clause was not expected in the context and its nongapping prosody induced a semantically implausible interpretation, it elicited P300-like anterior positivities and sustained posterior negative shifts. These ERP experiments provide important insights and show that prosodic parallelism modulates the interpretation preferences of ambiguous sentences. The results suggest that although

contextual bias may not decrease the costs for constructing a gapping representation, contextual information is taken into account when sentences are integrated into the discourse.

6.2 Interplay of prosody and discourse

The studies in this dissertation allow the straightforward comparison of neural correlates to prosody in isolated sentences and sentences with a discourse context, since identical stimuli were used in both paradigms. Based on findings from these experiments, it can be concluded which neural mechanisms are strictly related to the processing of specific prosodic functions, and which correlates may reflect global processes of information integration in the discourse.

ERP responses reflecting the processing of a specific linguistic function of prosody were identical in sentences with and without a discourse context. For instance, the processing of accented versus unaccented elements is reflected in a (right) anterior P200-like response, labeled "accent positivity", which has the same timing and similar distribution when sentences occur in congruous and incongruous discourse contexts (chapter 2) or in isolated sentences with and without a focus particle (chapter 3). The interpretation of corrective accents triggers the P600 component irrespective of the presence and type of discourse context (chapter 4), and gapping prosody evokes an N400 response not only regardless the availability of discourse context, but also independently of whether the sentence has good or poor thematic fit (chapter 5). The variety of neural responses is clearly correlated to the nature of linguistic processing, suggesting that neural responses do not reflect sensory processing of acoustically enhanced syllables but rather the meaningful interpretation of prosody. The fact that these mechanisms are scarcely modified by biasing or misleading information in the discourse context may indicate that prosodic prominence and information from the context both have strong and to some extent independent effects on online sentence comprehension. Future research should address how the human language processor balances

the contribution of prosodic and contextual information: Is context most important, as suggested by some previous behavioral studies, or is prosodic information too important to be neglected?

Discourse context clearly affects the neural processing of prosody and spoken language, mostly in the form of early and late positive effects reported in the present studies. The experiments show that discourse context leads to the anticipation of information structure in the answer (i.e., focus and accent): a mismatch between prosody and context changes the neural pattern of processing. For instance, an early response to contextual congruity has been found in the form of an early posterior positivity for incongruously accented background information in the discourse (chapter 2) as well as for incongruous neutral accents after corrective contexts (chapter 4). Although the exact functionality of this early positivity is not yet understood, it has clearly to do with the incongruity of prosody in the context that can only arise when the accented word is linked to the preceding discourse.

Furthermore, late positivities reminiscent of the P600 component have been found for contextually incongruous prosodies, such as accented background and unaccented focus (chapter 2), as well as for corrective accents in non-corrective contexts and neutral accents in corrective contexts (chapter 4). The P600 effects for incongruous prosody in the present dissertation can undoubtedly be attributed to the incongruous combination of prosody and discourse context and belong to a functionally distinct process as compared to the prosodic parsing process underlying the CPS component. The P600 reported here most likely reflects a neural mechanism that is activated by the linking of prosodic information (and its specific linguistic function) to the information structure projected by the discourse context, a process of integrating segmental and suprasegmental information, similar to the update processes of discourse memory suggested by Burkhardt (2007).

A functionally distinct process is activated when upcoming information is unexpected rather than incongruous. Adding an ambiguous clause that is new and not

expected given the preceding contextual question gives rise to effects reminiscent of the anterior P300 (P3a) component for the processing of novel information, together with posterior negativities that may reflect semantic integration (chapter 5). Since no such responses are evoked when all information is novel as is the case in isolated sentences, these findings suggest that context influences the pattern of processing incoming input. That is, listeners seem to validate the fit of upcoming information not only with respect to its congruity but also regarding its overall relevance in the discourse, presumably guided by a general pragmatic principle that only information that is asked for should be provided, as suggested by the Gricean maxims.

In conclusion, the present ERP studies demonstrate that the interpretation of linguistic functions of prosody engages a number of underlying neural mechanisms with distinct functionality, often lateralized in the right hemisphere. Of particular significance are the findings that (i) neural responses to the congruity of pitch accents change when no meta-linguistic task is included; (ii) focus particles have an immediate and long lasting influence on accent and speech comprehension in sentences without context; (iii) the construction of a gapping representation activates the N400, and (iv) the neural system specified in the processing of prosodic prominence engages sensory as well as cognitive resources that underlie the P200-like “accent positivity”. The dissertation shows that the generation of a linguistic representation proceeds in a similar way in sentences with and without discourse context. The prosodic realization of all incoming input is immediately anchored into the preceding context and interpreted with respect to its congruity with the information structure suggested by the discourse.

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Summary

The present dissertation represents a collection of ERP experiments that investigate how the human brain processes prosody and information structure in spoken sentences with and without discourse context. Prosody, that is the melody and rhythm of speech, allows speakers to structure a message into prominent accented elements, which usually indicate the most important information (focus), and less prominent unaccented elements, which indicate less important and mostly given information (background). In Germanic languages such as Dutch, the language under study, prosody plays in important role in the processing of information structure, semantics and syntax. The studies presented in this thesis provide neurocognitive evidence for how the brain processes these three main functions of prosody and pitch accents.

In Dutch, the most prominent pitch accent is often associated with the *focus* of the message and draws the listeners' attention to the accented element (Wilson & Wharton, 2006), which contributes to a deeper semantic processing (Wang et al., 2011). Chapter 2 and 3 study the neural correlate of pitch accent with the information structural function to signal focus, and show that accentuation activates an early P200-like positivity ("accent positivity) irrespective of the presence and congruity of the discourse context. Based on its latency (200-500 ms), the positivity is assumed to involve the cognitive evaluation of the stimulus in addition to its sensory processing that is typical for the P200. In isolated sentences, the neural source of the accent positivity is distributed over fronto-central sites in the right hemisphere, whereas in context, it is more broadly distributed. Although the accent positivity is independent from contextual congruity and is triggered by both accented focus and background, the positivity is modulated by the presence of an adjacent focus particle such as *alleen* (English *only*). Chapter 3 documents that *alleen* elicits broadly distributed positivities that weaken the response to adjacent, but not to nonadjacent, accented elements.

Apart from the presence of an accent, speech comprehension can be influenced by accent type due to the distinct functional meanings of accented focus elements. Chapter 4 addresses the neural processing of pitch accents which signal a corrective or a non-corrective

interpretation of the accented element. The studies compare the processing of words with two distinct accent types in Dutch: rising pitch used for correction (corrective accents) and falling pitch used in neutral situations (non-corrective accents). The data indicate that the brain is sensitive to differences in accent type and engages additional mechanisms (P600) for the processing of corrective accents, which presumably reflect the construction and replacement of an alternative needed to license the corrective meaning. Moreover, the data imply that acoustic differences between pitch accents such as pitch direction, pitch range and height do not activate sensory processing mechanisms that typically occur in the early stages of a stimulus (N1-P2), but rather late interpretation mechanisms such as the P600.

Pitch accents can also function on the syntactic level and can facilitate the disambiguation of sentences with verb ellipsis. In particular, prosodically parallel elements in two conjoined clauses are interpreted as syntactically parallel as, for example, subjects in the sentence "*JOHN invited Peter on Monday and MARTIN on Tuesday*". Chapter 5 provides evidence that the interpretation of an accented ambiguous element as the subject in a conjoined clause (gapping reading) engages a specific neural mechanism, the N400 component. The N400 appears to be related to the activation of verb phrase information and the assignment of a subject role (rather than an object role) to the accented element, and is identical for sentences with and without a biasing context. Moreover, the data indicate that gapping readings are not preferred; their structural complexity leads to the activation of late positive components reminiscent of the P600.

By directly comparing sentences with congruous, incongruous and no preceding contexts, the studies in this dissertation provide insights into the role of discourse on the neural processing of the prosodic functions discussed above. Overall, a question context projects the information structure of the upcoming answer and leads to the anticipation of the element that is in focus and hence accented. The current data show that the availability of a biasing discourse context facilitates the interpretation of corrective accents which elicit

earlier P600 effects in context than in isolation (chapter 4). Across all experiments, pitch accents that are incongruous in the discourse give rise to P600 effects related to the discourse integration of incongruous information. The P600 responses are triggered by various prosodic violations such as accented background and unaccented focus (chapter 2), and by corrective accents in incongruous non-corrective contexts and *vice versa* (chapter 4). The effects look similar to the P600 for structural complexity in isolated sentences with two focus cues (focus particle and nonadjacent accent, chapter 3) and for less preferred gapping readings of ambiguous conjoined clauses with good fit and gapping prosody (chapter 5).

Due to the strict stimulus matching procedures in this thesis, including the avoidance of boundaries in the vicinity of targets, we can exclude possible interference effects of prosodic phrasing and the processing of pitch accents. P600 effects clearly represent a response to the contextual incongruity of stimuli with identical prosodic realizations. Also as a result of our matching procedures, we have identified very early posterior positive effects (100-200 ms post stimulus) related to the processing of incongruous prosody in context (chapter 2 and chapter 4), which indicate the identification of a prosodic mismatch and seem to occur only after strongly predictive contexts.

Lastly, unlike most previous studies, the ERP experiments in this dissertation aimed to demonstrate speech processing in maximally naturalistic conditions and refrained from using trained speakers, participants with Linguistics background or meta-linguistic tasks that require the judgment of prosodic congruity of experimental stimuli. In all experiments a comprehension task was applied in no more than 25 % of all stimuli during which listeners indicated the semantic relation between a word and the overall meaning of the preceding stimulus. Hence, although the present dissertation did not guide listeners' attention explicitly to prosodic congruity, the brain was still sensitive to incongruous accents and various other aspects of speech prosody discussed above. Some of the current findings, for instance the N400 effect for incongruously accented background and its absence for incongruously

unaccented focus (chapter 2), are most likely related to the change in attentive processing and are consistent with the results of previous studies (Wang et al., 2011) suggesting that when no prosody judgment task is applied, the most deeply processed elements are the accented ones.

Samenvatting

Dit proefschrift bevat een verzameling van ERP experimenten gericht op hoe de menselijke hersenen prosodie en informatiestructuur verwerken in gesproken zinnen met en zonder discourse context. Prosodie, de melodie en het ritme van gesproken taal, biedt sprekers de mogelijkheid om onderscheid te maken tussen prominente, geaccentueerde delen, die de meest belangrijke informatie aangeven (focus), en minder prominente, onbeklemtoonde delen, die minder belangrijke en vooral gegeven informatie aangeven (achtergrond). In Germaanse talen zoals het Nederlands, de taal van dit onderzoek, is prosodie van belang voor de verwerking van drie soorten informatie: informatie-structuur, semantiek en syntaxis. Het onderzoek in dit proefschrift toont hoe deze drie hoofdfuncties van prosodie in de hersenen gestalte krijgen.

In het Nederlands wordt het meest prominente accent geassocieerd met de *focus* van een uiting en vestigt de aandacht van de luisteraar naar het geaccentueerde element (Wilson & Wharton, 2006), waarbij accent bijdraagt aan een diepere semantische verwerking (Wang et al., 2011). In hoofdstukken 2 en 3 zijn de neurale correlaten van accenten onderzocht die de functie hebben om focus aan te geven. De resultaten laten zien dat accentuering een vroege P200-achtige positiviteit tot gevolg heeft ('accentuering positiviteit'), ongeacht de aanwezigheid en de congruentie van het discourse context. Gebaseerd op de latentie van de positiviteit (200-500 ms), wordt aangenomen dat deze positiviteit betrekking heeft op de cognitieve evaluatie van de stimulus, naast de sensorische verwerking die typisch is voor de P200. In zinnen zonder context is de accentuering positiviteit met name zichtbaar op fronto-centrale gebieden op het rechter gedeelte van de scalp, terwijl in zinnen met context de verdeling breder is. Hoewel de accentuering positiviteit onafhankelijk is van contextuele congruentie en voor zowel geaccentueerde focus en achtergrond optreedt, wordt hij gemoduleerd door de aanwezigheid van aangrenzende focus partikelen zoals *alleen*. Hoofdstuk 3 laat zien dat het focus partikel *alleen* tot positiviteiten leidt met een brede scalpdistributie. De aanwezigheid van *alleen* beïnvloedt ook het accent effect voor

aangrenzende geaccentueerde elementen, niet voor niet-aangrenzende elementen.

Naast de aanwezigheid van een accent, kan ook het soort accent invloed hebben op taalverwerking. Hoofdstuk 4 richt zich op de neurale verwerking van accenten die een corrigerende of een niet-corrigerende interpretatie van het geaccentueerde element aangeven. Het onderzoek vergelijkt de verwerking van twee verschillende accent typen in het Nederlands, te weten de stijgende accenten voor correctie (corrigerende accenten) en de dalende accenten die gebruikt worden met een neutrale betekenis (niet-corrigerende accenten). De resultaten laten zien dat de hersenen gevoelig zijn voor verschillen in accent type. De opgeroepen positiviteit (P600) suggereert dat bij de verwerking van corrigerende accenten mogelijk een alternatief element wordt gecreëerd om de corrigerende betekenis te realiseren. De akoestische verschillen tussen de accenten zoals toonhoogte richting, bereik en hoogte lijken geen sensorische verwerkingsmechanismen te activeren die typisch in de vroege stadia van een stimulus optreden (N1-P2), maar eerder late mechanismen als de P600 die te maken hebben met interpretatie.

Accentuering speelt ook een belangrijke rol op syntactische gebied waar het de desambiguering van zinnen met werkwoord ellipsis kan faciliteren: prosodisch parallelle elementen in twee samengevoegde zinnen worden geïnterpreteerd als syntactisch parallel, zoals bijvoorbeeld in een zin als: *JOHN nodigde Peter op maandag uit en MARTIN op dinsdag*. Hoofdstuk 5 toont aan dat wanneer een geaccentueerd ambigu element geïnterpreteerd moet worden als onderwerp van de samengevoegde zin (gapping interpretatie) dit een specifiek neuraal mechanisme activeert, hetgeen zichtbaar is in een vergrote amplitude van de N400 component. Deze N400 heeft wellicht te maken met de activering van werkwoordinformatie en met de toewijzing van een syntactische onderwerp rol (in plaats van een voorwerp rol) aan het geaccentueerde element: de opgeroepen N400 is identiek voor zinnen met en zonder een context die tot gapping aanzet. De resultaten wijzen er verder erop dat gapping interpretaties nooit echt de voorkeursstructuur worden; hun

structurele complexiteit leidt tot de activering van late positieve componenten die als P600 geïnterpreteerd worden.

Door zinnen te vergelijken die zonder context worden aangeboden, met een congruente context, en met een niet-congruente context, geeft dit proefschrift inzicht in de rol van discourse in de neurale verwerking van de prosodische functies die hierboven besproken zijn. Globaal gezien leidt een voorafgaande vraagcontext, die de informatiestructuur van het komende antwoord projecteert, tot de verwachting van een element dat in focus is (en dus geaccentueerd is). De resultaten suggereren dat de aanwezigheid van een congruente discourse context de interpretatie van corrigerende accenten faciliteert: P600 effecten lijken vroeger te starten in zinnen met een correcte context dan in zinnen zonder context (hoofdstuk 4). In alle experimenten geven incongruente accenten aanleiding tot P600 effecten die waarschijnlijk gerelateerd zijn aan de integratie van incongruente informatie. De P600 werd opgeroepen door verschillende prosodische schendingen, zoals geaccentueerde achtergrond en onbeklemtoonde focus (hoofdstuk 2), en corrigerende accenten in niet-corrigerende contexten en *vice versa* (hoofdstuk 4). De effecten lijken op de P600 voor de structurele complexiteit in geïsoleerde zinnen met twee focus markers (focus partikel en niet-aangrenzend accent) (hoofdstuk 3) en voor gapping interpretaties van ambigue zinnen die geen voorkeur hebben (hoofdstuk 5).

Door de strikte 'stimulus-matching' procedures in dit proefschrift, met name het vermijden van prosodische grenzen in de buurt van de targets, kunnen wij mogelijke interferentie-effecten van prosodische frasering en de verwerking van accenten uitsluiten. P600 effecten zijn duidelijk een reactie op de contextuele incongruiteit van stimuli met identieke prosodische realisaties. Ook als gevolg van onze matching procedures, hebben we zeer vroege posterior positieve effecten geïdentificeerd (100-200 ms na stimulus onset) voor de verwerking van incongruente prosodie in de context (hoofdstuk 2 en hoofdstuk 4), die

alleen na sterk voorspellende contexten lijken op te treden en die de identificatie van een prosodische mismatch aangeven.

Ten slotte, in tegenstelling tot de meeste vroegere studies, zijn de ERP experimenten in dit proefschrift gericht op taalverwerking in maximaal natuurlijke omstandigheden; om die reden hebben we afgezien van het gebruik van getrainde sprekers, proefpersonen met taalkunde achtergrond, of metalinguïstische taken die naar de beoordeling van de prosodische congruentie van experimentele stimuli vragen. In alle experimenten is een begripstaak gebruikt op niet meer dan 25% van alle stimuli, waar luisteraars de semantische gerelateerdheid van een woord aan de algemene betekenis van de voorgaande zin aangegeven. Ook zonder dat de aandacht van luisteraars specifiek naar prosodische congruentie gericht werd, bleken de hersenen gevoelig voor incongruente accenten en verschillende andere aspecten van prosodie die hierboven werden besproken. Sommige van de huidige bevindingen, bijvoorbeeld het N400 effect voor incongruent geaccentueerde achtergrond in context en de afwezigheid ervan voor incongruent onbeklemtoonde focus (hoofdstuk 2), zijn zeer waarschijnlijk gerelateerd aan de verandering in niveau van verwerking en zijn consistent met bevindingen van eerdere studies (Wang et al., 2011) die suggereren dat wanneer er geen prosodische beoordelingstaak wordt toegepast, de meest diep verwerkte elementen de geaccentueerde zijn.

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Appendix

Chapter 2 and Chapter 3

For chapter 2, stimuli were the answers taken out of the dialogues presented below. For all stimuli, accentuation was varied between the direct object and the prepositional object. Focus position as determined by the question context was varied only in chpater 1.

A: Focus on direct object

1 Heeft de visser een paling of een zalm uit de beek gevist?
Hij heeft een paling uit de beek gevist.

2 Heeft hij zijn teen of zijn enkel bij het kegelen bezeerd?
Hij heeft zijn teen bij het kegelen bezeerd.

3 Heeft het kind een noot of een tak naar de bever gegooid?
Hij heeft een noot naar de bever gegooid.

4 Heeft de dierenverzorger de lama of de kameel naar de schuur gebracht?
Hij heeft de lama naar de schuur gebracht.

5 Heeft de verkoopster een droger of een wasmachine aan de dame verkocht?
Zij heeft een droger aan de dame verkocht.

6 Heeft de dierentuin stro of hooi aan de zebra's gegeven?
Zij hebben stro aan de zebra's gegeven.

7 Heeft hij radio of televisie via de kabel ontvangen?
Hij heeft radio via de kabel ontvangen.

8 Heeft de duiker de parel of de ketting op de bodem gevonden?
Hij heeft de parel op de bodem gevonden.

9 Hebben de rebellen de koning of de prins met een zweep gemarteld?
Zij hebben de koning met een zweep gemarteld.

10 Heeft zij de thee of de koffie in de bekers gedaan?
Zij heeft de thee in de bekers gedaan.

11 Heeft hij de hamer of de spijkers in de keet laten liggen?
Hij heeft de hamer in de keet laten liggen.

12 Heeft de sporter een vaantje of een medaille na het lopen gekregen?
Hij heeft een vaantje na het lopen gekregen.

13 Heeft zij een raaf of een ekster tegen het raam zien vliegen?
Zij heeft een raaf tegen het raam zien vliegen.

14 Heeft hij de blaadjes of de takjes met een bezem opgeruimd?
Hij heeft de blaadjes met een bezem opgeruimd.

15 Heeft zij een eend of een gans bij het meertje gevoerd?
Zij heeft een eend bij het meertje gevoerd.

16 Heeft zij haar motor of haar auto naar de koper gebracht?
Zij heeft haar motor naar de koper gebracht.

17 Hebben zij een schaats of een want op de kade gevonden?
Zij hebben een schaats op de kade gevonden.

18 Heeft de kat zijn poot of zijn staart tegen de lade geslagen?
Hij heeft zijn poot tegen de lade geslagen.

19 Heeft zij een naald of een schaar op de tegels laten vallen?
Zij heeft een naald op de tegels laten vallen.

20 Heeft hij een fabel of een mythe aan de knaap verteld?
Hij heeft een fabel aan de knaap verteld.

21 Hebben zij een bootje of een zeiljacht in de haven liggen?
Zij hebben een bootje in de haven liggen.

22 Heeft hij de kaars of de olielamp in de zaal neergezet?
Hij heeft de kaars in de zaal neergezet.

23 Heeft hij de leek of de non een preek horen voordragen?
Hij heeft de leek een preek horen voordragen.

24 Hebben zij een kool of een biet aan de schapen gevoerd?
Zij hebben een kool aan de schapen gevoerd.
25 Heeft de supporter een ratel of een toeter in het stadion laten klinken?
Hij heeft een ratel in het stadion laten klinken.
26 Heeft de ridder de draak of de heks met een zwaard gedood?
Hij heeft de draak met een zwaard gedood.
27 Hebben zij de schepen of de vliegtuigen via de radar gevolgd?
Zij hebben de schepen via de radar gevolgd.
28 Heeft zij haar kleedje of haar luchtbed in de schaduw neergelegd?
Zij heeft haar kleedje in de schaduw neergelegd.
29 Heeft het kind in december een reep of een cadeautje in zijn laarsje gevonden?
Hij heeft in december een reep in zijn laarsje gevonden.
30 Heeft de zuster een gaasje of een pleister op de snee gedaan?
Zij heeft een gaasje op de snee gedaan.
31 Hebben de brandweermannen de kater of de poes uit de toren gered?
Zij hebben de kater uit de toren gered.
32 Heeft hij het koor of het orkest in juli verlaten?
Hij heeft het koor in juli verlaten.
33 Heeft de sheriff de rover of de Indiaan op de prairie neergeschoten?
Hij heeft de rover op de prairie neergeschoten.
34 Heeft zij een mail of een brief van de leraar gekregen?
Zij heeft een mail van de leraar gekregen.
35 Heeft hij de boom of de struik met een zaag bijgewerkt?
Hij heeft de boom met een zaag bijgewerkt.
36 Heeft de hulpsint zijn cape of zijn mijter op de boot verloren?
Hij heeft zijn cape op de boot verloren.
37 Heeft hij de staat of de oceaan op de globe aangewezen?
Hij heeft de staat op de globe aangewezen.
38 Heeft de zwemmer een pees of een spier in zijn been gescheurd?
Hij heeft een pees in zijn been gescheurd.
39 Heeft de vrouw haar zoontje of haar dochtertje op haar schoot laten rusten?
Zij heeft haar zoontje op haar schoot laten rusten.
40 Heeft zij de kaas of de ham op de toastjes gedaan?
Zij heeft de kaas op de toastjes gedaan.
41 Heeft de dierenarts het speeksel of het bloed van de labrador onderzocht?
Hij heeft het speeksel van de labrador onderzocht.
42 Heeft zij de mazelen of de bof in de tropen opgelopen?
Zij heeft de mazelen in de tropen opgelopen.
43 Is zij de Maas of de Waal met een kano overgestoken?
Zij is de Maas met een kano overgestoken.
44 Heeft hij de wagen of de koets door een ezel laten trekken?
Hij heeft de wagen door een ezel laten trekken.
45 Hebben de verzorgers de beren of de wolven een stuk vlees gegeven?
Zij hebben de beren een stuk vlees gegeven.
46 Heeft hij stenen of vuurwerk naar de menigte gegooid?
Hij heeft stenen naar de menigte gegooid.
47 Heeft zij peper of zout door de jus gedaan?
Zij heeft peper door de jus gedaan.
48 Hebben zij de haan of de kip naar de slager gebracht?
Zij hebben de haan naar de slager gebracht.
49 Heeft hij zijn neef of zijn nicht bij zijn oom gebracht?
Hij heeft zijn neef bij zijn oom gebracht.
50 Heeft de eigenaar de ober of de serveerster naar de tafel gestuurd?
Hij heeft de ober naar de tafel gestuurd.
51 Heeft de student de maag of de lever van een aap ontleed?

Hij heeft de maag van een aap ontleed.

52 Heeft de recherche een kogel of een huls bij de dader gevonden?
Hij heeft een kogel bij de dader gevonden.

53 Heeft hij een teek of een luis op zijn oor gevonden?
Hij heeft een teek op zijn oor gevonden.

54 Heeft hij de gozer of de sloerie met een wapen uit de hal gejaagd?
Hij heeft de gozer met een wapen uit de hal gejaagd.

55 Heeft de kunstliefhebber een beeld of een doek van de meester gekocht?
Hij heeft een beeld van de meester gekocht.

56 Heeft hij een lelie of een anjer door het kereltje mee laten nemen?
Hij heeft een lelie door het kereltje mee laten nemen.

57 Heeft zij de ketel of de pan op het vuur gezet?
Zij heeft de ketel op het vuur gezet.

58 Heeft de archeoloog een poort of een zuil van de Moren opgegraven?
Hij heeft een poort van de Moren opgegraven.

59 Heeft hij twee azen of twee heren bij het pokeren laten vallen?
Hij heeft twee azen bij het pokeren laten vallen.

60 Heeft de man zijn kaak of zijn neus bij de ruzie gebroken?
Hij heeft zijn kaak bij de ruzie gebroken.

61 Heeft hij een cobra of een python in Azië gezien?
Hij heeft een cobra in Azie gezien.

62 Heeft hij het weer of het praatprogramma via de schotel ontvangen?
Hij heeft het weer via de schotel ontvangen.

63 Heeft zij de bami of de nasi uit de folie gehaald?
Zij heeft de bami uit de folie gehaald.

64 Heeft de gemeente pekel of zand over de wegen gestrooid?
Zij hebben pekel over de wegen gestrooid.

65 Heeft hij de waard of de portier naar de roker zien gaan?
Hij heeft de waard naar de roker zien gaan.

66 Heeft de vogelwacht een fuut of een reiger aan de hemel opgemerkt?
Hij heeft een fuut aan de hemel opgemerkt.

67 Heeft de club de speler of de trainer een premie gegeven?
Zij hebben een premie aan de speler gegeven.

68 Heeft hij de Deen of de Nederlander bij de loop om een handtekening gevraagd?
Hij heeft de Deen bij de loop om een handtekening gevraagd.

69 Heeft zij een kuurtje of een pilletje tegen de koorts gekregen?
Zij heeft een kuurtje tegen de koorts gekregen.

70 Heeft de scholier een kreet of een zucht tijdens rekenen geslaakt?
Hij heeft een kreet tijdens rekenen geslaakt.

71 Heeft zij een deken of een trui voor de baby gebreid?
Zij heeft een deken voor de baby gebreid.

72 Heeft hij een klavertje of een paardebloem voor zijn oma geplukt?
Hij heeft een klavertje voor zijn oma geplukt.

73 Heeft de astronaut de boodschap of de afbeelding vanaf de maan gestuurd?
Hij heeft de boodschap vanaf de maan gestuurd.

74 Heeft zij de manen of de hoeven van de paarden schoongemaakt?
Zij heeft de manen van de paarden schoongemaakt.

75 Heeft zij haar zwager of haar schoonzus naar de lezing gebracht?
Zij heeft haar zwager naar de lezing gebracht.

76 Heeft zij een kamer of een huisje in Groningen gevonden?
Zij heeft een kamer in Groningen gevonden.

77 Heeft de kwajongen een roos of een tulp uit de vaas gehaald?
Hij heeft een roos uit de vaas gehaald.

78 Heeft zij de sjaal of de handschoenen bij haar buren laten liggen?
Zij heeft de sjaal bij haar buren laten liggen.

79 Heeft de jager de ogen of de vacht van een haas opgemerkt?
Hij heeft de ogen van een haas opgemerkt.
80 Heeft zij kleren of schoenen voor het feest gekocht?
Zij heeft kleren voor het feest gekocht.
81 Heeft zij de kloof of de rivier in de schemer overgestoken?
Zij heeft de kloof in de schemer overgestoken.
82 Heeft zij de taart of de cake in de oven gezet?
Zij heeft de taart in de oven gezet.
83 Heeft zij de lego of de barbies in de doos gedaan?
Zij heeft de lego in de doos gedaan.
84 Hebben de bouwvakkers gaten of scheuren in de daken ontdekt?
Zij hebben gaten in de daken ontdekt.
85 Heeft zij zaden of vet aan de merels gegeven?
Zij heeft zaden aab de merels gegeven.
86 Hebben zij de fee of de tovenaar uit de sprookjes nagetekend?
Zij heeft de fee uit de sprookjes nagetekend.
87 Heeft de vogel zijn snavel of zijn vleugel aan de doorn verwond?
Hij heeft zijn snavel aan de doorn verwond.
88 Hebben zij cola of sinas uit de glazen gedronken?
Zij hebben cola uit de glazen gedronken.
89 Heeft hij een kever of een mier in de aarde zien graven?
Hij heeft een kever in de aarde zien graven.
90 Heeft zij stroop of poedersuiker op de wafel gedaan?
Zij heeft stroop op de wafel gedaan.
91 Heeft zij de bedelaar of de wees een brood gegeven?
Zij heeft de bedelaar een brood gegeven.
92 Heeft de crimineel een moord of een overval in de steeg gepleegd?
Hij heeft een moord in de steeg gepleegd.
93 Heeft hij zijn baas of zijn collega over de bonus horen praten?
Hij heeft zijn baas over de bonus horen praten.
94 Heeft de man zijn baard of zijn snor een jaar laten staan?
Hij heeft zijn baard een jaar laten staan.
95 Heeft hij hageltjes of ranja door de vla gedaan?
Hij heeft hageltjes door de vla gedaan.
96 Heeft de jongen de hoorn of de tuba op Kreta gekocht?
Hij heeft de hoorn op Kreta gekocht.
97 Heeft de hond het spoor of het geluid van een eland opgemerkt?
Hij heeft het spoor van een eland opgemerkt.
98 Heeft de supermarkt de bramen of de frambozen in doosjes gepresenteerd?
Zij hebben de bramen in doosjes gepresenteerd.
99 Heeft de ontsnapte gevangene een laken of een touw aan de goot bevestigd?
Hij heeft een laken aan de goot bevestigd.
100 Heeft de sterrenwacht een krater of een berg op Venus ontdekt?
Hij heeft een krater op Venus ontdekt.
101 Heeft zij een klooster of een kerk in Rome bezocht?
Zij heeft een klooster in Rome bezocht.
102 Heeft zij een tekening of een schilderij van de straat gemaakt?
Zij heeft een tekening van de straat gemaakt.
103 Heeft zij een cavia of een hamster van haar vader gekregen?
Zij heeft een cavia van haar vader gekregen.
104 Heeft de keeper de paal of de lat met zijn hoofd geraakt?
Hij heeft de paal met zijn hoofd geraakt.
105 Hebben zij een muurtje of een schutting naast hun woning neergezet?
Zij hebben een muurtje naast hun woning neergezet.
106 Heeft zij haar stage of haar scriptie in de zomer afgerond?

Zij heeft haar stage in de zomer afgerond.

107 Heeft hij de boter of de olie in de schaal gedaan?
Hij heeft de boter in de schaal gedaan.

108 Heeft de minister nieuwe uniformen of nieuwe pistolen an het leger beloofd?
Hij heeft nieuwe uniformen aan het leger beloofd.

109 Heeft de toerist een foto of een filmpje van een molen gemaakt?
Hij heeft een foto van een molen gemaakt.

110 Heeft zij een haar of een vlieg in de sla aangetroffen?
Zij heeft een haar in de sla aangetroffen.

111 Heeft hij de zwaluw of de ooievaar naar het oosten zien vliegen?
Hij heeft de zwaluw naar het oosten zien vliegen.

112 Heeft hij de peren of de aardbeien bij een kraampje gekocht?
Hij heeft de peren bij een kraampje gekocht.

113 Heeft de kok de kreeft of de krab met een lepel omgedraaid?
Hij heeft de kreeft met een lepel omgedraaid.

114 Heeft zij een krekel of een kikker in het water gehoord?
Zij heeft een krekel in het water gehoord.

115 Heeft de honkballer water of bier na de training gedronken?
Hij heeft water na de training gedronken.

116 Heeft hij kolen of hout in het vuur gegooid?
Hij heeft kolen in het vuur gegooid.

117 Heeft de gemeente de huurders of de huizenbezitters over de sloop geïnformeerd?
Zij hebben de huurders over de sloop geinvormeerd.

118 Heeft de weerman regen of hagel in de avond voorspeld?
Hij heeft regen in de avond voorspeld.

119 Heeft hij een uur of een kwartier op zijn maatje staan wachten?
Hij heeft een uur op zijn maatje staan wachten.

120 Heeft zij vandaag meel of eieren voor de cake gekocht?
Zij heeft vandaag meel voor de cake gekocht.

B: Focus on prepositional object

1 Heeft de visser een paling uit de beek of uit de poel gevist?
Hij heeft een paling uit de beek gevist.

2 Heeft hij zijn teen bij het kegelen of bij het golfen bezeerd?
Hij heeft zijn teen bij het kegelen bezeerd.

3 Heeft het kind een noot naar de bever of naar de otter gegooid?
Hij heeft een noot naar de bever gegooid.

4 Heeft de dierenverzorger de lama naar de schuur of naar de weide gebracht?
Hij heeft de lama naar de schuur gebracht.

5 Heeft de verkoopster een droger aan de dame of aan de heer verkocht?
Zij heeft een droger aan de dame verkocht.

6 Heeft de dierentuin stro aan de zebra’s of aan de giraffen gegeven?
Zij hebben stro aan de zebra's gegeven.

7 Heeft hij radio via de kabel of via de antenne ontvangen?
Hij heeft radio via de kabel ontvangen.

8 Heeft de duiker de parel op de bodem of op de oever gevonden?
Hij heeft de parel op de bodem gevonden.

9 Hebben de rebellen de koning met een zweep of met een gesel gemarteld?
Zij hebben de koning met een zweep gemarteld.

10 Heeft zij de thee in de bekers of in de thermoskan gedaan?
Zij heeft de thee in de bekers gedaan.

11 Heeft hij de hamer in de keet of in de bouwput laten liggen?
Hij heeft de hamer in de keet laten liggen.

12 Heeft de sporter een vaantje na het lopen of na het zwemmen gekregen?

Hij heeft een vaantje na het lopen gekregen.

13 Heeft zij een raaf tegen het raam of tegen het scherm zien vliegen?
Zij heeft een raaf tegen het raam zien vliegen.

14 Heeft hij de blaadjes met een bezem of met een hark opgeruimd?
Hij heeft de blaadjes met een bezem opgeruimd.

15 Heeft zij een eend bij het meertje of bij het parkje gevoerd?
Zij heeft een eend bij het meertje gevoerd.

16 Heeft zij haar motor naar de koper of naar de dealer gebracht?
Zij heeft haar motor naar de koper gebracht.

17 Hebben zij een schaats op de kade of op de bankjes gevonden?
Zij hebben een schaats op de kade gevonden.

18 Heeft de kat zijn poot tegen de lade of tegen de deur geslagen?
Hij heeft zijn poot tegen de lade geslagen.

19 Heeft zij een naald op de tegels of op de parketvloer laten vallen?
Zij heeft een naald op de tegels laten vallen.

20 Heeft hij een fabel aan de knaap of aan de meid verteld?
Hij heeft een fabel aan de knaap verteld.

21 Hebben zij een bootje in de loods of in de haven liggen?
Zij hebben een bootje in de haven liggen.

22 Heeft hij de kaars in de zaal of in de hal neergezet?
Hij heeft de kaars in de zaal neergezet.

23 Heeft hij de leek een preek of een gebed horen voordragen?
Hij heeft de leek een preek horen voordragen.

24 Hebben zij een kool aan de schapen of aan de geiten gevoerd?
Zij hebben een kool aan de schapen gevoerd.

25 Heeft de supporter een ratel in het stadion of in het busje laten klinken?
Hij heeft een ratel in het stadion laten klinken.

26 Heeft de ridder de draak met een zwaard of met een lans gedood?
Hij heeft de draak met een zwaard gedood.

27 Hebben zij de schepen via de radar of via de satelliet gevolgd?
Zij hebben de schepen via de radar gevolgd.

28 Heeft zij haar kleedje in de schaduw of in de zon neergelegd?
Zij heeft haar kleedje in de schaduw neergelegd.

29 Heeft het kind in december een reep in zijn slof of in zijn laarsje gevonden?
Hij heeft in december een reep in zijn laarsje gevonden.

30 Heeft de zuster een gaasje op de snee of op de brandwond gedaan?
Zij heeft een gaasje op de snee gedaan.

31 Hebben de brandweermannen de kater uit de toren of uit de eik gered?
Zij hebben de kater uit de toren gered.

32 Heeft hij het koor in juli of in augustus verlaten?
Hij heeft het koor in juli verlaten.

33 Heeft de sheriff de rover op de prairie of op de heuvel neergeschoten?
Hij heeft de rover op de prairie neergeschoten.

34 Heeft zij een mail van de leraar of van de rector gekregen?
Zij heeft een mail van de leraar gekregen.

35 Heeft hij de boom met een zaag of met een bijl bijgewerkt?
Hij heeft de boom met een zaag bijgewerkt.

36 Heeft de hulpsint zijn cape op de boot of op de schimmel verloren?
Hij heeft zijn cape op de boot verloren.

37 Heeft hij de staat op de globe of op de landkaart aangewezen?
Hij heeft de staat op de globe aangewezen.

38 Heeft de zwemmer een pees in zijn been of in zijn schouder gescheurd?
Hij heeft een pees in zijn been gescheurd.

39 Heeft de vrouw haar zoontje op haar schoot of op haar arm laten rusten?
Zij heeft haar zoontje op haar schoot laten rusten.

40 Heeft zij de kaas op de toastjes of op de crackers gedaan?
Zij heeft de kaas op de toastjes gedaan.
41 Heeft de dierenarts het speeksel van de labrador of van de teckel onderzocht?
Hij heeft het speeksel van de labrador onderzocht.
42 Heeft zij de mazelen in de tropen of in de kliniek opgelopen?
Zij heeft de mazelen in de tropen opgelopen.
43 Is zij de Maas met een kano of met een roeiboot overgestoken?
Zij is de Maas met een kano overgestoken.
44 Heeft hij de wagen door een ezel of door een os laten trekken?
Hij heeft de wagen door een ezel laten trekken.
45 Hebben de verzorgers de beren een stuk vlees of een stuk vis gegeven?
Zij hebben de beren een stuk vlees gegeven.
46 Heeft hij stenen naar de menigte of naar de agenten gegooid?
Hij heeft stenen naar de menigte gegooid.
47 Heeft zij peper door de jus of door de saus gedaan?
Zij heeft peper door de jus gedaan.
48 Hebben zij de haan naar de slager of naar de boer gebracht?
Zij hebben de haan naar de slager gebracht.
49 Heeft hij zijn neef bij zijn oom of bij zijn tante gebracht?
Hij heeft zijn neef bij zijn oom gebracht.
50 Heeft de eigenaar de ober naar de tafel of naar de bar gestuurd?
Hij heeft de ober naar de tafel gestuurd.
51 Heeft de student de maag van een aap of van een muis ontleed?
Hij heeft de maag van een aap ontleed.
52 Heeft de recherche een kogel bij de dader of bij de gewonde gevonden?
Hij heeft een kogel bij de dader gevonden.
53 Heeft hij een teek op zijn oor of op zijn rug gevonden?
Hij heeft een teek op zijn oor gevonden.
54 Heeft hij de gozer met een wapen of met een schreeuw uit de hal gejaagd?
Hij heeft de gozer met een wapen uit de hal gejaagd.
55 Heeft de kunstliefhebber een beeld van de meester of van de leerling gekocht?
Hij heeft een beeld van de meester gekocht.
56 Heeft hij een lelie door het kereltje of door het grietje mee laten nemen?
Hij heeft een lelie door het kereltje mee laten nemen.
57 Heeft zij de ketel op het vuur of op het aanrecht gezet?
Zij heeft de ketel op het vuur gezet.
58 Heeft de archeoloog een poort van de Moren of van de Etrusken opgegraven?
Hij heeft een poort van de Moren opgegraven.
59 Heeft hij twee azen bij het pokeren of bij het klaverjassen laten vallen?
Hij heeft twee azen bij het pokeren laten vallen.
60 Heeft de man zijn kaak bij de ruzie of bij de botsing gebroken?
Hij heeft zijn kaak bij de ruzie gebroken.
61 Heeft hij een cobra in Afrika of in Azie gezien?
Hij heeft een cobra in Azie gezien.
62 Heeft hij het weer via de schotel of via de laptop ontvangen?
Hij heeft het weer via de schotel ontvangen.
63 Heeft zij de bami uit de folie of uit de pan gehaald?
Zij heeft de bami uit de folie gehaald.
64 Heeft de gemeente pekel over de wegen of over de pleinen gestrooid?
Zij hebben pekel over de wegen gestrooid.
65 Heeft hij de waard naar de roker of naar de alcoholist zien gaan?
Hij heeft de waard naar de roker zien gaan.
66 Heeft de vogelwacht een fuut aan de hemel of aan de waterkant opgemerkt?
Hij heeft een fuut aan de hemel opgemerkt.
67 Heeft de club een premie aan de speler of aan de trainer gegeven?

Zij hebben een premie aan de speler gegeven.
68 Heeft hij de Deen bij de loop of bij de zevenkamp om een handtekening gevraagd?
Hij heeft de Deen bij de loop om een handtekening gevraagd.
69 Heeft zij een kuurtje tegen de koorts of tegen de allergie gekregen?
Zij heeft een kuurtje tegen de koorts gekregen.
70 Heeft de scholier een kreet tijdens rekenen of tijdens taal geslaakt?
Hij heeft een kreet tijdens rekenen geslaakt.
71 Heeft zij een deken voor de baby of voor de pop gebreid?
Zij heeft een deken voor de baby gebreid.
72 Heeft hij een klavertje voor zijn liefje of voor zijn oma geplukt?
Hij heeft een klavertje voor zijn oma geplukt.
73 Heeft de astronaut de boodschap vanaf de maan of vanaf de ruimtebasis gestuurd?
Hij heeft de boodschap vanaf de maan gestuurd.
74 Heeft zij de manen van de paarden of van de pony's schoongemaakt?
Zij heeft de manen van de paarden schoongemaakt.
75 Heeft zij haar zwager naar de lezing of naar de cursus gebracht?
Zij heeft haar zwager naar de lezing gebracht.
76 Heeft zij een kamer in Groningen of in Leiden gevonden?
Zij heeft een kamer in Groningen gevonden.
77 Heeft de kwajongen een roos uit de vaas of uit de tuin gehaald?
Hij heeft een roos uit de vaas gehaald.
78 Heeft zij de sjaal bij haar ouders of bij haar buren laten liggen?
Zij heeft de sjaal bij haar buren laten liggen.
79 Heeft de jager de ogen van een haas of van een ree opgemerkt?
Hij heeft de ogen van een haas opgemerkt.
80 Heeft zij kleren voor het werk of voor het feest gekocht?
Zij heeft kleren voor het feest gekocht.
81 Heeft zij de kloof in de schemer of in de nacht overgestoken?
Zij heeft de kloof in de schemer overgestoken.
82 Heeft zij de taart in de oven of in de koelkast gezet?
Zij heeft de taart in de oven gezet.
83 Heeft zij de lego in de doos of in de zak gedaan?
Zij heeft de lego in de doos gedaan.
84 Hebben de bouwvakkers gaten in de isolatie of in de daken ontdekt?
Zij hebben gaten in de daken ontdekt.
85 Heeft zij zaden aan de merels of aan de roodborstjes gegeven?
Zij heeft zaden aab de merels gegeven.
86 Hebben zij de fee uit de sprookjes of uit de tekenfilms nagetekend?
Zij heeft de fee uit de sprookjes nagetekend.
87 Heeft de vogel zijn snavel aan de doorn of aan de ijzerdraadjes verwond?
Hij heeft zijn snavel aan de doorn verwond.
88 Hebben zij cola uit de glazen of uit de fles gedronken?
Zij hebben cola uit de glazen gedronken.
89 Heeft hij een kever in de aarde of in de compost zien graven?
Hij heeft een kever in de aarde zien graven.
90 Heeft zij stroop op de pannenkoek of op de wafel gedaan?
Zij heeft stroop op de wafel gedaan.
91 Heeft zij de bedelaar een brood of een muntje gegeven?
Zij heeft de bedelaar een brood gegeven.
92 Heeft de crimineel een moord in de steeg of in de portiek gepleegd?
Hij heeft een moord in de steeg gepleegd.
93 Heeft hij zijn baas over de bonus of over de boekhouding horen praten?
Hij heeft zijn baas over de bonus horen praten.
94 Heeft de man zijn baard een jaar of een maand laten staan?
Hij heeft zijn baard een jaar laten staan.

95 Heeft hij hageltjes door de vla of door de yoghurt gedaan?
Hij heeft hageltjes door de vla gedaan.
96 Heeft de jongen de hoorn op Kreta of of Rhodos gekocht?
Hij heeft de hoorn op Kreta gekocht.
97 Heeft de hond het spoor van een eland of van een konijn opgemerkt?
Hij heeft het spoor van een eland opgemerkt.
98 Heeft de supermarkt de bramen in doosjes of in manden gepresenteerd?
Zij hebben de bramen in doosjes gepresenteerd.
99 Heeft de ontsnapte gevangene een laken aan de goot of aan de verwarming bevestigd?
Hij heeft een laken aan de goot bevestigd.
100 Heeft de sterrenwacht een krater op Venus of op Mars ontdekt?
Hij heeft een krater op Venus ontdekt.
101 Heeft zij een klooster in Rome of Florence bezocht?
Zij heeft een klooster in Rome bezocht.
102 Heeft zij een tekening van de straat of van de markt gemaakt?
Zij heeft een tekening van de straat gemaakt.
103 Heeft zij een cavia van haar vader of van haar vriendin gekregen?
Zij heeft een cavia van haar vader gekregen.
104 Heeft de keeper de paal met zijn hoofd of met zijn schouder geraakt?
Hij heeft de paal met zijn hoofd geraakt.
105 Hebben zij een muurtje naast hun woning of naast hun caravan neergezet?
Zij hebben een muurtje naast hun woning neergezet.
106 Heeft zij haar stage in de zomer of in de herfst afgerond?
Zij heeft haar stage in de zomer afgerond.
107 Heeft hij de boter in de pan of in de schaal gedaan?
Hij heeft de boter in de schaal gedaan.
108 Heeft de minister nieuwe uniformen aan het leger of aan het politiecorps beloofd?
Hij heeft nieuwe uniformen aan het leger beloofd.
109 Heeft de toerist een foto van een molen of van een klomp gemaakt?
Hij heeft een foto van een molen gemaakt.
110 Heeft zij een haar in de sla of in de bouillon aangetroffen?
Zij heeft een haar in de sla aangetroffen.
111 Heeft hij de zwaluw naar het oosten of naar het westen zien vliegen?
Hij heeft de zwaluw naar het oosten zien vliegen.
112 Heeft hij de peren bij een kraampje of bij een winkel gekocht?
Hij heeft de peren bij een kraampje gekocht.
113 Heeft de kok de kreeft met een lepel of met een tang omgedraaid?
Hij heeft de kreeft met een lepel omgedraaid.
114 Heeft zij een krekel in het water of in het gras gehoord?
Zij heeft een krekel in het water gehoord.
115 Heeft de honkballer water na de training of na de wedstrijd gedronken?
Hij heeft water na de training gedronken.
116 Heeft hij kolen in het vuur of in het hok gegooid?
Hij heeft kolen in het vuur gegooid.
117 Heeft de gemeente de huurders over de sloop of over de renovatie geinformeerd?
Zij hebben de huurders over de sloop geinvormeerd.
118 Heeft de weerman regen in de avond of in de ochtend voorspeld?
Hij heeft regen in de avond voorspeld.
119 Heeft hij een uur op zijn maatje of op zijn zus staan wachten?
Hij heeft een uur op zijn maatje staan wachten.
120 Heeft zij vandaag meel voor de cake of voor de koekjes gekocht?
Zij heeft vandaag meel voor de cake gekocht.

Chapter 4

Stimuli in experiment 1 were the answers taken out of the dialogues presented below for experiment 2. For all answers, the type of accent on the proper noun was varied between a neutral falling accent (H*L) and corrective rising accent (LH*). Focus was determined by a context question in experiment 2 only.

Experiment 2

A**: Neutral Focus**

1 Wie heeft de laatste strafschop genomen?
Volgens mij heeft Thomas de strafschop genomen.
2 Wie heeft zonet het raam opengedaan?
Volgens mij heeft Roos het raam opengedaan.
3 Wie heeft gisteren de vuilniszak weggebracht?
Volgens mij heeft Lucas de vuilniszak weggebracht.
4 Wie heeft vorige week de concertkaartjes opgehaald?
Volgens mij heeft Sara de kaartjes opgehaald.
5 Wie heeft dit seizoen de hockeyclub verlaten?
Volgens mij heeft Ruben de hockeyclub verlaten.
6 Wie heeft de inkopen voor de barbecue gedaan?
Volgens mij heeft Floor de inkopen gedaan.
7 Welke instructeur heeft de aerobics-les gegeven?
Volgens mij heeft Daan de aerobics-les gegeven.
8 Wie heeft vanochtend over de verstopping gebeld?
Volgens mij heeft Eva vanochtend gebeld.
9 Wie heeft het hoogste cijfer op de toets gehaald?
Volgens mij heeft Ate het hoogste cijfer gehaald.
10 Wie heeft de krant vanmiddag uit de bus gehaald?
Volgens mij heeft Suze vanmiddag de krant gehaald.
11 Wie heeft jouw balpen gepakt?
Volgens mij heeft David de balpen gepakt.
12 Wie heeft het varken gisteren gevoerd?
Volgens mij heeft Demi het varken gevoerd.
13 Wie heeft het pakketje naar het postkantoor gebracht?
Volgens mij heeft Owen het pakketje weggebracht.
14 Wie heeft jouw koffer van de loopband getild?
Volgens mij heeft Hugo de koffer getild.
15 Wie heeft vorige week de flessen weggebracht?
Volgens mij heeft Lara de flessen weggebracht.
16 Wie heeft bij de buurtbingo de hoofdprijs gewonnen?
Volgens mij heeft Noa de hoofdprijs gewonnen.
17 Wie heeft de studentenverkiezingen gewonnen?
Volgens mij heeft Merel de verkiezingen gewonnen.
18 Wie heeft als voorzitter van de studievereniging gewerkt?
Volgens mij heeft Adam als voorzitter gewerkt.
19 Wie heeft het internet op de school aangelegd?
Volgens mij heeft Aron het internet aangelegd.
20 Wie heeft het hotel voor het familieweekend geboekt?
Volgens mij heeft Marit het hotel geboekt.
21 Wie heeft de hond van opa gisteren uitgelaten?
Volgens mij heeft Clara de hond gisteren uitgelaten.
22 Wie heeft de thermostaat hoger gezet?

Volgens mij heeft Daniël de thermostaat hoger gezet.
23 Wie heeft de hoofdrol in het toneelstuk gespeeld?
Volgens mij heeft Noortje de hoofdrol gespeeld.
24 Wie heeft de dichtwedstrijd gewonnen?
Volgens mij heeft Luna de dichtwedstrijd gewonnen.
25 Wie heeft de stageplek in Haren gekregen?
Volgens mij heeft Stefan de stageplek gekregen.
26 Wie heeft de stofzuiger op zijn kamer staan?
Volgens mij heeft Erik de stofzuiger op zijn kamer staan.
27 Wie heeft de film naar de videotheek teruggebracht?
Volgens mij heeft Robin de film teruggebracht.
28 Wie heeft vannacht de muziek keihard aangezet?
Volgens mij heeft Joris de muziek keihard aangezet.
29 Wie heeft de schaar uit het kastje gepakt?
Volgens mij heeft Romy de schaar gepakt.
30 Wie heeft de lamp in de gang vervangen?
Volgens mij heeft Mona de lamp vervangen.
31 Wie heeft in de estafette als laatste gelopen?
Volgens mij heeft Luca als laatste gelopen.
32 Wie heeft de eerste vrije trap van de wedstrijd genomen?
Volgens mij heeft Rowan de eerste vrije trap genomen.
33 Wie heeft het laatste chocolaatje gepakt?
Volgens mij heeft Vera het laatste chocolaatje gepakt.
34 Wie heeft de vlek in het tafelkleed gemaakt?
Volgens mij heeft Guusje die vlek gemaakt.
35 Wie heeft de meeste stemmen bij de tv-show gekregen?
Volgens mij heeft Veerle de meeste stemmen gekregen.
36 Wie heeft de surprise voor jouw vriend gemaakt?
Volgens mij heeft Maartje de surprise gemaakt.
37 Wie heeft de hoogste prijs voor het schilderij geboden?
Volgens mij heeft Koos de hoogste prijs geboden.
38 Wie heeft de locatie voor het etentje uitgezocht?
Volgens mij heeft Aafke de locatie uitgezocht.
39 Wie heeft vorige week de wc schoongemaakt?
Volgens mij heeft Guus de wc schoongemaakt.
40 Wie is zeilkampioen geworden?
Volgens mij is Aagje zeilkampioen geworden.
41 Wie heeft de baan als manager gekregen?
Volgens mij heeft Doke die baan gekregen.
42 Wie heeft de kinderen geschopt?
Volgens mij heeft Jacob de kinderen geschopt.
43 Wie heeft het kunstwerk in het park gemaakt?
Volgens mij heeft Ada het kunstwerk gemaakt.
44 Wie heeft de juwelen uit het museum gestolen?
Volgens mij heeft Joost de juwelen gestolen.
45 Wie heeft als zanger de schoolband ondersteund?
Volgens mij heeft Maarten de schoolband ondersteund.
46 Wie heeft het misdrijf gepleegd?
Volgens mij heeft Yorick het misdrijf gepleegd.
47 Wie heeft het fotolijstje gebroken?
Volgens mij heeft Beau het fotolijstje gebroken
48 Wie heeft de stoelen in de bestuurkamer verplaatst?
Volgens mij heeft Jules de stoelen verplaatst.
49 Wie heeft het ongelukje tijdens het diner veroorzaakt?
Volgens mij heeft Erika het ongelukje veroorzaakt.

50 Wie heeft het persbericht naar de tijdschriften gemaild?
Volgens mij heeft Leo het persbericht gemaild.
51 Wie heeft de wijn ingeschonken?
Volgens mij heeft Alex de wijn ingeschonken.
52 Wie heeft in de show opgetreden?
Volgens mij heeft Boris in de show opgetreden.
53 Wie heeft haar het kaartje gestuurd?
Volgens mij heeft Geke haar het kaartje gestuurd.
54 Wie heeft de afspraak met de arts afgezegd?
Volgens mij heeft Jonas de afspraak afgezegd.
55 Wie heeft het huurcontract getekend?
Volgens mij is Joke het contract getekend.
56 Wie heeft de kozijnen geplaatst?
Volgens mij heeft Abel de kozijnen geplaatst.
57 Wie heeft er op het kind gepast?
Volgens mij heeft Grace op het kind gepast.
58 Wie heeft de klok de woonkamer stiekem verzet?
Volgens mij heeft Johan de klok stiekem verzet.
59 Wie heeft over de rechter in de strafzaak geklaagd?
Volgens mij heeft Berend over de rechter geklaagd.
60 Wie heeft het verjaardagsdiner gekookt?
Volgens mij heeft Geesje het diner gekookt.
61 Wie heeft het monument met graffiti bespoten?
Volgens mij heeft Fabian het monument bespoten.
62 Wie heeft de broek in de kleedkamer laten liggen?
Volgens mij heeft Kate de broek laten liggen.
63 Wie heeft de knuffelbeer aan de kleuter gegeven?
Volgens mij heeft Lucie de knuffelbeer aan hem gegeven.
64 Wie heeft het vakantiehuisje geverfd?
Volgens mij heeft Dave het huisje geverfd.
65 Wie heeft vandaag de plant water gegeven?
Volgens mij heeft Meta de plant water gegeven.
66 Wie heeft de zak snoep leeg gegeten?
Volgens mij heeft Lola de snoep leeg gegeten.
67 Wie heeft het gedicht tijdens de kerkdienst voorgedragen?
Volgens mij heeft Dana het gedicht voorgedragen.
68 Wie heeft de cd-speler uitgezet?
Volgens mij heeft Monica de cd-speler uitgezet.
69 Wie heeft met de docent na het praatje gediscussieerd?
Volgens mij heeft Jaap met de docent gediscussieerd.
70 Wie heeft de heg in het stadspark gesnoeid?
Volgens mij heeft Adri de heg in het stadspark gesnoeid.
71 Wie heeft het filmpje op de bruiloft opgenomen?
Volgens mij heeft Aad het filmpje opgenomen.
72 Wie heeft vanmiddag met de makelaar gebeld?
Volgens mij heeft Nely met de makelaar gebeld.
73 Wie heeft de kast in de slaapkamer gerepareerd?
Volgens mij heeft Ewoud de kast gerepareerd.
74 Wie heeft het studentencongres georganiseerd?
Volgens mij heeft Aart het congres georganiseerd.
75 Wie heeft gisteren de verhuisberichten verstuurd?
Volgens mij heeft Gerard de verhuisberichten verstuurd.
76 Wie heeft de iPod bij de verloting gewonnen?
Volgens mij heeft Floris de iPod gewonnen.
77 Wie heeft de poster van de popgroep verscheurd?

Volgens mij heeft Freek de poster verscheurd.
78 Wie heeft de reiskosten van de secretaresse betaald?
Volgens mij heeft Juul de reiskosten betaald.
79 Wie heeft er voor de geluidsoverlast gezorgd?
Volgens mij heeft Karel voor de geluidsoverlast gezorgd.
80 Wie heeft de muziek voor de party uitgekozen?
Volgens mij heeft Joop de muziek uitgekozen.
81 Wie heeft de groentewinkel overgenomen?
Volgens mij heeft Robert de groentewinkel overgenomen.
82 Wie heeft de fiets naar het station meegenomen?
Volgens mij heeft Ruud de fiets meegenomen.
83 Wie heeft op de toeristen op de luchthaven gewacht?
Volgens mij heeft Gabi op de toeristen gewacht.
84 Wei heeft er promotie tot chefkok gemaakt?
Volgens mij heeft Jeen de promotie gemaakt.
85 Wie heeft de tv uit de electronicawinkel gestolen?
Volgens mij heeft Ludo de tv uit de winkel gestolen
86 Wie heeft als reservespeler de voetbalwedstrijd gespeeld?
Volgens mij heeft Rody als reservespeler gespeeld.
87 Wie heeft de schat van de piraat gevonden?
Volgens mij heeft Steven de schat gevonden.
88 Wie heeft tijdens de modeshow een horloge gevonden?
Volgens mij heeft Neeltje een horloge gevonden.
89 Wie heeft de weddenschap over de paardenrace verloren?
Volgens mij heeft Petra de weddenschap verloren.
90 Wie heeft het porseleinen soepbord gebroken?
Volgens mij heeft Roland het soepbord gebroken.
91 Wie heeft voor de gasten een liedje gezongen?
Volgens mij heeft Trudy een liedje gezongen.
92 Wie heeft het dak van het ziekenhuis gerepareerd?
Volgens mij heeft Sjaak van het dak gerepareerd.
93 Wie heeft als drummer voor de rockband gesolliciteerd?
Volgens mij heeft Rudy als drummer gesolliciteerd.
94 Wie heeft het standbeeld bij de veiling gekocht?
Volgens mij heeft Cora het standbeeld gekocht.
95 Wie heeft de leeuw uit het circus getemd?
Volgens mij heeft Caren de leeuw getemd.
96 Wie heeft het lintje bij de openingsceremonie doorgeknipt?
Volgens mij heeft Eef het lintje doorgeknipt.
97 Wie heeft de titel van sterkste man van het land gekregen?
Volgens mij heeft Joram die titel gekregen.
98 Wie heeft de kamer van de kinderen opgeruimd?
Volgens mij heeft Take de kamer opgeruimd.
99 Wie heeft de functie van hoofdcommissaris gekregen?
Volgens mij heeft Peter die functie gekregen.
100 Wie heeft de boodschappen voor de bejaarde gedaan?
Volgens mij heeft Jolanda de boodschappen gedaan.
101 Wie heeft het brandhout voor het vuur verzameld?
Volgens mij heeft Geert het brandhout verzameld.
102 Wie heeft de spotjes in het plafond bevestigd?
Volgens mij heeft Rohan de spotjes bevestigd.
103 Wie heeft over de nieuwe liefde van de filmster geschreven?
Volgens mij heeft Pablo over haar nieuwe liefde geschreven.
104 Wie heeft de hulpdienst gebeld?
Volgens mij heeft Toos de hulpdienst gebeld.

105 Wie heeft de liefdesbrief aan de juf geschreven?
Volgens mij heeft Jozef de liefdesbrief geschreven.
106 Wie heeft de presentatie over het nieuwe product gehouden?
Volgens mij heeft Doortje de presentatie gehouden.
107 Wie heeft de gaten in de muur geboord?
Volgens mij heeft Ruurd de gaten in de muur geboord.
108 Wie heeft het optreden van de balletgroep gefilmd?
Volgens mij heeft Klaartje het optreden gefilmd.
109 Wie heeft de crimineel opgespoord?
Volgens mij heeft Pedro de crimineel opgespoord.
110 Wie heeft de bloemen uit de tuin geplukt?
Volgens mij heeft Geertje de bloemen geplukt.
111 Wie heeft de vakantie voor de kinderen betaald?
Volgens mij heeft Karin de vakantie betaald.
112 Wie heeft de sinterklaascadeaus verstopt?
Volgens mij heeft Toby de sinterklaascadeaus verstopt.
113 Wie heeft de mooiste sportwagen gekocht?
Volgens mij heeft Ronald de mooiste wagen gekocht.
114 Wie heeft er in zijn eentje op het strand gelegen?
Volgens mij heeft Remi in zijn eentje gelegen.
115 Wie heeft de kerstboom met slingers versierd?
Volgens mij heeft Koosje de kerstboom versierd.
116 Wie heeft van de kersenvlaai gesnoept?
Volgens mij heeft Paco van de kersenvlaai gesnoept.
117 Wie heeft de bal door het raam geschoten?
Volgens mij heeft Toon de bal geschoten.
118 Wie heeft de afstandsbediening als laatste gehad?
Volgens mij heeft Julia hem als laatste gehad.
119 Wie heeft de wijn ontkurkt?
Volgens mij heeft Rosa de wijn ontkurkt.
120 Wie heeft de hoogste bonus gekregen?
Volgens mij heeft Janus de hoogste bonus gekregen.

B: Corrective focus

1 Wist jij dat Robbie de laatste strafschop heeft genomen?
Volgens mij heeft Thomas de strafschop genomen.
2 Wist jij dat Anneke zonet het raam heeft opgedaan?
Volgens mij heeft Roos het raam opengedaan.
3 Wist jij dat André gisteren de vuilniszak heeft weggebracht?
Volgens mij heeft Lucas de vuilniszak weggebracht.
4 Wist jij dat Liesbeth de concertkaartjes heeft opgehaald?
Volgens mij heeft Sara de kaartjes opgehaald.
5 Wist jij dat Chris dit seizoen de hockeyclub heeft verlaten?
Volgens mij heeft Ruben de hockeyclub verlaten.
6 Wist jij dat Jeanine de inkopen voor de barbecue heeft gedaan?
Volgens mij heeft Floor de inkopen gedaan.
7 Wist jij dat John de aerobics-les heeft gegeven?
Volgens mij heeft Daan de aerobics-les gegeven.
8 Wist jij dat Nienke vanochtend over de verstopping heeft gebeld?
Volgens mij heeft Eva vanochtend gebeld.
9 Wist jij dat Patrick het hoogste cijfer op de toets heeft gehaald?
Volgens mij heeft Ate het hoogste cijfer gehaald.
10 Wist jij dat Femke vanmiddag de krant uit de bus heeft gehaald?
Volgens mij heeft Suze vanmiddag de krant gehaald.

11 Wist jij dat Richard jouw balpen heeft gepakt?
Volgens mij heeft David de balpen gepakt.
12 Wist jij dat Michel het varken gisteren heeft gevoerd?
Volgens mij heeft Demi het varken gevoerd.
13 Wist jij dat Sander het pakketje naar het postkantoor heeft gebracht?
Volgens mij heeft Owen het pakketje weggebracht.
14 Wist jij dat Martijn jouw koffer van de loopband heeft getild?
Volgens mij heeft Hugo de koffer getild.
15 Wist jij dat Kim vorige week de flessen heeft weggebracht?
Volgens mij heeft Lara de flessen weggebracht.
16 Wist jij dat Bente bij de buurtbingo de hoofdprijs heeft gewonnen?
Volgens mij heeft Noa de hoofdprijs gewonnen.
17 Wist jij dat Jessica de studentenverkiezingen heeft gewonnen?
Volgens mij heeft Merel de verkiezingen gewonnen.
18 Wist jij dat Nico als voorzitter van de studievereniging heeft gewerkt?
Volgens mij heeft Adam als voorzitter gewerkt.
19 Wist jij dat Marcel het internet op de school heeft aangelegd?
Volgens mij heeft Aron het internet aangelegd.
20 Wist jij dat Carmen het hotel voor het familieweekend heeft geboekt?
Volgens mij heeft Marit het hotel geboekt.
21 Wist jij dat Daphne de hond van opa gisteren heeft uitgelaten?
Volgens mij heeft Clara de hond gisteren uitgelaten.
22 Wist jij dat Eddy de thermostaat hoger heeft gezet?
Volgens mij heeft Daniël de thermostaat hoger gezet.
23 Wist jij dat Silke de hoofdrol in het toneelstuk heeft gespeeld?
Volgens mij heeft Noortje de hoofdrol gespeeld.
24 Wist jij dat Janneke de dichtwedstrijd heeft gewonnen?
Volgens mij heeft Luna de dichtwedstrijd gewonnen.
25 Wist jij dat Gerrit de stageplek in Haren heeft gekregen?
Volgens mij heeft Stefan de stageplek gekregen.
26 Wist jij dat Joep de stofzuiger op zijn kamer heeft staan?
Volgens mij heeft Erik de stofzuiger op zijn kamer staan.
27 Wist jij dat Lorenzo de film naar de videotheek heeft teruggebracht?
Volgens mij heeft Robin de film teruggebracht.
28 Wist jij dat Eldert vannacht de muziek keihard heeft aangezet?
Volgens mij heeft Joris de muziek keihard aangezet.
29 Wist jij dat Marloes de schaar uit het kastje heeft gepakt?
Volgens mij heeft Romy de schaar gepakt.
30 Wist jij dat Carla de lamp in de gang heeft vervangen?
Volgens mij heeft Mona de lamp vervangen.
31 Wist jij dat Pim in de estafette als laatste heeft gelopen?
Volgens mij heeft Luca als laatste gelopen.
32 Wist jij dat Christian de eerste vrije trap van de wedstrijd heeft genomen?
Volgens mij heeft Rowan de eerste vrije trap genomen.
33 Wist jij dat Sylvia het laatste chocolaatje heeft gepakt?
Volgens mij heeft Vera het laatste chocolaatje gepakt.
34 Wist jij dat Baukje de vlek in het tafelkleed heeft gemaakt?
Volgens mij heeft Guusje die vlek gemaakt.
35 Wist jij dat Christien de meeste stemmen bij de tv-show heeft gekregen?
Volgens mij heeft Veerle de meeste stemmen gekregen.
36 Wist jij dat Andrea de surprise voor jouw vriend heeft gemaakt?
Volgens mij heeft Maartje de surprise gemaakt.
37 Wist jij dat Tinus de hoogste prijs voor het schilderij heeft geboden?
Volgens mij heeft Koos de hoogste prijs geboden.
38 Wist jij dat Lieneke de locatie voor het etentje heeft uitgezocht?

Volgens mij heeft Aafke de locatie uitgezocht.
39 Wist jij dat Arvid vorige week de wc heeft schoongemaakt?
Volgens mij heeft Guus de wc schoongemaakt.
40 Wist jij dat Merle zeilkampioen is geworden?
Volgens mij is Aagje zeilkampioen geworden.
41 Wist jij dat René de baan als manager heeft gekregen?
Volgens mij heeft Doke die baan gekregen.
42 Wist jij dat Sylvester de kinderen heeft geschopt?
Volgens mij heeft Jacob de kinderen geschopt.
43 Wist jij dat Margje het kunstwerk in het park heeft gemaakt?
Volgens mij heeft Ada het kunstwerk gemaakt.
44 Wist jij dat Harry de juwelen uit het museum heeft gestolen?
Volgens mij heeft Joost de juwelen gestolen.
45 Wist jij dat Douwe als zanger de schoolband heeft ondersteund?
Volgens mij heeft Maarten de schoolband ondersteund.
46 Wist jij dat Danny het misdrijf heeft gepleegd?
Volgens mij heeft Yorick het misdrijf gepleegd.
47 Wist jij dat Froukje het fotolijstje heeft gebroken?
Volgens mij heeft Beau het fotolijstje gebroken
48 Wist jij dat Lindert de stoelen in de bestuurkamer heeft verplaatst?
Volgens mij heeft Jules de stoelen verplaatst.
49 Wist jij dat Jacqueline het ongeluk tijdens het diner heeft veroorzaakt?
Volgens mij heeft Erika het ongelukje veroorzaakt.
50 Wist jij dat Mark het persbericht heeft gemaild?
Volgens mij heeft Leo het persbericht gemaild.
51 Wist jij dat Paul de wijn heeft ingeschonken?
Volgens mij heeft Alex de wijn ingeschonken.
52 Wist jij dat Jim in de show heeft opgetreden?
Volgens mij heeft Boris in de show opgetreden.
53 Wist jij dat Alette haar het kaartje heeft gestuurd?
Volgens mij heeft Geke haar het kaartje gestuurd.
54 Wist jij dat Pieter de afspraak met de arts heeft afgezegd?
Volgens mij heeft Jonas de afspraak afgezegd.
55 Wist jij dat Gerry het huurcontract heeft getekend?
Volgens mij is Joke het contract getekend.
56 Wist jij dat Jeroen de kozijnen heeft geplaatst?
Volgens mij heeft Abel de kozijnen geplaatst.
57 Wist jij dat Elise op het kind heeft gepast?
Volgens mij heeft Grace op het kind gepast.
58 Wist jij dat Casper de klok in de woonkamer stiekem heeft verzet?
Volgens mij heeft Johan de klok stiekem verzet.
59 Wist jij dat Jeremy over de rechter in de strafzaak heeft geklaagd?
Volgens mij heeft Berend over de rechter geklaagd.
60 Wist jij dat Lidy het verjaardagsdiner heeft gekookt?
Volgens mij heeft Geesje het diner gekookt.
61 Wist jij dat Glenn het monument met graffiti heeft bespoten?
Volgens mij heeft Fabian het monument bespoten.
62 Wist jij dat Diny de broek in de kleedkamer heeft laten liggen?
Volgens mij heeft Kate de broek laten liggen.
63 Wist jij dat Gerdie de knuffelbeer aan de kleuter heeft gegeven?
Volgens mij heeft Lucie de knuffelbeer aan hem gegeven.
64 Wist jij dat Quinten het vakantiehuisje heeft geverfd?
Volgens mij heeft Dave het huisje geverfd.
65 Wist jij dat Hilde vandaag de plant water heeft gegeven?
Volgens mij heeft Meta de plant water gegeven.

66 Wist jij dat Rianne de zak snoep heeft leeg gegeten?
Volgens mij heeft Lola de snoep leeg gegeten.
67 Wist jij dat Rina het gedicht tijdens de kerkdienst heeft voorgedragen?
Volgens mij heeft Dana het gedicht voorgedragen.
68 Wist jij dat Jantina de cd-speler heeft uitgezet?
Volgens mij heeft Monica de cd-speler uitgezet.
69 Wist jij dat Piet met de docent na het praatje heeft gediscussieerd?
Volgens mij heeft Jaap met de docent gediscussieerd.
70 Wist jij dat Siemen de heg in het stadspark heeft gesnoeid?
Volgens mij heeft Adri de heg in het stadspark gesnoeid.
71 Wist jij dat Bernard het filmpje op de bruiloft heeft opgenomen?
Volgens mij heeft Aad het filmpje opgenomen.
72 Wist jij dat Patricia vanmiddag met de makelaar heeft gebeld?
Volgens mij heeft Nely met de makelaar gebeld.
73 Wist jij dat Arjan de kast in de slaapkamer heeft gerepareerd?
Volgens mij heeft Ewoud de kast gerepareerd.
74 Wist jij dat Milos het studentencongres heeft georganiseerd?
Volgens mij heeft Aart het congres georganiseerd.
75 Wist jij dat Dirk gisteren de verhuisberichten heeft verstuurd?
Volgens mij heeft Gerard de verhuisberichten verstuurd.
76 Wist jij dat Jan de iPod bij de verloting heeft gewonnen?
Volgens mij heeft Floris de iPod gewonnen.
77 Wist jij dat Rutger de poster van de popgroep heeft verscheurd?
Volgens mij heeft Freek de poster verscheurd.
78 Wist jij dat Hendrik de reiskosten van de secretaresse heeft betaald?
Volgens mij heeft Juul de reiskosten betaald.
79 Wist jij dat Roy voor de geluidsoverlast heeft gezorgd?
Volgens mij heeft Karel voor de geluidsoverlast gezorgd.
80 Wist jij dat Mathijs de muziek voor de party heeft uitgekozen?
Volgens mij heeft Joop de muziek uitgekozen.
81 Wist jij dat Frits de groentewinkel heeft overgenomen?
Volgens mij heeft Robert de groentewinkel overgenomen.
82 Wist jij dat Lodewijk de fiets naar het station heeft meegenomen?
Volgens mij heeft Ruud de fiets meegenomen.
83 Wist jij dat Sanne op de toeristen op de luchthaven heeft gewacht?
Volgens mij heeft Gabi op de toeristen gewacht.
84 Wist jij dat Rens promotie tot chefkok heeft gemaakt?
Volgens mij heeft Jeen de promotie gemaakt.
85 Wist jij dat Jasper de tv uit de electronicawinkel heeft gestolen?
Volgens mij heeft Ludo de tv uit de winkel gestolen
86 Wist jij dat Henk als reservespeler de voetbalwedstrijd heeft gespeeld?
Volgens mij heeft Rody als reservespeler gespeeld.
87 Wist jij dat Sjoerd de schat van de piraat heeft gevonden?
Volgens mij heeft Steven de schat gevonden.
88 Wist jij dat Hendrika tijdens de modeshow een horloge heeft gevonden?
Volgens mij heeft Neeltje een horloge gevonden.
89 Wist jij dat Evelien de weddenschap over de paardenrace heeft verloren?
Volgens mij heeft Petra de weddenschap verloren.
90 Wist jij dat Dennis het porseleinen soepbord heeft gebroken?
Volgens mij heeft Roland het soepbord gebroken.
91 Wist jij dat Anna voor de gasten een liedje heeft gezongen?
Volgens mij heeft Trudy een liedje gezongen.
92 Wist jij dat Jan het dak van het ziekenhuis heeft gerepareerd?
Volgens mij heeft Sjaak van het dak gerepareerd.
93 Wist jij dat Justin als drummer voor de rockband heeft gesolliciteerd?

Volgens mij heeft Rudy als drummer gesolliciteerd.
94 Wist jij dat Bianca het standbeeld bij de veiling heeft gekocht?
Volgens mij heeft Cora het standbeeld gekocht.
95 Wist jij dat Kitty de leeuw uit het circus heeft getemd?
Volgens mij heeft Caren de leeuw getemd.
96 Wist jij dat Suzanne het lintje bij de openingsceremonie heeft doorgeknipt?
Volgens mij heeft Eef het lintje doorgeknipt.
97 Wist jij dat Marlon de titel van sterkste man van het land heeft gekregen?
Volgens mij heeft Joram die titel gekregen.
98 Wist jij dat Jelmer de kamer van de kinderen heeft opgeruimd?
Volgens mij heeft Take de kamer opgeruimd.
99 Wist jij dat Rob de functie van hoofdcommissaris heeft gekregen?
Volgens mij heeft Peter die functie gekregen.
100 Wist jij dat Carola de boodschappen voor de bejaarde heeft gedaan?
Volgens mij heeft Jolanda de boodschappen gedaan.
101 Wist jij dat Bert het brandhout voor het vuur heeft verzameld?
Volgens mij heeft Geert het brandhout verzameld.
102 Wist jij dat Leo de spotjes in het plafond heeft bevestigd?
Volgens mij heeft Rohan de spotjes bevestigd.
103 Wist jij dat Dennis over de nieuwe liefde van de filmster heeft geschreven?
Volgens mij heeft Pablo over haar nieuwe liefde geschreven.
104 Wist jij dat Marlies de hulpdienst heeft gebeld?
Volgens mij heeft Toos de hulpdienst gebeld.
105 Wist jij dat Dirk-Jan de liefdesbrief aan de juf heeft geschreven?
Volgens mij heeft Jozef de liefdesbrief geschreven.
106 Wist jij dat Claire de presentatie over het nieuwe product heeft gehouden?
Volgens mij heeft Doortje de presentatie gehouden.
107 Wist jij dat Tim heeft de gaten in de muur heeft geboord?
Volgens mij heeft Ruurd de gaten in de muur geboord.
108 Wist jij dat Alie het optreden van de balletgroep heeft gefilmd?
Volgens mij heeft Klaartje het optreden gefilmd.
109 Wist jij dat Klaas de crimineel heeft opgespoord?
Volgens mij heeft Pedro de crimineel opgespoord.
110 Wist jij dat Sabrina de bloemen uit de tuin heeft geplukt?
Volgens mij heeft Geertje de bloemen geplukt.
111 Wist jij dat Bertine de vakantie voor de kinderen heeft betaald?
Volgens mij heeft Karin de vakantie betaald.
112 Wist jij dat Piet de sinterklaascadeaus heeft verstopt?
Volgens mij heeft Toby de sinterklaascadeaus verstopt.
113 Wist jij dat Edwin de mooiste sportwagen heeft gekocht?
Volgens mij heeft Ronald de mooiste wagen gekocht.
114 Wist jij dat John in zijn eentje op het strand heeft gelegen?
Volgens mij heeft Remi in zijn eentje gelegen.
115 Wist jij dat Monique de kerstboom met slingers heeft versierd?
Volgens mij heeft Koosje de kerstboom versierd.
116 Wist jij dat Mario van de kersenvlaai heeft gesnoept?
Volgens mij heeft Paco van de kersenvlaai gesnoept.
117 Wist jij dat Wiebe de bal door het raam heeft geschoten?
Volgens mij heeft Toon de bal geschoten.
118 Wist jij dat Sofie de afstandsbediening als laatste heeft gehad?
Volgens mij heeft Julia hem als laatste gehad.
119 Wist jij dat Esther de wijn heeft ontkurkt?
Volgens mij heeft Rosa de wijn ontkurkt.
120 Wist jij dat Bert de hoogste bonus heeft gekregen?
Volgens mij heeft Janus de hoogste bonus gekregen.

Chapter 5

In experiment 1, stimuli were the answers and statements taken out of the dialogues for experiment 2 presented below. For all stimuli, prosody was determined by context.

Experiment 2

A: Thematic Fit: Gapping Question, Gapping statement

1 Wanneer hebben de jongens Ivar gezien?
Lars zag Ivar op een zondag en Thomas op een maandag.
OK, dus Thomas zag Ivar op een maandag.

2 Waarvoor hebben de jongens Sido geroepen?
Tim riep Sido voor de koffie en Lucas voor de thee.
OK, dus Lucas riep Sido voor de thee.

3 Waar hebben de zakenmannen Gosse getroffen?
Rutger trof Gosse tijdens het congres en Ruben tijdens de workshops.
OK, dus Ruben trof Gosse tijdens de workshops.

4 Waarmee hebben de huishoudsters Kathy geholpen?
Saskia hielp Kathy met het koken en Demi met de afwas.
OK, dus Demi hielp Kathy met de afwas.

5 Wanneer hebben de collega's Sjors gebeld?
Marc belde Sjors in de avond en Jamie in de ochtend.
OK, dus Jamie belde Sjors in de ochtend.

6 Waarvan hebben de jongemannen Emiel gered?
Lorenzo redde Emiel van een val en David van een ongeluk.
OK, dus David redde Emiel van een ongeluk.

7 Waar hebben de vechtersbazen Simon geslagen?
Rik sloeg Simon op zijn neus en Gary op zijn kaak.
OK, dus Gary sloeg Simon op zijn kaak.

8 Waar hebben de kinderen Willem getikt?
Jorrit tikte Willem bij de zandbak en Hugo bij de boom.
OK, dus Hugo tikte Willem bij de boom.

9 Waarnaar hebben de toeristen Bob gevraagd?
Roy vroeg Bob naar de weg en Adam naar het tijdstip.
OK, dus Adam vroeg Bob naar het tijdstip.

10 Waar hebben de gasten Rintje gezocht?
Maurits zocht Rintje in de kelder en Aaron op de zolder.
OK, dus Aaron zocht Rintje op de zolder.

11 Waar hebben de broers Ids gebracht?
Jesper bracht Ids naar de tennisbaan en Daniel naar de feesttent.
OK, dus Daniel bracht Ids naar de feesttent.

12 Wanneer hebben de studenten Ted gefilmd?
Martijn filmde Ted tijdens het interview en Stefan tijdens het avondeten.
OK, dus Stefan filmde Ted tijdens het avondeten.

13 Waarvoor hebben de toehoorders Bastiaan geloofd?
Rens loofde Bastiaan voor de zangkunsten en Erik voor het kunstwerk.
OK, dus Erik loofde Bastiaan voor het kunstwerk.

14 Waar hebben de jongens Cas genoemd?
Niels noemde Cas bij de rechter en Robin bij de commissaris.
OK, dus Robin noemde Cas bij de commissaris.

15 Waar hebben de jongens Job gepest?
Michael pestte Job in de klas en Luca op het schoolplein.
OK, dus Luca pestte Job op het schoolplein.

16 Waarbij hebben de sporters Jort geraakt?

Wiebe raakte Jort bij het tennissen en Juul bij het schaatsen.
OK, dus Juul raakte Jort bij het schaatsen.

17 Waarheen zijn de vrienden Adriaan gevolgd?
Jorn volgde Adriaan naar het feest en Karel naar de bioscoop.
OK, dus Karel volgde Adriaan naar de bioscoop.

18 Hoe hebben de bandleden Bas gewenkt?
Jurjen wenkte Bas met een hoofdknik en Joris met een handgebaar.
OK, dus Joris wenkte Bas met een handgebaar.

19 Waarin hebben de gezinsleden Ronnie begrepen?
Max begreep Ronnie in zijn standpunt en Rowan in zijn emotie.
OK, dus Rowan begreep Ronnie in zijn emotie.

20 Wanneer hebben de broers Marco bezocht?
Steffen bezocht Marco in het voorjaar en Guus in de winter.
OK, dus Guus bezocht Marco in de winter.

21 Waarin hebben de collega's Janny geschoold?
Sigrid schoolde Janny in het lezen en Roos in het rekenen.
OK, dus Roos schoolde Janny in het rekenen.

22 Waar hebben de vriendinnen Jolanda mee verrast?
Nynke verraste Jolanda met een etentje en Sara met een borrel.
OK, dus Sara verraste Jolanda met een borrel.

23 Waarmee hebben de gastvrouwen Helen verwend?
Martine verwende Helen met een bad en Floor met een tijdschrift.
OK, dus Floor verwende Helen met een tijdschrift.

24 Wat hebben de vrouwen Annemiek verzocht?
Jannie verzocht Annemiek om een uitleg en Jorien om een voorstel.
OK, dus Jorien verzocht Annemiek om een voorstel.

25 Waarmee hebben de vrouwen Jeannette geamuseerd?
Femke amuseerde Jeannette met een mop en Eva met een lied.
OK, dus Eva amuseerde Jeanette met een lied.

26 Waarmee hebben de criminelen Jos bedreigd?
Christoph bedreigde Jos met een mes en Daan met een pistool.
OK, dus Daan bedreigde Jos met een pistool.

27 Hoe hebben de teamgenoten Annabel begroet?
Maaike begroette Annabel met een zoen en Suze met een knuffel.
OK, dus Suze begroette Annabel met een knuffel.

28 Waarmee hebben de rivalen Jasper beledigd?
Hidde beledigde Jasper met een e-mail en Fabio met een opmerking.
OK, dus Fabio beledigde Jasper met een opmerking.

29 Waarvoor hebben de vrouwen Diana benaderd?
Ingeborg benaderde Diana voor een gesprek en Noa voor een meeting.
OK, dus Noa benaderde Diana voor een meeting.

30 Waarvoor hebben de vrouwen Krista bestrafd?
Marrit bestrafde Krista voor het stelen en Vrony voor het liegen.
OK, dus Vrony bestrafde Krista voor het liegen.

31 Waaruit hebben de helden Casper bevrijd?
Stijn bevrijdde Casper uit een schuurtje en Jacob uit een loods.
OK, dus Jacob bevrijdde Casper uit een loods.

32 Wanneer hebben de vrouwen Marja geknuffeld?
Simone knuffelde Marja na de wedstrijd en Clara na de show.
OK, dus Clara knuffelde Marja na de show.

33 Waar hebben de voetballers Wim ontmoet?
Wesley ontmoette Wim in een bar en Boris op een receptie.
OK, dus Boris ontmoette Wim op een receptie.

34 Waar hebben de geheim agenten Andreas ontvoerd?
Sierd ontvoerde Andreas uit zijn auto en Floris uit zijn woonkamer.

OK, dus Floris ontvoerde Andreas uit zijn woonkamer.
35 Waarmee hebben de toneelspeelsters Wilma verbaasd?
Bente verbaasde Wilma met haar intelligentie en Romy met haar passie.
OK, dus Romy verbaasde Wilma met haar passie.
36 Waarmee hebben de vrouwen Nicky vermoeid?
Inge vermoeide Nicky met de verhalen en Amy met de foto´s.
OK, dus Amy vermoeide Nicky met de foto´s.
37 Waarmee hebben de toneelspeelsters Brecht verraadden?
Kim verraadde Brecht met een brief en Vera met een leugen.
OK, dus Vera verraadde Brecht met een leugen.
38 Waarmee hebben de oma's Agnes verwarmd?
Gea verwarmde Agnes met een deken en Guusje met een kruik.
OK, dus Guusje verwarmde Agnes met een kruik.
39 Waar hebben de zusters Nancy verzorgd?
Welmoed verzorgde Nancy in het revalidatiecentrum en Dewi in het ziekenhuis.
OK, dus Dewi verzorgde Nancy in het ziekenhuis.
40 Waarover hebben de collega's Myrte geadviseerd?
Laura adviseerde Myrte over de beslissing en Aagje over de aanpak.
OK, dus Aagje adviseerde Myrte over de aanpak.
41 Waar hebben de vriendinnen Sylvia gegroet?
Esther groette Sylvia in de supermarkt en Lara in de stomerij.
OK, dus Esther groette Lara in de stomerij.
42 Wanneer hebben de nichtjes Sandra omarmd?
Ingrid omarmde Sandra na de bruiloft en Merel na de feestelijkheid.
OK, dus Ingrid omarmde Merel na de feestelijkheid.
43 Waar hebben de mannen Sander ontvangen?
Eldert ontving Sander in het café en Maarten in het hotel.
OK, dus Eldert ontving Maarten in het hotel.
44 Waarmee hebben de tieners Frank geplaagd?
Rickey plaagde Frank met zijn accent en Joost met zijn uiterlijk.
OK, dus Rickey plaagde Joost met zijn uiterlijk.
45 Waarmee hebben de vakkenvullers Pieter geschokt?
Paul schokte Pieter met het nieuws en Joram met het ontslag.
OK, dus Paul schokte Joram met het ontslag.
46 Waarmee hebben de kameraden Jeffrey gesteund?
Herman steunde Jeffrey met het verdriet en Beau met de teleurstelling.
OK, dus Herman steunde Beau met de teleurstelling.
47 Waarbij hebben de broers John gestoord?
Mitchel stoorde John bij het bellen en Jules bij het koken.
OK, dus Mitchel stoorde Jules bij het koken.
48 Waarvoor hebben de docenten Hendrik gestrikt?
Nick strikte Hendrik voor een modeshow en Leon voor een musical.
OK, dus Nick strikte Leon voor een musical.
49 Waar hebben de dames Ellen heen gestuurd?
Hanna stuurde Ellen naar de bakker en Noortje naar de slager.
OK, dus Hanna stuurde Noortje naar de slager.
50 Waarmee hebben de artiesten Remco getekend?
Nico tekende Remco met een potlood en Abel met een stift.
OK, dus Nico tekende Abel met een stift.
51 Waar hebben de eerstejaars Tom getoetst?
Tjerk toetste Tom in de zaal en Alex in het kamertje.
OK, dus Tjerk toetste Alex in het kamertje.
52 Waarvoor hebben de juryleden Elma verkozen?
Hedwig verkoos Elma om de schoonheid en Lora om de kennis.
OK, dus Hedwig verkoos Lora om de kennis.

53 Wanneer hebben de rugby'ers Koen gevloerd?
Kevin vloerde Koen in de blessuretijd en Kobus in de verlenging.
OK, dus Kevin vloerde Kobus in de verlenging.
54 Waarvoor hebben de slachtoffers Vincent bedankt?
Reitse bedankte Vincent voor het geld en Ludo voor het onderdak.
OK, dus Reitse bedankte Ludo voor het onderdak.
55 Waarmee hebben de vinders Ilse beloond?
Amber beloonde Ilse met een cadeautje en Erika met een bloemetje.
OK, dus Amber beloonde Erika met een bloemetje.
56 Waarmee hebben de zieken Geertjan besmet?
Jordy besmette Geertjan met de griep en Berend met een verkoudheid.
OK, dus Jordy besmette Berend met een verkoudheid.
57 Waarmee hebben de knapen Harrie bespot?
Yanniek bespotte Harrie met het fotootje en Dave met het gedicht.
OK, dus Yanniek bespotte Dave met het gedicht.
58 Wanneer hebben de vrienden Dicky betaald?
Jenne betaalde Dicky op een donderdag en Aart op een vrijdag.
OK, dus Jenne betaalde Aart op een vrijdag.
59 Waarmee hebben de klasgenoten Reiner gekieteld?
Wietse kietelde Reiner met een grasspriet en Felix met een veertje.
OK, dus Wietse kietelde Felix met een veertje.
60 Wanneer hebben de mannen Gerd genegeerd?
Arjen negeerde Gerd tijdens de vergadering en Abe tijdens het eten.
OK, dus Arjen negeerde Abe tijdens het eten.
61 Waarbij hebben de vriendinnen Iris begeleid?
Elle begeleidde Iris bij de voorstelling en Eef bij de repetitie.
OK, dus Elle begeleidde Eef bij de repetitie.
62 Waartegen hebben de kerels Carlos beschermd?
Sjouke beschermde Carlos tegen de leeuwen en Johan tegen de beren.
OK, dus Sjouke beschermde Johan tegen de beren.
63 Tot wat hebben de leden Sidney bevorderd?
Ben bevorderde Sidney tot een directielid en Owen tot een voorman.
OK, dus Ben bevorderde Owen tot een voorman.
64 Waarom hebben de dames Tiny bewonderd?
Emma bewonderde Tiny om het enthousiasme en Monica om het talent.
OK, dus Emma bewonderde Monica om het talent.
65 Waaraan hebben de studiegenoten Mieke herinnerd?
Kimberly herinnerde Mieke aan een feestje en Gabi aan een tentamen.
OK, dus Kimberly herinnerde Gabi aan een tentamen.
66 Waarmee hebben de vriendinnen Lidy geimponeerd?
Marise imponeerde Lidy met de armband en Geke met de oorbellen.
OK, dus Marise imponeerde Geke met de oorbellen.
67 Waarmee hebben de trainsters Mien gemotiveerd?
Marloes motiveerde Mien met een speech en Geertje met een snoepreep.
OK, dus Marloes motiveerde Geertje met een snoepreep.
68 Waar hebben de criminelen Hans ondervraagd?
Thijs ondervroeg Hans op het bureau en Julian in de rechtszaal.
OK, dus Thijs ondervroeg Julian in de rechtszaal.
69 Waarvan hebben de vriendinnen Bianca overtuigd?
Daphne overtuigde Bianca van het idee en Joke van de noodzaak.
OK, dus Daphne overtuigde Joke van de noodzaak.
70 Waar hebben de collega's Wendy op getrakteerd?
Afke trakteerde Wendy op een cappucino en Karin op een ijsje.
OK, dus Afke trakteerde Karin op een ijsje.
71 Hoe hebben de boksers Alfred verdedigd?

Andries verdedigde Alfred met een klap en Remi met een stoot.
OK, dus Andries verdedigde Remi met een stoot.

72 Waarheen hebben de meisjes Elisabeth gebracht?
Sabine bracht Elisabeth naar het theater en Klaartje naar het gala.
OK, dus Sabine bracht Klaartje naar het gala.

73 Waarheen hebben de dispuutgenoten Linda vergezeld?
Marlies vergezelde Linda naar de coffeeshop en Koosje naar de discotheek.
OK, dus Marlies vergezelde Koosje naar de discotheek.

74 Wanneer hebben de vriendinnen Patricia verpleegd?
Berber verpleegde Patricia na de operatie en Lucie na de chemo.
OK, dus Berber verpleegde Lucie na de chemo.

75 Wanneer hebben de meisjes Jelena verwacht?
Melissa verwachtte Jelena na haar werk en Lola na het college.
OK, dus Melissa verwachtte Lola na het college.

76 Waarom hebben de collega's Catharina gewaardeerd?
Britt waardeerde Catharina voor de hulp en Mabel voor de aandacht.
OK, dus Britt waardeerde Mabel voor de aandacht.

77 Waarop hebben de groepsleden Cornelia beoordeeld?
Jenna beoordeelde Cornelia op het verhaal en Geesje op het taalgebruik.
OK, dus Jenna beoordeelde Geesje op het taalgebruik.

78 Hoe hebben de vriendinnen Adriana geïnformeerd?
Marije informeerde Adriana via haar mobieltje en Klaasje via de mail.
OK, dus Marije informeerde Klaasje via de mail.

79 Waarover hebben de journalisten Monique geinterviewd?
Barbara interviewde Monique over de pophit en Nely over de sportprestatie.
OK, dus Barbara interviewde Nely over de sportprestatie.

80 Waar hebben de meisjes Ilona gefotografeerd?
Feikje fotografeerde Ilona bij de toren en Veerle op het plein.
OK, dus Feikje fotografeerde Veerle op het plein.

B: Thematic Fit: Nongapping question, Nongapping statement

1 Wanneer heeft Lars de jongens gezien?
Lars zag Ivar op een zondag en Thomas op een maandag.
OK, dus Lars zag Thomas op een maandag.

2 Waarvoor heeft Tim de jongens geroepen?
Tim riep Sido voor de koffie en Lucas voor de thee.
OK, dus Tim riep Lucas voor de thee.

3 Waar heeft Rutger de zakenmannen getroffen?
Rutger trof Gosse tijdens het congres en Ruben tijdens de workshops.
OK, dus Rutger trof Ruben tijdens de workshops.

4 Waarmee heeft Saskia de huisvrouwen geholpen?
Saskia hielp Kathy met het koken en Demi met de afwas.
OK, dus Saskia hielp Demi met de afwas.

5 Wanneer heeft Marc de collega's gebeld?
Marc belde Sjors in de avond en Jamie in de ochtend.
OK, dus Marc belde Jamie in de ochtend.

6 Waarvan heeft Lorenzo de jongemannen gered?
Lorenzo redde Emiel van een val en David van een ongeluk.
OK, dus Lorenzo redde David van een ongeluk.

7 Waar heeft Rik de vechtersbazen geslagen?
Rik sloeg Simon op zijn neus en Gary op zijn kaak.
OK, dus Rik sloeg Gary op zijn kaak.

8 Waar heeft Jorrit de kinderen getikt?
Jorrit tikte Willem bij de zandbak en Hugo bij de boom.
OK, dus Jorrit tikte Hugo bij de boom.
9 Waarnaar heeft Roy de mannen gevraagd?
Roy vroeg Bob naar de weg en Adam naar het tijdstip.
OK, dus Roy vroeg Adam naar het tijdstip.
10 Waar heeft Maurits de kinderen gezocht?
Maurits zocht Rintje in de kelder en Aaron op de zolder.
OK, dus Maurits zocht Aaron op de zolder.
11 Waar heeft Jesper de broers gebracht?
Jesper bracht Ids naar de tennisbaan en Daniel naar de feesttent.
OK, dus Jesper bracht Daniel naar de feesttent.
12 Wanneer heeft Martijn de studenten gefilmd?
Martijn filmde Ted tijdens het interview en Stefan tijdens het avondeten.
OK, dus Martijn filmde Stefan tijdens het avondeten.
13 Waarvoor heeft Rens de toehoorders geloofd?
Rens loofde Bastiaan voor de zangkunsten en Erik voor het kunstwerk.
OK, dus Rens loofde Erik voor het kunstwerk.
14 Waar heeft Niels de jongens genoemd?
Niels noemde Cas bij de rechter en Robin bij de commissaris.
OK, dus Niels noemde Robin bij de commissaris.
15 Waar heeft Michael de jongens gepest?
Michael pestte Job in de klas en Luca op het schoolplein.
OK, dus Michael pestte Luca op het schoolplein.
16 Waarbij heeft Wiebe de sporters geraakt?
Wiebe raakte Jort bij het tennissen en Juul bij het schaatsen.
OK, dus Wiebe raakte Juul bij het schaatsen.
17 Waarheen is Jorn de vrienden gevolgd?
Jorn volgde Adriaan naar het feest en Karel naar de bioscoop.
OK, dus Jorn volgde Karel naar de bioscoop.
18 Hoe heeft Jurjen de fans gewenkt?
Jurjen wenkte Bas met een hoofdknik en Joris met een handgebaar.
OK, dus Jurjen wenkte Joris met een handgebaar.
19 Waarin heeft Max de gezinsleden begrepen?
Max begreep Ronnie in zijn standpunt en Rowan in zijn emotie.
OK, dus Max begreep Rowan in zijn emotie.
20 Wanneer heeft Steffen de broers bezocht?
Steffen bezocht Marco in het voorjaar en Guus in de winter.
OK, dus Steffen bezocht Guus in de winter.
21 Waarin heeft Sigrid de collega's geschoold?
Sigrid schoolde Janny in het lezen en Roos in het rekenen.
OK, dus Sigrid schoolde Roos in het rekenen.
22 Waar heeft Nynke de vriendinnen mee verrast?
Nynke verraste Jolanda met een etentje en Sara met een borrel.
OK, dus Nynke verraste Sara met een borrel.
23 Waarmee heeft Martine de gasten verwend?
Martine verwende Helen met een bad en Floor met een tijdschrift.
OK, dus Martine verwende Floor met een tijdschrift.
24 Wat heeft Jannie de vrouwen verzocht?
Jannie verzocht Annemiek om een uitleg en Jorien om een voorstel.
OK, dus Jannie verzocht Jorien om een voorstel.
25 Waarmee heeft Femke de vrouwen geamuseerd?
Femke amuseerde Jeannette met een mop en Eva met een lied.
OK, dus Femke amuseerde Eva met een lied.
26 Waarmee heeft Cristoph de criminelen bedreigd?

Christoph bedreigde Jos met een mes en Daan met een pistool.
OK, dus Christoph bedreigde Daan met een pistool.

27 Hoe heeft Maaike de teamgenoten begroet?
Maaike begroette Annabel met een zoen en Suze met een knuffel.
OK, dus Maaike begroette Suze met een knuffel.

28 Waarmee heeft Hidde de rivalen beledigd?
Hidde beledigde Jasper met een e-mail en Fabio met een opmerking.
OK, dus Hidde beledigde Fabio met een opmerking.

29 Waarvoor heeft Ingeborg de vrouwen benaderd?
Ingeborg benaderde Diana voor een gesprek en Noa voor een meeting.
OK, dus Ingeborg benaderde Noa voor een meeting.

30 Waarvoor heeft Marrit de meisjes bestrafd?
Marrit bestrafde Krista voor het stelen en Vrony voor het liegen.
OK, dus Marrit bestrafde Vrony voor het liegen.

31 Waaruit heeft Stijn de slachtoffers bevrijd?
Stijn bevrijdde Casper uit een schuurtje en Jacob uit een loods.
OK, dus Stijn bevrijdde Jacob uit een loods.

32 Wanneer heeft Simone de vrouwen geknuffeld?
Simone knuffelde Marja na de wedstrijd en Clara na de show.
OK, dus Simone knuffelde Clara na de show.

33 Waar heeft Wesley de voetballers ontmoet?
Wesley ontmoette Wim in een bar en Boris op een receptie.
OK, dus Wesley ontmoette Boris op een receptie.

34 Waar heeft Sierd de verdachten ontvoerd?
Sierd ontvoerde Andreas uit zijn auto en Floris uit zijn woonkamer.
OK, dus Sierd ontvoerde Floris uit zijn woonkamer.

35 Waarmee heeft Bente de toneelspeelsters verbaasd?
Bente verbaasde Wilma met haar intelligentie en Romy met haar passie.
OK, dus Bente verbaasde Romy met haar passie.

36 Waarmee heeft Inge de vrouwen vermoeid?
Inge vermoeide Nicky met de verhalen en Amy met de foto´s.
OK, dus Inge vermoeide Amy met de foto´s.

37 Waarmee heeft Kim de toneelspeelsters verraden?
Kim verraadde Brecht met een brief en Vera met een leugen.
OK, dus Kim verraadde Vera met een leugen.

38 Waarmee heeft Gea de meisjes verwarmd?
Gea verwarmde Agnes met een deken en Guusje met een kruik.
OK, dus Gea verwarmde Guusje met een kruik.

39 Waar heeft Welmoed de vrouwen verzorgd?
Welmoed verzorgde Nancy in het revalidatiecentrum en Dewi in het ziekenhuis.
OK, dus Welmoed verzorgde Dewi in het ziekenhuis.

40 Waarover heeft Laura de collega's geadviseerd?
Laura adviseerde Myrte over de beslissing en Aagje over de aanpak.
OK, dus Laura adviseerde Aagje over de aanpak.

41 Waar heeft Esther de vriendinnen gegroet?
Esther groette Sylvia in de supermarkt en Lara in de stomerij.
OK, dus Lara groette Sylvia in de stomerij.

42 Wanneer heeft Ingrid de nichtjes omarmd?
Ingrid omarmde Sandra na de bruiloft en Merel na de feestelijkheid.
OK, dus Merel omarmde Sandra na de feestelijkheid.

43 Waar heeft Eldert de mannen ontvangen?
Eldert ontving Sander in het café en Maarten in het hotel.
OK, dus Maarten ontving Sander in het hotel.

44 Waarmee heeft Rickey de tienerd geplaagd?
Rickey plaagde Frank met zijn accent en Joost met zijn uiterlijk.

OK, dus Joost plaagde Frank met zijn uiterlijk.
45 Waarmee heeft Paul de vakkenvullers geschokt?
Paul schokte Pieter met het nieuws en Joram met het ontslag.
OK, dus Joram schokte Pieter met het ontslag.
46 Waarmee heeft Herman de kameraden gesteund?
Herman steunde Jeffrey met het verdriet en Beau met de teleurstelling.
OK, dus Beau steunde Jeffrey met de teleurstelling.
47 Waarbij heeft Mitchel de broers gestoord?
Mitchel stoorde John bij het bellen en Jules bij het koken.
OK, dus Jules stoorde John bij het koken.
48 Waarvoor heeft Nick de docenten gestrikt?
Nick strikte Hendrik voor een modeshow en Leon voor een musical.
OK, dus Leon strikte Hendrik voor een musical.
49 Waar heeft Hanna de meisjes heen gestuurd?
Hanna stuurde Ellen naar de bakker en Noortje naar de slager.
OK, dus Noortje stuurde Ellen naar de slager.
50 Waarmee heeft Nico de artiesten getekend?
Nico tekende Remco met een potlood en Abel met een stift.
OK, dus Abel tekende Remco met een stift.
51 Waar heeft Tjerk de eerstejaars getoetst?
Tjerk toetste Tom in de zaal en Alex in het kamertje.
OK, dus Alex toetste Tom in het kamertje.
52 Waarvoor heeft Hedwig de kandidatinnen verkozen?
Hedwig verkoos Elma om de schoonheid en Lora om de kennis.
OK, dus Lora verkoos Elma om de kennis.
53 Wanneer heeft Kevin de rugby'ers gevloerd?
Kevin vloerde Koen in de blessuretijd en Kobus in de verlenging.
OK, dus Kobus vloerde Koen in de verlenging.
54 Waarvoor heeft Reitse de vrienden bedankt?
Reitse bedankte Vincent voor het geld en Ludo voor het onderdak.
OK, dus Ludo bedankte Vincent voor het onderdak.
55 Waarmee heeft Amber de vinders beloond?
Amber beloonde Ilse met een cadeautje en Erika met een bloemetje.
OK, dus Erika beloonde Ilse met een bloemetje.
56 Waarmee heeft Jordy de collega's besmet?
Jordy besmette Geertjan met de griep en Berend met een verkoudheid.
OK, dus Berend besmette Geertjan met een verkoudheid.
57 Waarmee heeft Yanniek de knapen bespot?
Yanniek bespotte Harrie met het fotootje en Dave met het gedicht.
OK, dus Dave bespotte Harrie met het gedicht.
58 Wanneer heeft Jenne de vrienden betaald?
Jenne betaalde Dicky op een donderdag en Aart op een vrijdag.
OK, dus Aart betaalde Dicky op een vrijdag.
59 Waarmee heeft Wietse de klasgenoten gekieteld?
Wietse kietelde Reiner met een grasspriet en Felix met een veertje.
OK, dus Felix kietelde Reiner met een veertje.
60 Wanneer heeft Arjen de mannen genegeerd?
Arjen negeerde Gerd tijdens de vergadering en Abe tijdens het eten.
OK, dus Abe negeerde Gerd tijdens het eten.
61 Waarbij heeft Elle de vriendinnen begeleid?
Elle begeleidde Iris bij de voorstelling en Eef bij de repetitie.
OK, dus Eef begeleidde Iris bij de repetitie.
62 Waartegen heeft Sjouke de kerels beschermd?
Sjouke beschermde Carlos tegen de leeuwen en Johan tegen de beren.
OK, dus Johan beschermde Carlos tegen de beren.

63 Tot wat heeft Ben de leden bevorderd?
Ben bevorderde Sidney tot een directielid en Owen tot een voorman.
OK, dus Owen bevorderde Sidney tot een voorman.
64 Waarom heeft Emma de dames bewonderd?
Emma bewonderde Tiny om het enthousiasme en Monica om het talent.
OK, dus Monica bewonderde Tiny om het talent.
65 Waaraan heeft Kimberly de studiegenoten herinnerd?
Kimberly herinnerde Mieke aan een feestje en Gabi aan een tentamen.
OK, dus Gabi herinnerde Mieke aan een tentamen.
66 Waarmee heeft Marise de vriendinnen geimponeerd?
Marise imponeerde Lidy met de armband en Geke met de oorbellen.
OK, dus Geke imponeerde Lidy met de oorbellen.
67 Waarmee heeft Marloes de trainers gemotiveerd?
Marloes motiveerde Mien met een speech en Geertje met een snoepreep.
OK, dus Geertje motiveerde Mlien met een snoepreep.
68 Waar heeft Thijs de criminelen ondervraagd?
Thijs ondervroeg Hans op het bureau en Julian in de rechtszaal.
OK, dus Julian ondervroeg Hans in de rechtszaal.
69 Waarvan heeft Daphne de vriendinnen overtuigd?
Daphne overtuigde Bianca van het idee en Joke van de noodzaak.
OK, dus Joke overtuigde Bianca van de noodzaak.
70 Waar heeft Afke de collega's op getrakteerd?
Afke trakteerde Wendy op een cappucino en Karin op een ijsje.
OK, dus Karin trakteerde Wendy op een ijsje.
71 Hoe heeft Andries de vrienden verdedigd?
Andries verdedigde Alfred met een klap en Remi met een stoot.
OK, dus Remi verdedigde Alfred met een stoot.
72 Waarheen heeft Sabine de meisjes gebracht?
Sabine bracht Elisabeth naar het theater en Klaartje naar het gala.
OK, dus Klaartje bracht Elisabeth naar het gala.
73 Waarheen heeft Marlies de dispuutgenoten vergezeld?
Marlies vergezelde Linda naar de coffeeshop en Koosje naar de discotheek.
OK, dus Koosje vergezelde Linda naar de discotheek.
74 Wanneer heeft Berber de vriendinnen verpleegd?
Berber verpleegde Patricia na de operatie en Lucie na de chemo.
OK, dus Lucie verpleegde Patricia na de chemo.
75 Waar heeft Melissa de meisjes verwacht?
Melissa verwachtte Jelena na haar werk en Lola na het college.
OK, dus Lola verwachtte Jelena na het college.
76 Waarom heeft Britt de collega's gewaardeerd?
Britt waardeerde Catharina voor de hulp en Mabel voor de aandacht.
OK, dus Mabel waardeerde Catharina voor de aandacht.
77 Waarop heeft Jenna de groepsleden beoordeeld?
Jenna beoordeelde Cornelia op het verhaal en Geesje op het taalgebruik.
OK, dus Geesje beoordeelde Cornelia op het taalgebruik.
78 Hoe heeft Marije de vriendinnen geïnformeerd?
Marije informeerde Adriana via haar mobieltje en Klaasje via de mail.
OK, dus Klaasje informeerde Adriana via de mail.
79 Waarover heeft Barbara de journalisten geinterviewd?
Barbara interviewde Monique over de pophit en Nely over de sportprestatie.
OK, dus Nely interviewde Monique over de sportprestatie.
80 Waar heeft Feikje de meisjes gefotografeerd?
Feikje fotografeerde Ilona bij de toren en Veerle op het plein.
OK, dus Veerle fotografeerde Ilona op het plein.

C: Poor Thematic fFit: Gapping question, Correct statement

1 Voor wie hebben de bakkers de cake gebakken?
Auke bakte de cake voor de medewerkers en Aad voor de klanten.
OK, dus Auke bakte de cake voor de medewerkers.

2 Hoe hebben de kwekers de plant bemest?
Bart bemestte de plant met de koemest en Manuel met de kunstmest.
OK, dus Bart bemestte de plant met de koemest.

3 Waar hebben de secretaresses de postzegels bewaard?
Christel bewaarde de postzegels in een envelop en Luna in een kist.
OK, dus Christel bewaarde de postzegels in een envelop.

4 Wanneer hebben de studenten het artikel bewerkt?
Jan bewerkte het artikel in de middag en Freek in de avonduren.
OK, dus Jan bewerkte het artikel in de middag.

5 Wanneer hebben de bedienden een vaas gebroken?
Debby brak de vaas tijdens de schoonmaak en Mona tijdens de verhuizing.
OK, dus Debby brak de vaas tijdens de schoonmaak.

6 Waar hebben de boerenzonen een varken gecastreerd?
Anton castreerde het varken in de stal en Gerard in de wei.
OK, dus Anton castreerde het varken in de stal.

7 Hoe hebben de jongens het vuur gedoofd?
Melwin doofde het vuur met een doek en Jaap met een deksel.
OK, dus Melwin doofde het vuur met een doek.

8 Hoe hebben de barkeepers de fles gedopt?
Jelte dopte de bierfles met zijn tanden en Joop met een flesopener.
OK, dus Jelte dopte de bierfles met zijn tanden.

9 Waar hebben de vrienden wijn gedronken?
Gerrit dronk de wijn in de lounge en Jozef op de hotelkamer.
OK, dus Gerrit dronk de wijn in de lounge.

10 Waar hebben de vissers de vis gefileerd?
Sven fileerde de vis in de kombuis en Paco op het dek.
OK, dus Sven fileerde de vis in de kombuis.

11 Waarvoor hebben de koks de salade gegarneerd?
Elmar garneerde de salade voor het lunchgerecht en Pavel voor het diner.
OK, dus Elmar garneerde de salade voor het lunchgerecht.

12 Waarin hebben de dienstmeisjes het water gegoten?
Maria goot het water in de put en Grace in de gootsteen.
OK, dus Maria goot het water in de put.

13 Waar hebben de studenten het ijs gehalveerd?
Hessel halveerde het ijs in de kom en Kees in het schaaltje.
OK, dus Hessel halveerde het ijs in de kom.

14 Waar hebben de matrozen het zeil hersteld?
Niek herstelde het zeil op de boeg en Ate op het achterdek.
OK, dus Niek herstelde het zeil op de boeg.

15 Waaruit hebben de dieven een geldbedrag gejat?
Mike jatte het geldbedrag uit de kassa en Peter uit het schoolgebouw.
OK, dus Mike jatte het geldbedrag uit de kassa.

16 Waarmee hebben de moeders de slagroom geklopt?
Anna klopte de slagroom met een vork en Kate met een garde.
OK, dus Anna klopte de slagroom met een vork.

17 Waarmee hebben de huisvrouwen het deeg gekneed?
Jeanine kneedde het deeg met haar handen en Ada met haar mixer.
OK, dus Jeanine kneedde het deeg met haar handen.

18 Waarmee hebben de medewerkers de kaartjes geknipt?
Maico knipte de kaartjes met een tangetje en Jeen met een schaar.

OK, dus Maico knipte de kaartjes met een tangetje.
19 Waar hebben de modeontwerpsters de trui gekocht?
Kelly kocht de trui op de markt en Cora in de klerenwinkel.
OK, dus Kelly kocht de trui op de markt.
20 Waar hebben de meisjes de klaprozen gekweekt?
Bauke kweekte de klaprozen in de kas en Neeltje in een pot.
OK, dus Bauke kweekte de klaprozen in de kas.
21 Waar hebben de meisjes de fiets gerepareerd?
Anouk repareerde de fiets in de garage en Maartje op de stoep.
OK, dus Anouk repareerde de fiets in de garage.
22 Waarvoor hebben de vriendinnen aardappels gerooid?
Rixt rooide de aardappels voor de verkoop en Aafke voor de voorraad.
OK, dus Rixt rooide de aardappels voor de verkoop.
23 Waar hebben de broers de sigaar gerookt?
Dennis rookte de sigaar op het balkon en Roland op de veranda.
OK, dus Dennis rookte de sigaar op het balkon.
24 Wanneer hebben de lezeressen een boek geruild?
Sanne ruilde het boek tijdens de actieweek en Alie in de vakantie.
OK, dus Sanne ruilde het boek tijdens de actieweek.
25 Waarmee hebben de grootouders de appel geschild?
Lotte schilde de appel met een dunschiller en Bea met een zakmes
OK, dus Lotte schilde de appel met een dunschiller.
26 Waarin hebben de assistentes de thee geschonken?
Esmeé schonk de thee in een mok en Gloria in een theeglas.
OK, dus Esmeé schonk de thee in een mok.
27 Waarvoor hebben de componisten de muziek geschreven?
Patrick schreef de muziek voor de opera en Leendert voor het concert.
OK, dus Patrick schreef de muziek voor de opera.
28 Waar hebben de mannen de plank in geschroefd?
Arnoud schroefde de plank in de kast en Ruud in de muur.
OK, dus Arnoud schroefde de plank in de kast.
29 Waarmee hebben de meisjes het mes geslepen?
Mandy sleep het mes met de machine en Doortje met de steen.
OK, dus Mandy sleep het mes met de machine.
30 Waarvoor hebben de zieken medicijnen geslikt?
Hilde slikte de medicijnen voor de buikpijn en Dana voor de hoofdpijn.
OK, dus Hilde slikte de medicijnen voor de buikpijn.
31 Waarvoor hebben de ambtenaren de folder gestencild?
Wessel stencilde de folder voor de staking en Mario voor de campagne.
OK, dus Wessel stencilde de folder voor de staking.
32 Waar hebben de bouwvakkers het beton gestort?
Piet stortte het beton voor het huis en Theo voor de fietsschuur.
OK, dus Piet stortte het beton voor het huis.
33 Waar hebben de koks het zout op gestrooid?
Fleur strooide het zout op de vis en Marion op de aardappelen.
OK, dus Fleur strooide het zout op de vis.
34 Voor wie hebben de mannen een schuurtje getimmerd?
Wilco timmerde een schuurtje voor de kinderen en Edo voor de buren.
OK, dus Wilco timmerde een schuurtje voor de kinderen.
35 Waar hebben de vrouwen het hout verbrand?
Sophie verbrandde het hout in de tuin en Judith op de oprit.
OK, dus Sophie verbrandde het hout in de tuin.
36 Waar hebben de verkopsters dvd's verkocht?
Mies verkocht de dvd's op de jaarmarkt en Fredau in de winkel.
OK, dus Mies verkocht de dvd's op de jaarmarkt.

37 Waar hebben de vrouwen het bewijs vernietigd?
Martha vernietigde het bewijs in de versnipperaar en Tara in het vuur.
OK, dus Martha vernietigde het bewijs in de versnipperaar.
38 Waarin hebben de kampeerders de macaroni verpakt?
Rachel verpakte de macaroni in de folie en Trees in het bakje.
OK, dus Rachel verpakte de macaroni in de folie.
39 Hoe hebben de ontwerpsters de baljurk versteld?
Natasja verstelde de baljurk met de hand en Julie met de naaimachine.
OK, dus Natasja verstelde de baljurk met de hand.
40 In welke taal hebben de tolken de novelle vertaald?
Jessica vertaalde de novelle in het Duits en Stefanie in het Frans.
OK, dus Jessica vertaalde de novelle in het Duits.
41 Wanneer hebben de buschauffeurs de krant gelezen?
Jouke las de krant tijdens het ontbijt en Sjaak tijdens de koffie.
OK, dus Jouke las de krant tijdens de koffie.
42 Waar hebben de broers het geld geleend?
Haye leende het geld van zijn vrienden en Steven van de bank.
OK, dus Haye leende het geld van de bank.
43 Waarmee hebben de tuinmannen het gras gemaaid?
Wietse maaide het gras met een grasmaaier en Take met een tractor.
OK, dus Wietse maaide het gras met een tractor.
44 Hoe hebben de oma's de appels gemalen?
Marieke maalde de appels met een zeef en Meta met een keukenmachine.
OK, dus Marieke maalde de appels met een keukenmachine.
45 Waarmee hebben de barmannen het vruchtensap gemengd?
Björn mengde het vruchtensap met de Wodka en Toby met de Bacardi.
OK, dus Björn mengde het vruchtensap met de Bacardi.
46 Waarin hebben de koks het taartbeslag gemixed?
Pierre mixte het taartbeslag in een ovenschaal en Geert in een beslagkom.
OK, dus Pierre mixte het taartbeslag in een beslagkom.
47 Wanneer hebben de arbeiders een broodje genuttigd?
Benjamin nuttigde het broodje tijdens de lunch en Klaas tijdens de maaltijd.
OK, dus Benjamin nuttigde het broodje tijdens de maaltijd.
48 Hoe hebben de mangagers het contract ondertekend?
Sjoerd ondertekende het contract met een vulpen en Rody met een balpen.
OK, dus Sjoerd ondertekende het contract met een balpen.
49 Waar hebben de journalisten de bombrief ontcijferd?
Carl ontcijferde de bombrief in de postkamer en Bruce in zijn kantoor.
OK, dus Carl ontcijferde de bombrief in zijn kantoor.
50 Waar hebben de kelners een fles geopend?
Rob opende de fles op het terras en Eelco in de keuken.
OK, dus Rob opende de fles in de keuken.
51 Hoe hebben de groenteboeren de mandarijn gepeld?
Gerrie pelde de mandarijn met zijn vingers en Eduard met een mesje.
OK, dus Gerrie pelde de mandarijn met een mesje.
52 Waar hebben de secretaresses de stencils geperforeerd?
Gonnie perforeerde de stencils bij de printer en Petra bij het kopieerapparaat.
OK, dus Gonnie perforeerde de stencils bij het kopieerapparaat.
53 Waarop hebben de fans de posters geplakt?
Hidde plakte de posters op de deur en Arie op de ramen.
OK, dus Hidde plakte de posters op de ramen.
54 Waar hebben de stukadoors de wand mee geplamuurd?
Jeroen plamuurde de wand met een spaan en Aaldert met een plamuurmes.
OK, dus Jeroen plamuurde de wand met een plamuurmes.
55 Wanneer hebben de boeren het land geploegd?

Sam ploegde het land in de ochtend en Fabian in de namiddag.
OK, dus Sam ploegde het land in de namiddag.
56 Wanneer hebben de telers de appels geplukt?
Richard plukte de appels in de herfst en Govert in de zomer.
OK, dus Richard plukte de appels in de zomer.
57 Waar hebben de kelners het bestek gepoetst?
Michel poetste het bestek in het stookhok en Dorus in de eetzaal.
OK, dus Michel poetste het bestek in de eetzaal.
58 Waar hebben de schoonmaaksters de spiegel gepolijst?
Anke polijstte de spiegel in de gang en Coby in de slaapkamer.
OK, dus Anke polijstte de spiegel in de slaapkamer.
59 Waarin hebben de tuiniers de plant gepoot?
Albert pootte de plant in het bloemperk en Luuk in de bloempot.
OK, dus Albert pootte de plant in de bloempot.
60 Waar hebben de detectives de brief gepost?
Ivan postte de brief op het postkantoor en Dorian op het station.
OK, dus Ivan postte de brief op het station.
61 Waarvoor hebben de schrijfsters een tekst verzonnen?
Minke verzon de tekst voor het toneelstuk en Truus voor de proloog.
OK, dus Minke verzon de tekst voor de proloog.
62 Waar hebben de schoonmaaksters de emmer gevuld?
Tessa vulde de emmer in de bijkeuken en Lora in de schuur.
OK, dus Tessa vulde de emmer in de schuur.
63 Voor welk doel hebben de vrouwen het hout gezaagd?
Wilhelmina zaagde het hout voor de kachels en Trudy voor de haarden.
OK, dus Wilhelmina zaagde het hout voor de haarden.
64 Wanneer hebben de buurvrouwen het gras gezaaid?
Andrea zaaide het gras in de lente en Toos in het najaar.
OK, dus Andrea zaaide het gras in het najaar.
65 Wanneer hebben de knutselaars de machine gedemonteerd?
Bernd demonteerde de machine in het najaar en Rudy in het voorjaar.
OK, dus Bernd demonteerde de machine in het voorjaar.
66 Hoe hebben de vakantiegangers hun reis geannuleerd?
Margot annuleerde de reis via het internet en Lena via de telefoon.
OK, dus Margot annuleerde de reis via de telefoon.
67 Wanneer hebben de levensgenieters de wijnfles ontkurkt?
Irene ontkurkte de wijnfles bij het voorgerecht en Jana bij het dessert.
OK, dus Irene ontkurkte de wijnfles bij het dessert.
68 Waarmee hebben de topkoks de tofu gemarineerd?
Andrew marineerde de tofu met de sojasaus en Raphael met de sambal.
OK, dus Andrew marineerde de tofu met de sambal.
69 Weer hebben de nieuwe huurders de dozen geleegd?
Alida leegde de dozen op het vloerkleed en Juna op de overloop.
OK, dus Alida leegde de dozen op de overloop.
70 Hoe hebben de klussers de serre verbouwd?
Jens verbouwde de serre met een beunhaas en Tony met een professional.
OK, dus Jens verbouwde de serre met een professional.
71 Voor wie hebben de oma's de kleertjes gebreid?
Deborah breide de kleertjes voor haar kleindochter en Caren voor haar kleinzoon.
OK, dus Deborah breide de kleertjes voor haar kleinzoon.
72 Hoe hebben de tuiniers de rozen gesnoeid?
Amanda snoeide de rozen volgens het boekje en Edith vanuit haar intuitie.
OK, dus Amanda snoeide de rozen vanuit haar intuitie.
73 Voor wie hebben de juffen de bananen geprakt?
Marianne prakte een banaan voor de baby en Jori voor de peuter.

OK, dus Marianne prakte een banaan voor de peuter.
74 Hoe hebben de jongens de boompjes gekapt?
Matt kapte de boompjes in het openbaar en Olaf in het geheim.
OK, dus Matt kapte de boompjes in het geheim.
75 Wanneer hebben de studentes het verslag getypt?
Antje typte het verslag rond het middaguur en Mara in de ochtenduren.
OK, dus Antje typte het verslag in de ochtenduren.
76 Hoe hebben de atletes hun enkel verstuikt?
Marylène verstuikte zijn enkel bij het joggen en Jody bij het turnen.
OK, dus Marylène verstuikte zijn enkel bij het turnen.
77 Waarom hebben de vrouwen het bankstel gestoffeerd?
Vivian stoffeerde het bankstel voor de euro's en Rosa voor de lol.
OK, dus Vivian stoffeerde het bankstel voor de lol.
78 Waarmee hebben de ambtenaressen de pakjes gefrankeerd?
Freya frankeerde de pakjes met een stempel en Dora met een postzegel.
OK, dus Freya frankeerde de pakjes met een postzegel.
79 Waarin hebben de chefs de kroketten gefrituurd?
Philip frituurde de kroketten in de olie en Jonas in het vet.
OK, dus Philip frituurde de kroketten in het vet.
80 Waarin hebben de kleutertjes hun neus gesnoten?
Silke snoot de neus in haar zakdoek en Claartje in een servet.
OK, dus Silke snoot de neus in een servet.

D: Poor Thematic Fit: Nongapping question, Incorrect statement

1 Wat heeft Auke gebakken?
Auke bakte de cake voor de medewerkers en Aad voor de klanten.
OK, dus Auke bakte de cake voor de klanten.
2 Wat heeft Bart bemest?
Bart bemestte de plant met de koemest en Manuel met de kunstmest.
OK, dus Bart bemestte de plant met de kunstmest.
3 Wat heeft Christel bewaard?
Christel bewaarde de postzegels in een envelop en Luna in een kist.
OK, dus Christel bewaarde de postzegels in een kist.
4 Wat heeft Jan bewerkt?
Jan bewerkte het artikel in de middag en Freek in de avonduren.
OK, dus Jan bewerkte het artikel in de avonduren.
5 Wat heeft Debby gebroken?
Debby brak de vaas tijdens de schoonmaak en Mona tijdens de verhuizing.
OK, dus Debby brak de vaas tijdens de verhuizing.
6 Wat voor soort dier heeft Anton gecastreerd?
Anton castreerde het varken in de stal en Gerard in de wei.
OK, dus Anton castreerde het varken in de wei.
7 Wat heeft Melwin gedoofd?
Melwin doofde het vuur met een doek en Jaap met een deksel.
OK, dus Melwin doofde het vuur met een deksel.
8 Wat heeft Jelte gedopt?
Jelte dopte de bierfles met zijn tanden en Joop met een flesopener.
OK, dus Jelte dopte de bierfles met een flesopener.
9 Wat heeft Gerrit gedronken?
Gerrit dronk de wijn in de lounge en Jozef op de hotelkamer
OK, dus Gerrit dronk de wijn op de hotelkamer.
10 Wat heeft Sven gefileerd?

Sven fileerde de vis in de kombuis en Paco op het dek
OK, dus Sven fileerde de vis op het dek.
11 Wat heeft Elmar gegarneerd?
Elmar garneerde de salade voor het lunchgerecht en Pavel voor het diner.
OK, dus Elmar garneerde de salade voor het diner.
12 Wat heeft Maria gegoten?
Maria goot het water in de put en Grace in de gootsteen.
OK, dus Maria goot het water in de gootsteen.
13 Wat heeft Hessel gehalveerd?
Hessel halveerde het ijs in de kom en Kees in het schaaltje.
OK, dus Hessel halveerde het ijs in het schaaltje.
14 Wat heeft Niek hersteld?
Niek herstelde het zeil op de boeg en Ate op het achterdek.
OK, dus Niek herstelde het zeil op het achterdek.
15 Wat heeft Mike gejat?
Mike jatte het geldbedrag uit de kassa en Peter uit het schoolgebouw.
OK, dus Mike jatte het geldbedrag uit het schoolgebouw.
16 Wat heeft Anna geklopt?
Anna klopte de slagroom met een vork en Kate met een garde.
OK, dus Anna klopte de slagroom met een garde.
17 Wat heeft Jeanine gekneed?
Jeanine kneedde het deeg met haar handen en Ada met haar mixer.
OK, dus Jeanine kneedde het deeg met haar mixer.
18 Wat heeft Maico geknipt?
Maico knipte de kaartjes met een tangetje en Jeen met een schaar.
OK, dus Maico knipte de kaartjes met een schaar.
19 Wat heeft Kelly gekocht?
Kelly kocht de trui op de markt en Cora in de klerenwinkel.
OK, dus Kelly kocht de trui in de klerenwinkel.
20 Wat heeft Bauke gekweekt?
Bauke kweekte de klaprozen in de kas en Neeltje in een pot.
OK, dus Bauke kweekte de klaprozen in een pot.
21 Wat heeft Anouk gerepareerd?
Anouk repareerde de fiets in de garage en Maartje op de stoep.
OK, dus Anouk repareerde de fiets op de stoep.
22 Wat heeft Rixt gerooid?
Rixt rooide de aardappels voor de verkoop en Aafke voor de voorraad.
OK, dus Rixt rooide de aardappels voor de voorraad.
23 Wat heeft Dennis gerookt?
Dennis rookte de sigaar op het balkon en Roland op de veranda.
OK, dus Dennis rookte de sigaar op de veranda.
24 Wat heeft Sanne geruild?
Sanne ruilde het boek tijdens de actieweek en Alie in de vakantie.
OK, dus Sanne ruilde het boek in de vakantie.
25 Wat heeft Lotte geschild?
Lotte schilde de appel met een dunschiller en Bea met een zakmes
OK, dus Lotte schilde de appel met een zakmes.
26 Wat heeft Esmeé ingeschonken?
Esmeé schonk de thee in een mok en Gloria in een theeglas.
OK, dus Esmeé schonk de thee in een theeglas.
27 Wat heeft Patrick geschreven?
Patrick schreef de muziek voor de opera en Leendert voor het concert.
OK, dus Patrick schreef de muziek voor het concert.
28 Wat heeft Arnoud in elkaar geschroefd?
Arnoud schroefde de plank in de kast en Ruud in de muur.

OK, dus Arnoud schroefde de plank in de muur.
29 Wat heeft Mandy geslepen?
Mandy sleep het mes met de machine en Doortje met de steen.
OK, dus Mandy sleep het mes met de steen.
30 Wat heeft Hilde geslikt?
Hilde slikte de medicijnen voor de buikpijn en Dana voor de hoofdpijn.
OK, dus Hilde slikte de medicijnen voor de hoofdpijn.
31 Wat heeft Wessel gestencild?
Wessel stencilde de folder voor de staking en Mario voor de campagne.
OK, dus Wessel stencilde de folder voor de campagne.
32 Wat heeft Piet gestort?
Piet stortte het beton voor het huis en Theo voor de fietsschuur.
OK, dus Piet stortte het beton voor de fietsschuur.
33 Wat heeft Fleur gestrooid?
Fleur strooide het zout op de vis en Marion op de aardappelen.
OK, dus Fleur strooide het zout op de aardappelen.
34 Wat heeft Wilco getimmerd?
Wilco timmerde een schuurtje voor de kinderen en Edo voor de buren.
OK, dus Wilco timmerde een schuurtje voor de buren.
35 Wat heeft Sophie verbrand?
Sophie verbrandde het hout in de tuin en Judith op de oprit.
OK, dus Sophie verbrandde het hout op de oprit.
36 Wat heeft Mies verkocht?
Mies verkocht de dvd's op de jaarmarkt en Fredau in de winkel.
OK, dus Mies verkocht de dvd's in de winkel.
37 Wat heeft Martha vernietigd?
Martha vernietigde het bewijs in de versnipperaar en Tara in het vuur.
OK, dus Martha vernietigde het bewijs in de vuur.
38 Wat heeft Rachel verpakt?
Rachel verpakte de macaroni in de folie en Trees in het bakje.
OK, dus Rachel verpakte de macaroni in de bakje.
39 Wat heeft Natasja versteld?
Natasja verstelde de baljurk met de hand en Julie met de naaimachine.
OK, dus Natasja verstelde de baljurk met de naaimachine.
40 Wat heeft Jessica vertaald?
Jessica vertaalde de novelle in het Duits en Stefanie in het Frans.
OK, dus Jessica vertaalde de novelle in het Frans.
41 Wat heeft Jouke gelezen?
Jouke las de krant tijdens het ontbijt en Sjaak tijdens de koffie.
OK, dus Jouke las de krant tijdens de koffie.
42 Wat heeft Haye geleend?
Haye leende het geld van zijn vrienden en Steven van de bank.
OK, dus Haye leende het geld van de bank.
43 Wat heeft Wietse gemaaid?
Wietse maaide het gras met een grasmaaier en Take met een tractor.
OK, dus Wietse maaide het gras met een tractor.
44 Wat heeft Marieke gemalen?
Marieke maalde de appels met een zeef en Meta met een keukenmachine.
OK, dus Marieke maalde de appels met een keukenmachine.
45 Wat heeft Björn gemengd?
Björn mengde het vruchtensap met de Wodka en Toby met de Bacardi.
OK, dus Björn mengde het vruchtensap met de Bacardi.
46 Wat heeft Pierre gemixed?
Pierre mixte het taartbeslag in een ovenschaal en Geert in een beslagkom.
OK, dus Pierre mixte het taartbeslag in een beslagkom.

47 Wat heeft Benjamin genuttigd?
Benjamin nuttigde het broodje tijdens de lunch en Klaas tijdens de maaltijd.
OK, dus Benjamin nuttigde het broodje tijdens de maaltijd.
48 Wat heeft Sjoerd ondertekend?
Sjoerd ondertekende het contract met een vulpen en Rody met een balpen.
OK, dus Sjoerd ondertekende het contract met een balpen.
49 Wat heeft Carl ontcijferd?
Carl ontcijferde de bombrief in de postkamer en Bruce in zijn kantoor.
OK, dus Carl ontcijferde de bombrief in zijn kantoor.
50 Wat heeft Rob geopend?
Rob opende de fles op het terras en Eelco in de keuken.
OK, dus Rob opende de fles in de keuken.
51 Wat heeft Gerrie gepeld?
Gerrie pelde de mandarijn met zijn vingers en Eduard met een mesje.
OK, dus Gerrie pelde de mandarijn met een mesje.
52 Wat heeft Gonnie geperforeerd?
Gonnie perforeerde de stencils bij de printer en Petra bij het kopieerapparaat.
OK, dus Gonnie perforeerde de stencils bij het kopieerapparaat.
53 Wat heeft Hidde geplakt?
Hidde plakte de posters op de deur en Arie op de ramen.
OK, dus Hidde plakte de posters op de ramen.
54 Wat heeft Jeroen geplamuurd?
Jeroen plamuurde de wand met een spaan en Aaldert met een plamuurmes.
OK, dus Jeroen plamuurde de wand met een plamuurmes.
55 Wat heeft Sam geploegd?
Sam ploegde het land in de ochtend en Fabian in de namiddag.
OK, dus Sam ploegde het land in de namiddag.
56 Wat heeft Richard geplukt?
Richard plukte de appels in de herfst en Govert in de zomer.
OK, dus Richard plukte de appels in de zomer.
57 Wat heeft Michel gepoetst?
Michel poetste het bestek in het stookhok en Dorus in de eetzaal.
OK, dus Michel poetste het bestek in de eetzaal.
58 Wat heeft Anke gepolijst?
Anke polijstte de spiegel in de gang en Coby in de slaapkamer.
OK, dus Anke polijstte de spiegel in de slaapkamer.
59 Wat heeft Albert gepoot?
Albert pootte de plant in het bloemperk en Luuk in de bloempot.
OK, dus Albert pootte de plant in het bloempot.
60 Wat heeft Ivan gepost?
Ivan postte de brief op het postkantoor en Dorian op het station.
OK, dus Ivan postte de brief op het station.
61 Wat heeft Minke verzonnen?
Minke verzon de tekst voor het toneelstuk en Truus voor de proloog.
OK, dus Minke verzon de tekst voor de proloog.
62 Wat heeft Tessa gevuld?
Tessa vulde de emmer in de bijkeuken en Lora in de schuur.
OK, dus Tessa vulde de emmer in de schuur.
63 Wat heeft Wilhelmina gezaagd?
Wilhelmina zaagde het hout voor de kachels en Trudy voor de haarden.
OK, dus Wilhelmina zaagde het hout voor de haarden.
64 Wat heeft Andrea gezaaid?
Andrea zaaide het gras in de lente en Toos in het najaar.
OK, dus Andrea zaaide het gras in de najaar.
65 Wat heeft Bernd gedemonteerd?

Bernd demonteerde de machine in het najaar en Rudy in het voorjaar.
OK, dus Bernd demonteerde de machine in het voorjaar.
66 Wat heeft Margot geannuleerd?
Margot annuleerde de reis via het internet en Lena via de telefoon.
OK, dus Margot annuleerde de reis via de telefoon.
67 Wat heeft Irene ontkurkt?
Irene ontkurkte de wijnfles bij het voorgerecht en Jana bij het dessert.
OK, dus Irene ontkurkte de wijnfles bij het dessert.
68 Wat heeft Andrew gemarineerd?
Andrew marineerde de tofu met de sojasaus en Raphael met de sambal.
OK, dus Andrew marineerde de tofu met de sambal.
69 Wat voor dingen heeft Alida geleegd?
Alida leegde de dozen op het vloerkleed en Juna op de overloop.
OK, dus Alida leegde de dozen op de overloop.
70 Wat heeft Jens verbouwd?
Jens verbouwde de serre met een beunhaas en Tony met een professional.
OK, dus Jens verbouwde de serre met een professional.
71 Wat heft Deborah gebreid?
Deborah breide de kleertjes voor haar kleindochter en Caren voor haar kleinzoon.
OK, dus Deborah breide de kleertjes voor haar kleinzoon.
72 Wat heeft Amanda gesnoeid?
Amanda snoeide de rozen volgens het boekje en Edith vanuit haar intuitie.
OK, dus Amanda snoeide de rozen volgens haar intuitie.
73 Wat heeft Marianne geprakt?
Marianne prakte een banaan voor de baby en Jori voor de peuter.
OK, dus Marianne prakte een banaan voor de peuter.
74 Wat heeft Matt gekapt?
Matt kapte de boompjes in het openbaar en Olaf in het geheim.
OK, dus Matt kapte de boompjes in het geheim.
75 Wat heeft Antje getypt?
Antje typte het verslag rond het middaguur en Mara in de ochtenduren.
OK, dus Antje typte het verslag in de ochtenduren.
76 Wat heeft Maryléne verstuikt?
Marylène verstuikte haar enkel bij het joggen en Jody bij het turnen.
OK, dus Marylène verstuikte zijn enkel bij het turnen.
77 Wat heeft Vivian gestoffeerd?
Vivian stoffeerde het bankstel voor de euro's en Rosa voor de lol.
OK, dus Vivian stoffeerde het bankstel voor de lol.
78 Wat heeft Freya gefrankeerd?
Freya frankeerde de pakjes met een stempel en Dora met een postzegel.
OK, dus Freya frankeerde de pakjes met een postzegel.
79 Wat heeft Philip gefrituurd?
Philip frituurde de kroketten in de olie en Jonas in het vet.
OK, dus Philip frituurde de kroketten in het vet.
80 Wat heeft Silke gedaan?
Silke snoot de neus in haar zakdoek en Claartje in een servet.
OK, dus Silke snoot de neus in een servet.

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