The role of contrastive intonation contours in the retrieval of contextual alternatives

Bettina Braun and Lara Tagliapietra

Max Planck Institute for Psycholinguistics, Nijmegen

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Address for correspondence:

Bettina Braun

Max Planck Institute for Psycholinguistics

P.O Box 310

6500AH Nijmegen, The Netherlands

Phone: 0031-243521-372, Fax: 0031-243521-213

Bettina.Braun@mpi.nl

Abstract

Sentences with a contrastive intonation contour are usually produced when the speaker entertains alternatives to the accented words. However, such contrastive sentences are frequently produced without making the alternatives explicit for the listener. In two cross-modal associative priming experiments we tested in Dutch whether such contextual alternatives become available to listeners upon hearing a sentence with a contrastive intonation contour compared to a sentence with a non-contrastive one. The first experiment tested the recognition of contrastive associates (contextual alternatives to the sentence-final primes), the second one the recognition of non-contrastive associates (generic associates which are not alternatives). Results showed that contrastive associates were facilitated when the primes occurred in sentences with a contrastive intonation contour but not in sentences with a non-contrastive intonation. Non-contrastive associates were weakly facilitated independent of intonation. Possibly, contrastive contours trigger an accommodation mechanism by which listeners retrieve the contrast available for the speaker.

Keywords: Intonation, contrast, alternative-set semantics, cross-modal priming, sentence processing, Dutch

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Introduction

'Ben stood up and said: 'I still have some work to do'. He said this in such a way as to imply that I was the one who had nothing to do'[1]. In reading this passage from a novel aloud, the utterance 'I still have some work to do' is probably produced first with a neutral intonation contour (see Figure 1a). However, in light of the last sentence ('He said this in such a way as to imply that I was the one who had nothing to do'), one would probably reread this sentence in a different, contrastive way, accenting the two words *I* and *work* (Figure 1b). Such contrastive utterances are part of our daily life. They have two peculiarities. First, they are spoken with a characteristic intonation contour. Second, differently from a neutral realization, sentences with such a contrastive intonation not only assert a fact (e.g., Ben has to go back to work), but also presuppose contrastive alternatives to the accented words (i.e., someone else doesn't have to work). Although speakers do not explicitly disclose these alternatives, they can become part of the interpretation of the sentence. Apparently, listeners automatically retrieve the alternatives that led the speaker to produce a contrastive utterance. In this paper, we investigated whether a contrastive intonation contour *per se* triggers a process by which listeners have immediate access to these contextually salient alternatives.

(Figure 1 about here)

One mechanism available for listeners to deal with lacking background information is called 'bridging' (e.g., Clark, 1977) or 'accommodation' (e.g., Lewis,

[1] First author's translation of the quotation: "Ben stand auf. Ich muss noch was tun. Er sagte das so, als sei ich derjenige, der nichts tun muß." (Timm, 2003, p. 156).

1979, Stalnaker, 2002). Accommodation is mainly discussed in the semantics and pragmatics literature and describes 'the phenomenon of accommodating (inserting) something into the context that has not been explicitly mentioned' (Kadmon, 2001, p. 174). It has been argued, for instance, that definite articles presuppose the existence of an entity (e.g., 'I have to pick up my sister from the airport') and factive predicates presuppose the truth of the subordinate clause (e.g., 'He was surprised that he passed the test'). All of the above mentioned theories deal with the accommodation of a common ground, i.e. a set of propositions that speakers take for granted and encode as such (e.g., the proposition 'I have a sister' in 'I have to pick up my sister from the airport). We believe that a process similar to accommodation can explain the intuition that listeners generate contextually salient alternatives to contrastively accented words in sentences like 'I still have some WORK to do'[2], in which the prosodic contour signals that the speaker entertains salient alternatives (e.g., *YOU* have *NOTHING* to do).

Alternatives play an important role in the formalization of accentuation and narrow focus (Jackendoff, 1972; Rooth, 1992; Steedman, 2000, among others). Adapting an example from Steedman, the sentence 'Marcel discovered a SECRET' is formalized via functional abstraction of the accented word, leaving a variable *x* ('Marcel discovered *x*', or, more formally, *λx[discovered'(x,Marcel')]*). In this semantic formula, *x* can be replaced by any contextually or situationally available alternative, resulting in so-called alternative sets (such as {Pluto,a cookie,three dimes} in this example). These alternative sets are more restricted for sentences with a narrow, contrastive focus in which only the focused constituent (i.e. 'a secret' in the above example) contributes new information. Narrow focus sentences serve as answers to specific questions such as 'What did he

[2] Accents will be marked by underscored capitals.

discover?' Therefore, the alternatives usually have the same syntactic class as the focused constituent (a noun phrase in this example) and belong to the same semantic class ('something that can be discovered' in this example). In contrast, alternative sets become much more varied for sentences with a larger focus domain, such as a verb phrase focus or sentence focus (responses to questions like 'What did he do?' or 'What happened?').

In the experiments that follow we investigated whether this way of formalizing sentences with a narrow focus has any psychological reality, i.e. we tested whether relevant contextual alternatives become immediately salient for listeners upon hearing sentences with a contrastive intonation contour. Note that there are already a number of studies that investigated the interpretation of sentences with contrastive intonation contours. Listeners, for instance, successfully exploit intonational information to determine whether the speaker intends to continue with the previously mentioned referent or whether s/he will introduce a new, contrasting one. In an eye-tracking experiment, Dahan, Tanenhaus, and Chambers (2002) used a sequence of two instructions (e.g. 'Move the candle above the triangle. Now move the candy below the square') and asked their participants to click on the respective target object (e.g., 'candy'). An accented referent in the second instruction (e.g. 'Move the candle above the triangle. Now move the CANDY below the square') led to more fixations to the new, as-yet unmentioned object (e.g., 'candy') compared to an unaccented referent. Since these effects were observed before the speech signal unambiguously identified the target, they can only be attributed to the different prosodic realizations of the instructions. Similarly, upon hearing two instructions (e.g., 'Click on the purple violin. Now click on the red violin') an accented adjective in the 2nd instruction (e.g., 'RED violin') results in more fixations to an object

of the same type as in the first instruction (e.g., 'violin') than to another red object (e.g., 'vase') displayed on the screen (Weber, Braun & Crocker, 2006; Ito & Speer, 2008). Interestingly, listeners not only make use of pitch accent distribution (i.e. accentuation of referent or adjective) but also appear to be sensitive to pitch accent type: A contrastive pitch accent such as L+H* (high pitch on the stressed syllable preceded by a low tone which results in a steep rise to the peak) creates a strong bias towards contrastive referents, while H* signals both new and contrastive referents (Watson, Tanenhaus & Gunlogson, 2008). Taken together, these results show that listeners use intonational contrast marking and the situational context (e.g., the objects in the computer display) to identify the intended referents (i.e., new referent, same type of object or contrastive referent).

However, the results of these eye-tracking studies cannot answer the question whether listeners have access to contrastive alternatives that are *not* explicitly available, i.e., when contrastive sentences are produced without sufficient context (e.g., 'I still have some WORK to do'). Therefore, it is largely unknown how listeners process such sentences, which occur frequently in everyday conversation. The issue, however, can be addressed with the cross-modal associative priming paradigm (Swinney, Onifer, Prather, & Hirschkowitz, 1979; Tabossi, 1996). Differently from eye-tracking experiments, this technique does not offer a preceding context in which contrastive alternatives are explicitly provided. Through these means, implicit rather than explicit alternative processing can be studied. In cross-modal priming experiments, participants first hear a prime (e.g., a word) and then usually perform a lexical decision task on a visually

presented target word. Priming effects result in faster lexical decisions (e.g., to CAT) after related auditory primes (e.g., *dog*) than after unrelated ones (e.g., *bus*)[3].

Recently, Norris, McQueen, Cutler and Butterfield (2006) provided compelling evidence that associative priming is not due to an automatic mechanism following lexical access. Rather, this technique taps into the processing occurring at the level of conceptual representation of the current interpretation of the utterance. Therefore, cross-modal associative priming is sensitive to semantic effects of the context. For example, providing a discourse context incoherent with the association between the prime and the target hampers the recognition of related visual targets (Blutner & Sommer, 1988, Williams, 1988; Tabossi, 1988). Williams (1988), for instance, found priming for visual targets (e.g., TABLE), when primes (e.g., *chair*) were presented in isolation, in random word lists (e.g., 'when brass heard could in that only land as more film to interested to is chair because which came could all ice in'), and in sentences related to the targets (e.g., 'The man entered the dining room and sat down on a chair in eager anticipation of a hearty meal'). On the other hand, priming was not observed when the prime occurred in sentences that were unrelated to the target (e.g., 'The man found that he could only reach the best apples by standing on a chair because they were all so high up'). Similarly, Tabossi (1988) reported facilitation for visual targets (e.g., FAT) only when sentences underlined aspects of the primes' meaning related to the target (e.g., 'To follow her diet, the woman eliminated the use of butter'); however, there were no reliable effects when the sentences focused on features unrelated to the target (e.g., 'To soften it, the woman heated a piece of butter'). Associative effects are hence subject to the presence of a relevant or 'effective

[3] Throughout this article, auditory primes will be marked by italics and visual targets by capitals.

context' (Foss & Ross, 1983; Williams, 1988), which is part of the current interpretation of the utterance (Norris et al., 2006).

More importantly, cross-modal associative priming appears to be sensitive to prosodic effects. A contrastive intonation contour is one of the factors that may encourage deeper semantic processing and hence lead to priming effects (Norris et al., 2006). In Experiment 4C, Norris et al. presented sentences (e.g., 'He suggested that it was really the *date* of the election that mattered') with a contrastive accent on either the prime (e.g., '*date*') or on another word later in the sentence (e.g., 'election'). The visual targets were presented at the offset of the prime (e.g., '*date*'). Priming effects for related targets (e.g., TIME) were detected for both conditions, but were stronger and more reliable after accented primes than after unaccented ones. However, these results cannot be solely attributed to contrastive accentuation as most of the experimental sentences contained syntactic and lexical presupposition triggers (e.g., 'We hoped that…', 'The odd thing was …') or focus particles (e.g., 'It was only when') that might have drawn listeners' attention to the part of the sentence containing the prime. Therefore, it is conceivable that priming was encouraged also by the syntactic constructions used and not solely by contrastive pitch accents.

Hence, it is still an open question if a contrastive pitch accent *per se* can serve as an 'effective context' for the recognition of words, and in particular, whether a contrastive pitch accent facilitates the recognition of contrastive alternatives. In two cross-modal priming experiments we investigated the effect of a contrastive intonation on the recognition of words associated to sentence-final primes (e.g., *flamingo*, 'flamingo'). The associated words were either contrastive alternatives (e.g., PELIKAAN 'pelican';

henceforth: contrastive associates), or generic associates that are not contrastive alternatives (e.g., ROZE, 'pink'; henceforth: non-contrastive associates). More specifically, in Experiment 1a we tested whether contrastive alternatives are easier to recognize upon hearing a sentence with a contrastive intonation contour than after hearing a sentence with a non-contrastive one. In Experiment 1b we tested the effect of the same prosodic contours on the recognition of non-contrastive associates to ascertain whether this effect is specific for contrastive alternatives or whether a contrastive intonation in general makes all kinds of related words more easily accessible.

As contrastive intonation contour we chose a double contrast ('A did B but X did Y', resulting in a contrast on the first constituent and on the sentence-final prime). Sentences with such a double contrast are unambiguously contrastive (Braun, 2005, 2006), while sentences with only one accent on the sentence-final noun (e.g. 'Marcel discovered a SECRET') may be perceived as ambiguous between a narrow focus interpretation and a broad focus interpretation (Bartels & Kingston, 1994; Ladd, 1983; Birch & Clifton, 1995; Welby, 2003). Furthermore, the number and the positions of accented words can be matched in sentences with a double contrast and sentences with a hat pattern, which is the most frequent neutral intonation contour in Dutch (Cohen and 't Hart, 1967; 't Hart, Collier & Cohen, 1990; see Figure 2 for an illustration). The neutral hat pattern consists of a pitch rise on the first accented word, a slightly declining high plateau, and a fall on the second accented word. In our materials, the rise and the fall in the non-contrastive hat pattern are realized on the same words as the two pitch falls in the contrastive intonation contour (on the first content word in the sentence and on the sentence-final word respectively). Hence, the only difference between the two intonation

contours is the type of pitch accent on the accented words – i.e. the exact tonal realization – and not the number or the position of the accented words.

If the semantic formalization of contrastive focus using alternative sets has any cognitive relevance, we would expect contrastive associates to be more easily accessible and hence facilitated upon hearing a sentence with a contrastive intonation contour but not upon hearing a sentence with a non-contrastive intonation. This explanation only holds, however, if the recognition of non-contrastive associates is not affected by a contrastive intonation contour. If the recognition of non-contrastive associates is modulated by sentence intonation in the same way as the recognition of contrastive associates, then contrastive intonation contours make all kinds of associates more accessible (Norris et al., 2006).

Methods

Materials

Thirty-six quadruplets of Dutch words were selected to use as experimental items. Each quadruplet comprised a related prime (e.g., flamingo 'flamingo'), a contrastive associate to the related prime (e.g., pelikaan 'pelican'), a non-contrastive associate to the related prime (e.g., roze 'pink') and a control prime that was unrelated to each member of the quadruplet (e.g., beroemdheid 'celebrity'). These quadruplets were created with the following procedure.

Eighty high frequency (> 0.07 occurrences per million) Dutch tri-syllabic mono-morphemic nouns with stress on the second syllable were extracted from the CELEX lemma dictionary (Baayen, Piepenbrock, & Gulikers, 1995) for use as potential related

primes. Words with large alternative sets (e.g. proper names, places, etc.) were avoided. These 80 related prime candidates were used in a free association web experiment, in which 31 Dutch participants had to produce one free associate in response to each given stimulus. Words that did not elicit a clear associate (i.e., one given by less than 25% of the participants), words that resulted in two equally frequent associates, and words for which participants provided a contrastive alternative (a word of the same word type and semantic class that could be used in sentences such as 'He didn't buy X but Y') were discarded. This selection resulted in 44 related primes that had a frequent non-contrastive associate (produced by 39% of participants, on average). A Dutch native speaker constructed 44 syntactically and semantically neutral sentences (i.e., word orders that do not induce a contrast) that ended in these potential primes. Most of them were subject-verb-object sentences (e.g., 'Our neighbors assembled an antenna'), but there were also three with a preverbal preposition phrase (e.g., 'On Saturday I went to the theater'), two with an expletive (e.g., 'There was air-conditioning in the cabin'), and two passive constructions (e.g., 'The inflammation was caused by a bacteria'). Further, a semantic alternative for each word in this context to use as contrastive associates was selected (e.g., 'dish' for 'antenna' – which are both means to receive broadcast, 'virus' for 'bacteria' – which are both sources for infection). The association strength between the 44 related primes and their contrastive and non-contrastive associates was then tested in a web based rating experiment with 20 Dutch participants. Every participant rated a total of 88 words, 44 related ones and 44 unrelated ones. Each participant rated the relationship between the prime and either the contrastive or the non-contrastive associate (on a scale from 1, 'unrelated' to 7, 'strongly related'). Then, 36 triplets were selected from the set of

44 so that the association strengths of the related primes with the contrastive associate (M = 5.5, SD = 0.77) and with the non-contrastive associate (M = 6.2, SD = 0.55) were as balanced as possible. Nevertheless, the relatedness scores for non-contrastive associates were significantly higher than for contrastive ones ($t(35) = 4.9$, $p < 0.0001$).

The contrastive associates appeared as visual targets in Experiment 1a, and the non-contrastive associates appeared as targets in Experiment 1b. The mean frequency of the eventually selected 36 related primes was 8.6 occurrences per million (o.p.m.), SD = 11.3, according to the CELEX database. Contrastive targets were 7.8 letters long on average and had a mean frequency of 19.0 o.p.m. (SD = 54.2). Non-contrastive targets were 5.5 letters long with an average frequency of 115.2 o.p.m. (SD = 203.0). Given the elicitation procedure for non-contrastive associates and the constraints on the selection of contrastive associates, the lexical frequency and number of characters could not be matched. Contrastive associates were significantly longer than non-contrastive ones ($t(35) = 4.22$, $p < 0.0001$) and less frequent ($t(35) = 2.77$, $p < 0.01$).

Finally, for each related prime and its (contrastive and non-contrastive) associates, a control prime unrelated to all three was chosen. Similar to the related primes, control primes were all tri-syllabic words stressed on the second syllable (mean frequency of 10.5 out of a million, SD = 23.4); further, control primes could be inserted in the same sentence as their paired related primes. Durations of the experimental and control primes (divided by the respective utterance durations to account for speech rate) did not differ across the two intonational realizations ($t(35) = 1.80$, $p > 0.05$, $t(35) = 0.54$, $p > 0.5$). Experimental primes lasted on average 37.8% of the overall utterance duration, control primes 38.5%. All the experimental materials are listed in Table 1.

Further, 164 filler sentences and six practice sentences were constructed, structurally and semantically similar to the experimental ones. Eighteen of the filler items had a non-word visual target that was phonologically related to the sentence-final word, 92 had a non-word visual target unrelated to the sentence-final word, and 54 had an existing word as visual target that was unrelated to the sentence final word. The six practice sentences were paired with 3 word and 3 non-word visual targets. Filler and practice targets were matched to the experimental targets in terms of the distribution of the number of characters.

All the sentences were recorded by a trained female speaker of Dutch in a soundproof room and directly digitized onto a PC (44 kHz, 16 bit). She read the 36 experimental sentences and the 36 control sentences both neutrally, resulting in a declining hat pattern as shown in Figure 2a, and with a double contrast realized on the first content word of the sentence and the sentence-final prime (Figure 2b). The contrastive intonation was cued by a contrastive precursor and a contrastive connector (e.g., '<u>WE</u> assembled a <u>SATELLITE</u> dish, but…'). Half of the filler sentences and half of the familiarization sentences were recorded with a non-contrastive and half with a contrastive intonation contour. As can be seen in Figure 2, the f0-excursion of the pitch fall on the sentence-final prime word was significantly larger in sentences with a contrastive intonation contour than in sentences with an non-contrastive one ($t(71) = 48.6$, $p < 0.0001$). The excursion was on average 180.0 Hz for contrastive contours compared to 36.3 Hz for non-contrastive ones[4]. The intonational annotation for the sentences

[4] The f0-values were extracted from the middle of the stressed and post-stressed vowel for contrastive contours and in the middle of the pre-stressed and stressed vowel for non-contrastive contours.

following ToDI (Transcription of Dutch Intonation, see Gussenhoven, 2005) is provided on the third tier.

(Figure 2 about here)

Participants

Eighty Dutch students from the Radboud University Nijmegen, naïve with respect to the purpose of the experiment, participated for a small fee, 40 in each experiment. They had not taken part in the earlier web experiments, had good or corrected vision and no history of hearing problems.

Procedure

Participants were tested individually in a soundproof cabin sitting in front of a computer screen. Each sentence was played in stereo at a comfortable loudness via headphones. The visual target appeared in white Arial 72pt characters on black background immediately after the end of the sentence. Participants received written instructions, in which they were asked to press the right button when the string of letters they saw on the screen was a Dutch word or proper name and the left button when it was not. Left-handed participants had to press the left button for 'yes'-responses. Responses slower than 2 seconds after the appearance of the visual target were not recorded.

Four experimental lists were constructed by rotating through the four conditions, crossing the two within-subjects, between-items factors intonation of the target sentence (contrastive or non-contrastive) and prime type (control or related). There were hence

nine items per condition. Each list further contained all the practice and filler items, totaling in 206 trials. Two orders were made for each list, avoiding that two or three subsequent sentences could be interpreted as part of a coherent discourse. Participants were randomly assigned to one of these lists.

Results

Due to an oversight, one control prime was identical to one of the related primes. The two pairs containing these primes were therefore excluded from the analyses.

Experiment 1a – contrastive associates

Six trials were excluded because there was no button press (timeout) and an additional 55 trials were discarded because of an incorrect response. Errors were distributed evenly across conditions and participants. Reaction times for the remaining trials were log-transformed. One participant with exceptionally long reaction times (mean log-RT larger than 2 standard deviations from the overall mean) was not included in the analysis.

Log-RTs within 2 standard deviations of the mean were analyzed (range 5.88 to 6.91) using mixed-effects models with participants and items as crossed random factors, and contrast coding for factors (N = 1280). This analysis has been chosen over the more traditional separate subject and items analyses as it is less dependent on normality and sphericity assumptions, can cope well with missing data, and allows for the combined analysis of categorical and continuous predictors (e.g., Quené & van den Bergh, 2004; Baayen, 2007, Barr, 2008; Jaeger, 2008). The crucial predictors were intonation (contrastive or non-contrastive) and prime type (control or related prime). Further, the

model included a number of predictors that have been shown to affect reaction times in lexical decision experiments, such as log-lexical frequency as extracted from the CELEX word form dictionary, number of characters, the reaction time to the preceding trial, whether the preceding filler trial had a word or non-word target, and the correctness of the preceding response.

The initial model included all predictors and the interaction between intonation and prime type. Predictors with a p-value larger than 0.1 were removed if this did not deteriorate the fit of the model (as estimated by a likelihood-ratio test). The log-likelihood of the full model was 405.5, that of the final model 405.9 ($\chi^2 = 0.85$, df = 2, $p > 0.5$). Then, the more parsimonious model was refitted. Data points with residuals larger than 2.5 standard deviations were removed. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results of the final model are summarized in Table 2.

(Table 2 about here)

As expected, responses were slower to visual targets with more letters and for which the reaction time to the preceding filler trial was longer. Crucially, results for the contrastive visual targets showed a significant interaction between the intonation of the sentence and the relation between prime and target. Responses were on average 19.3 ms faster after related primes if the sentence containing the prime was spoken with a contrastive intonation contour. There was no facilitation for contrastively related visual targets when sentences had a neutral intonation contour. The mean RT for each condition, calculated

on the basis of the statistical model for a mean reaction time to the preceding filler trial (6.47) and a median number of characters for the target (8), are illustrated in Figure 3.

(Figure 3 about here)

Experiment 1b – non-contrastive associates

Twenty trials with incorrect responses were discarded. Log-RTs within 2 standard deviations of the mean were analyzed (range 5.85 to 6.79), N = 1290. The fitting procedure and predictors were the same as described for Experiment 1a. The log-likelihood of the full model was 588.6 compared to 590.1 for the final model ($\chi^2 = 2.9$, df = 4, $p > 0.5$). Results of the final model are summarized in Table 3.

(Table 3 about here)

Similar to Experiment 1a, responses were slower to visual targets with more letters and for which the reaction time to the preceding filler trial was longer. Furthermore, responses were faster to targets with a higher lexical frequency. Moreover, results for the non-contrastive associates showed a main effect for prime type only. Responses were on average 8.4 ms faster when the auditory prime was related to the visual target than when it was not (on average 538.1 ms for control primes compared to 529.7ms for related ones). There was no effect of intonation (p(MCMC) > 0.5) and no interaction between intonation and prime type (p(MCMC) > 0.25). The recognition of generically related

visual targets is hence independent of the intonation contour. There is a weak facilitation for related primes, which is consistent with earlier findings in cross-modal priming[5].

Note that upon hearing a sentence with a contrastive intonation contour the priming effect for non-contrastive targets is smaller than for contrastive ones (8.4 ms vs. 19.3 ms), despite the fact that the non-contrastive targets had a stronger relation to the prime than the contrastive ones. The results of the two experiments cannot be directly compared, however, because of the lexical differences of the targets across experiments. As reported in the material section, non-contrastive targets were shorter and more frequent than the contrastive associates. These differences are probably the reason that participants responded on average 55.9 ms faster to non-contrastive targets than to contrastive ones ($t(2488.7) = 11.4$, $p < 0.001$), since mean responses per participant for filler trials did not differ across experiments ($t(79) = .1$, $p > 0.9$).

General Discussion

In two cross-modal priming experiments we manipulated sentence intonation (contrastive vs. non-contrastive) and the relation between prime and visual target (unrelated vs. contrastively and non-contrastively associated). Results showed that contrastive associates – which are contextual alternatives to the primes - are facilitated only when the primes are realized in sentences with a contrastive intonation. On the other hand, non-contrastive associates – which are generic associates that are not contextual alternatives –

[5] Note that while contrastive visual targets were uniformly nouns, four of the non-contrastive visual targets had a different part-of-speech (3 adjectives and 1 verb). This non-uniformity in part-of-speech might influence the priming effects. However, excluding those items does not change the results in any way, so we report the statistical analysis of all items.

are weakly facilitated independent of the intonation contour. These results show that a contrastive intonation contour modulates the interpretation of a sentence. In particular, the present results indicate that only a contrastive interpretation of the sentence makes contextually relevant alternatives more accessible and hence easier to recognize.

The observed facilitation of contrastive associates upon hearing a sentence with a contrastive intonation contour appears to be genuinely driven by the interpretation of sentences with a contrastive intonation contour. This effect cannot be simply explained by a more salient production of the primes. Contrastively accented primes were, indeed, realized with a larger pitch movement than the primes in sentences with a non-contrastive intonation. If this explanation were correct, the presence of the larger pitch movement would have also affected the recognition of the non-contrastive associates in Experiment 1b. However, no interaction of prosodic contour and prime-target relation was detected in the second experiment. Also, this effect can not be explained by the fact that contrastive, category associates generally elicit stronger priming than non-contrastive ones, even when they are barely related to the prime (Fischler, 1977 and Lupker, 1984 for visual-visual priming; Ostrin & Tyler, 1993 for auditory-auditory priming). If this were the case, contrastive associates should have also been facilitated in sentences with a non-contrastive intonation contour.

Finally, one might argue that a contrastive intonation contour only serves the function of attracting attention to the accented words and therefore makes less strongly related associates (i.e. the contrastive associates in this study) also accessible. This explanation would predict the same interaction observed for contrastive associates also for those non-contrastive associates that are only weakly related to the auditory prime. To

test this hypothesis, we split the non-contrastive associates into two halves, highly related ones (rating > 6.3) and weakly related ones (rating <= 6.3). The weakly related items had a mean rating of 5.8 (SD = 0.60) – compared to a mean rating of 5.5 (SD = 0.77) for the contrastive associates. They were analyzed using the same model as for the contrastive associates. There were neither main effects of intonation or prime type, nor an interaction between the two factors (p(MCMC) > 0.5). The lack of interaction between intonation and prime type for the weakly related non-contrastive associates suggests that a contrastive intonation contour does not simply have a highlighting function by which less strongly related associates become more accessible. Therefore, it appears more plausible that a contrastive intonation contour especially makes contextually sensible alternatives to the accented words salient.

The present findings support and extend the conclusion drawn by Norris et al. (2006) that prosody alters the interpretation of the sentence. Using syntactically and semantically neutral sentences we could show that prosody per se acts as an 'effective context' (Williams, 1988) and affects sentence interpretation. Furthermore, the effect of prosody proved to be extremely specific. Only contrastive alternatives were facilitated by a contrastive realization, whereas non-contrastive associates were available for both contrastive and non-contrastive intonation contours. The present results also extend previous findings from the eye-tracking literature. The observed facilitation of contrastive alternatives upon hearing *isolated* sentences with a contrastive intonation contour shows that contrastive alternatives become accessible even in the absence of linguistic or pragmatic context.

From an intonational perspective, the present data suggest that during the processing of utterances with a non-contrastive intonation contour, only highly related associates (i.e. non-contrastive associates which had a higher rating than the contrastive ones) become accessible and hence are recognized faster. During the processing of utterances with a contrastive intonation, contrastive associates (i.e. contextual alternatives to the accented items) become also salient.

From a linguistic or pragmatic perspective, the present findings support the use of alternative sets to formalize contrastive focus. In sentences with a contrastive intonation contour, in which the alternative sets to the accented words are rather small and of a restricted type, listeners rapidly generate salient contextual alternatives. On the contrary, for sentences with a non-contrastive intonation contour these alternatives are not immediately accessible.

Differently from sentences with only one accent on the sentence-final noun (e.g., 'Marcel discovered a SECRET'), which can be interpreted as neutral or contrastive, the double-peak contour employed in this study (e.g. 'MARCEL discovered a SECRET) unambiguously signals contrast. This prosodic contour, however, encodes contrastive alternatives for both accented words, so that listeners potentially retrieved alternatives for both the sentence-final prime and for the sentence-initial constituent. The additional alternative set for the sentence-initial words may have decreased the facilitation of the contrastive associates. Therefore, in sentences with a single contrast on the prime only, this effect might have been larger.

Taken together, the present experiments support the intuition that contrastive accentuation on a word makes contextual alternatives to that word salient to the listener.

The fact that salient alternatives are generated upon hearing isolated sentences is especially noteworthy, as listeners frequently encounter utterances that are not sufficiently grounded, i.e. for which the speakers did not provide all the relevant background information beforehand. We suggest that this is due to an accommodation mechanism, through which listeners adopt assumptions implicit in the speaker's use of contrastive marking and generate plausible alternatives. Our data suggest that this accommodation mechanism is automatic and occurs early in the recognition process. Once more, language proves to be an efficient means of communication, as listeners effortlessly exploit prosodic information to accommodate the information that the linguistic structure does not explicitly encode (e.g., contextual alternatives).

Appendix

(Put Table 1 here)

References

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Table 1: Materials

Auditory sentence (sentence-final prime)	control prime	non-contrastive target	contrastive target
Onze buren monteerden een antenne	trapeze	televisie	schotel
‘Our neighbors assembled an antenna’	'trapeze'	‘television’	‘dish’
De ontsteking werd veroorzaakt door een bacterie	verwonding	ziek	virus
‘The inflammation was caused by a bacteria’	'injury'	‘ill’	‘virus’
Er was airconditioning in de cabine	centrale	vliegtuig	kamer
‘There was air-conditioning in the cabin'	'head office'	‘plane’	‘room’
De kinderen gooiden met confetti	spaghetti	carnaval	serpentine
‘The children threw with confetti'	'spaghetti'	'carnival'	‘paper streamer’
Mark spiekte tijdens het examen	gefluister	stress	proefwerk
'Mark copied off someone during the exam'	'whispering'	'stress'	‘test’
In Florida fotografeerde hij een flamingo			
‘In Florida he fotographedphotographed a	beroemdheid	roze	pelikaan
flamingo’	'celebrity'	‘pink’	‘pelican’
Anne is verkleed als gorilla	kabouter	aap	chimpansee
‘Anne is dressed up as a gorilla'	'gnome'	‘ape’	‘chimpanzee’
Roeland repareerde de horloge	insigne	tijd	klok
‘Roeland repaired the wrist watch’	'badge'	‘time’	‘clock’
Henk bestelde een jenever	risotto	drank	brandewijn
‘Henk ordered a jenever’	‘risotto’	‘drink’	‘brandy’
Anke noteerde iets op de kalender	papiertje	jaar	rooster
'Anke wrote something down in her	‘piece of paper’	‘year’	‘schedule’

calendercalendar’			
De keuken ruikt naar kamille	andijvie	thee	lavendel
‘The kitchen smells like camomilechamomile'	'endive'	‘tea’	‘lavender’
Marlies voerde de kanarie	koala	vogel	parkiet
‘Marlies fed the canary’	'koala'	‘bird’	‘parakeet’
De slachtoffers sliepen in de kazerne	taveerne	brandweer	sporthal
‘The victims slept in the barracks'	'tavern'	‘fire brigade’	‘gymnasium’
Er waren kokkels in de lagune	terrine	water	rivier
‘There were cockles in the lagoon’	'tureen'	‘water’	‘river’
Marloes ging naar het Lyceum	gebergte	school	mavo
‘Marloes attended the lyceum’	'mountain range'	‘school’	‘lower general sec. education'
De dierenarts moest naar de manege	savanne	paard	boerderij
‘The vet had to go to the stables'	'savanna'	‘horse’	‘farm house’
Mijn broer zit bij de marine	fanfare	boot	luchtmacht
‘My brother is at the marines’	'brass band'	‘boat’	‘air force’
De sculpturen stonden in het museum	noordoosten	kunst	archief
‘The sculptures stood in the museum’	‘north east’	‘art’	‘archive’
De kamelendrijver zag een oase	toeriste	woestijn	luchtspiegeling
'The camel-driver saw an oasis'	‘tourist’	‘desert’	‘illusion’
De hond kauwde op een pantoffel’	Kastanje	sloffen	slippers
‘The dog chewed on a slipper'	'chestnut'	'slippers'	‘flip-flop’
De huisarts gaf hem een placebo	Verklaring	nep	medicijn
‘The GP gave him a placebo’	'explanationt'	‘fake’	‘medicin’
Mijn buurman werkte voor de provincie	politie	land	gemeente

‘My neighbour works for the Province'	‘police’	‘country’	‘community’
De poster hing aan de punaise	piano	prikbord	spijker
‘The poster hang from the drawing pin'	‘piano’	'notice board'	‘nail’
Mijn vader draagt een pyjama	kalkoentje	slapen	nachthemd
‘My father wears a pyjamapajama’	'little turkey'	‘to sleep’	‘nightgown’
Het stel sprak af in de ruine	pagode	kasteel	bunker
‘The couple agreed to meet at the ruin'	'pagoda'	'castle'	‘bunker’
In de lente gingen zij op safari	karate	jungle	trektocht
‘In spring they went on safari’	‘karate’	‘jungle’	‘hiking tour’
Mijn tante ontving een klein salaris	cadeautje	geld	subsidie
‘My aunt received a small salary’	‘small present’	‘money’	‘subsidy'
Christel eet het liefst sardine	komkommer	vis	zalm
‘Christel preferably eats sardine'	‘cucumber’	‘fish’	‘salmon’
Onze zoon houdt van spinazie	sukade	groente	kool
‘Our son loves spinach’	'candied peel'	'vegetable'	‘cabbage’
Hans kocht een stuk suede	verlengsnoer	leer	zijde
‘Hans bought a piece of suede'	'extension lead'	'leather'	‘silk’
Zaterdag ging ik naar het theater	orakel	voorstelling	bioscoop
‘On Saturday I went to the theater’	'oracle'	'performance'	‘film theatre’
Zijn lievelingssmaak was vanille	tomaten	ijs	kaneel
‘His favourite taste was vanillae’	‘tomatoes’	‘ice cream’	‘cinnamon’
De socialist imponeerde de elite	projectgroep	rijk	burgers
‘The socialist impressed the elite’	'project group'	‘rich’	‘citizens’
De majoor stopte bij de douane	veranda	grens	marechaussee
‘The major stopped at the customs'	'veranda'	'border'	‘military police’
De technicus werkte in de garage	vakantie	auto	hangar

‘The technician worked in the garage'	‘holiday’	‘car’	‘hangar’
De collega gaat op vakantie ‘The colleague went on holidays’	auditie 'audition'	zon ‘sun’	zakenreis ‘business trip’

Table 2: Estimates, confidence intervals, and p-values for Experiment 1a. Positive estimates indicate the amount of increase in log-RT relative to the Intercept. For factors, the change from the Intercept applies for the level given in italics

	Estimate	Lower Bound	Upper Bound	p (MCMC)
Intercept *(non-contrastive intonation, unrelated prime)*	5.732	5.457	6.015	0.0001
Intonation (*contrastive*)	0.006	-0.017	0.029	*n.s.*
Prime Type (*related*)	0.008	-0.015	0.032	*n.s.*
Previous Log-RT	0.070	0.030	0.111	< 0.001
Number of characters	0.028	0.016	0.038	< 0.0005
Intonation:Prime Type (*contrastive:related*)	-0.039	-0.073	-0.007	< 0.05

Table 3: Estimates, confidence intervals, and p-values for Experiment 1b.

	Estimate	Lower Bound	Upper Bound	p (MCMC)
Intercept *(non-contrastive intonation, unrelated prime)*	5.645	5.366	5.910	0.0001
Prime Type (*related*)	-0.016	-0.031	-0.002	< 0.05
Previous Log-RT	0.114	0.074	0.152	0.0001
Number of characters	0.009	0.003	0.016	< 0.01
Log-Freq	-0.019	-0.027	-0.011	0.0001

Figure 1: Neutral realization (a) and contrastive realization (b).

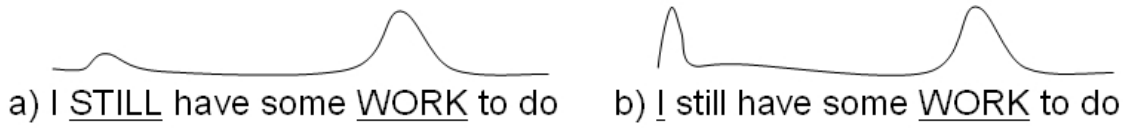
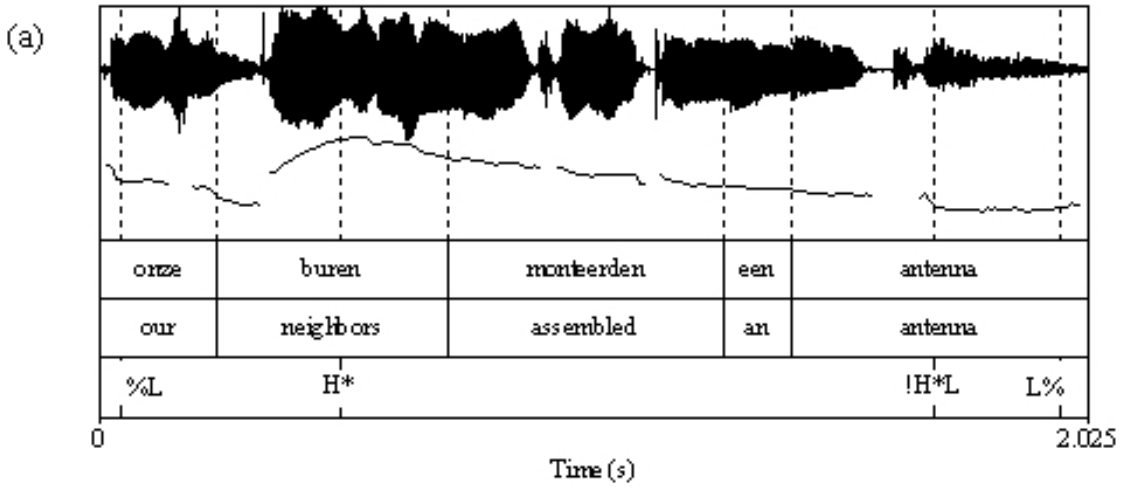


Figure 2: Examples of the hat pattern intonation contour in the non-contrastive condition (a) and of the double peak contour in the contrastive condition (b)



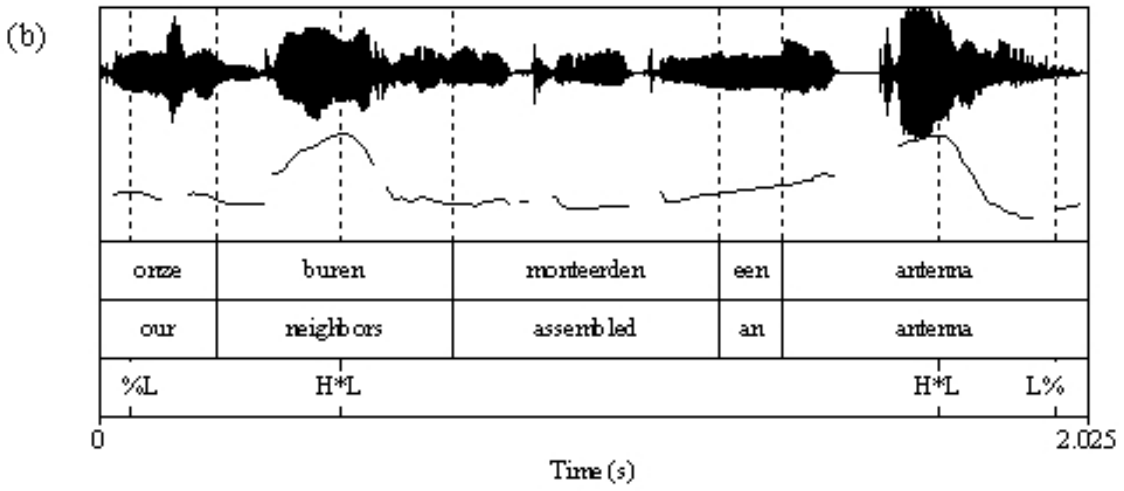


Figure 3: Mean Log-RTs for Experiment 1a (contrastive visual targets) as a function of the experimental conditons: intonation (contrastive vs. non-contrastive) and Prime Type (control vs. related). Error bars represent standard error