

# Prosodic cues to semantic structure in native and nonnative listening\*

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*Listeners efficiently exploit sentence prosody to direct attention to words bearing sentence accent. This effect has been explained as a search for focus, furthering rapid apprehension of semantic structure. A first experiment supported this explanation: English listeners detected phoneme targets in sentences more rapidly when the target-bearing words were in accented position or in focussed position, but the two effects interacted, consistent with the claim that the effects serve a common cause. In a second experiment a similar asymmetry was observed with Dutch listeners and Dutch sentences. In a third and a fourth experiment, proficient Dutch users of English heard English sentences; here, however, the two effects did not interact. The results suggest that less efficient mapping of prosody to semantics may be one way in which nonnative listening fails to equal native listening.*

## Introduction

The prosodic structure of speech conveys a wealth of semantic information. Consider, for instance, the utterances (1) and (2).

- (1) The tourist DIDn't fly home.
- (2) The tourist didn't FLY home.

The two statements consist of the same words, and only differ in where sentence accent falls (denoted by upper case). Their implications, however, are quite different. Both imply a contrast with an earlier intention to fly home; but (1) can be used in a situation in which the tourist extended a visit (and is by implication thus still here), while (2) involves a contrast between flying and other means of transport, and implies that the tourist has used some such other means to go home (and is thus no longer here). Other accent placements, with still other implications, are of course also conceivable. In the choice of accent placement, speakers encode significant information for listeners.

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There is abundant empirical evidence that listeners process sentence accent patterns, and the discourse implications they convey, with efficiency and rapidity (see Cutler, Dahan and Donselaar, 1997, for a review). This evidence comes, however, from studies of native listening. In the present study, by contrast, we focus on nonnative listening. At issue is the question of whether nonnative listeners can process prosodic information for semantic structure as efficiently as native listeners.

Difficulty with phonetic distinctions, lower vocabulary size, lesser accumulated lexical familiarity, and unfamiliarity with idiomatic expressions all combine to make nonnative comprehension of spoken language less efficient than comprehension by native listeners. Whether processing of the accentual structure of utterances also causes problems for nonnative listeners is still an open question, since this issue has received little research attention to date. There are studies of word-level prosodic processing by nonnative listeners; thus stress distinctions are difficult for speakers of non-stress languages to process, and, especially, to retain in memory (Dupoux, Pallier, Sebastián-Gallés and Mehler, 1997; Peperkamp and Dupoux, 2002), as are tone distinctions for speakers of non-tone languages (Broselow, Hurtig and Ringen, 1987; Shen, 1989). Effects of the first language on perception of word-level stress in a second language have been observed; thus speakers of tone and pitch-accent languages attend more to pitch change in judging English stress than native listeners do (Watanabe, 1988) and fail to abstract grammatical regularities in English stress (Archibald, 1997), while speakers of stress languages resort to native stress-assignment principles in making stress judgements in a second language in which other

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principles apply (Archibald, 1992, 1993). Prosodic effects of syntactic phrasing have also been investigated; thus one study of prosodic disambiguation of syntactic ambiguity in English showed similar use of prosodic information by native English and nonnative (Hebrew) listeners (Berkovits, 1980), while another found that nonnative listeners (of various language backgrounds) paid greater attention to contextual than to prosodic cues to the same structure (Ying, 1996), and a third found that for nonnative (Cantonese) listeners prosodic cues overrode syntactic information in cases of conflict (Harley, Howard and Hart, 1995). Prosodic cues which distinguish idiomatic versus non-idiomatic readings of English strings such as *skating on thin ice* are easy for native listeners to apprehend, but very difficult for nonnative listeners (Vanlancker-Sidtis, 2003).

We are aware of only one study concerned with the processing of focussing accentuation in English by nonnative listeners, and it is a memory study rather than a study of sentence perception. Pennington and Ellis (2000) tested Cantonese-native users of English as a second language for recognition memory of two prosodic versions of sentences, some of which involved a focus contrast across the two versions. In a first phase of the experiment the listeners heard 24 simple sentences; in a second phase they heard 48 sentences and were required to judge for each one whether or not it had occurred in the first phase. The nonnative speakers' memory for prosodically coded information was in general poor, so that they often accepted prosodically altered sentences as having been heard before. When they were explicitly instructed to attend to prosody, their performance improved with the contrastive focus pairs (though their performance with other types of prosodic information did not). This lesser memory performance could have arisen from less efficient perceptual processing of accentual structure by the nonnative listeners, but the results provide no direct information about such processing.

Studies of native perception show that there are two sides to listeners' processing of accentual structure. First, accented syllables themselves receive rapid processing. Word-initial phonemes are detected more quickly, and mispronunciations are spotted more easily, in words which bear sentence accent than in words which do not (Shields, McHugh and Martin, 1974; Cutler and Foss, 1977; Cole, Jakimik and Cooper, 1978). Since accent increases word duration (Klatt, 1976; van Santen and Olive, 1990; Eefting, 1991; Dahan and Bernard, 1996) and leads to greater spectral clarity (Koopmans-van Beinum and van Bergem, 1989), accented syllables are often acoustically clearer and hence easier to process at relatively early levels. But the processing advantage of accented words is not solely due to such factors, because the second noteworthy aspect of accent processing is that listeners actively direct attention to parts of an utterance where

accent will fall. In a phoneme-detection study by Cutler (1976), sentences were recorded in two prosodic versions, one in which the target-bearing word bore contrastive accent (e.g. (3a)) and one in which contrastive accent fell elsewhere (e.g. (3b)).

- (3) *Target /b/*
- a. The couple had quarrelled over a BOOK they had read.
  - b. The couple had quarrelled over a book they hadn't even READ.

The target-bearing word itself (i.e. *book*) was then edited out of each version and replaced by acoustically identical copies of the same word taken from a third recording of the same sentence, in which no contrastive accents occurred. This procedure produced two versions of each experimental sentence, with acoustically identical target-bearing words but different prosodic contours on the words preceding the target: in one case the prosody was consistent with sentence accent occurring at the location of the target, in the other case it was consistent with accent falling elsewhere. Listeners detected the target in the "accented" position significantly faster than the target in the "unaccented" position. Since there were no acoustic differences between the target words themselves, and the preceding context differed only in prosody, the listeners must have been using prosodic information to predict where accent would occur.

This advantage for words with predicted accent is robust, appearing also when pitch variation is removed (Cutler and Darwin, 1981); only direct conflict between different prosodic cues (e.g. rhythm suggesting accent on the target-bearing word, in the presence of pitch cues to a different accent placement) can remove the advantage (Cutler, 1987), suggesting that such exploitation of prosodic structure is highly sensitive to the consistency of the separate prosodic dimensions.

The predicted-accent effect in phoneme detection links accentual processing to semantic processing, because it is directly paralleled by an effect of semantic focus. Cutler and Fodor (1979) showed this in a study in which they manipulated focus by means of a question preceding the sentence in which the target occurred. Preceding an utterance with a question can determine focus within that utterance (Selkirk, 1995). For instance, (4a) might be preceded by either of the questions (4b) or (4c).

- (4) *Target /b/*
- a. The man on the corner was wearing the blue hat.
  - b. Which hat was the man wearing?
  - c. Which man was wearing the hat?

Although in Cutler and Fodor's study the sentence itself was acoustically identical whichever question preceded it, the focussing manipulation had a strong effect: targets were detected more rapidly when the words they began

answered the question. In (4a), the /b/ of *blue* was thus detected faster when the sentence was preceded by (b) than when it was preceded by (c). The /k/ of *corner* could also be a specified target; it was then detected faster after (c) than after (b).

Cutler and Fodor suggested that the predicted-accent effect and the effect of question-induced focus actually comprise two aspects of the same processing operation, namely a search for the semantically most central portion of a speaker's message. Listeners find it worthwhile to exploit cues in the prosodic contour preceding an accent to locate as rapidly as possible the points at which accent falls, and the reason for this is that accent falls on semantically central, i.e. focussed, words and listeners must identify the focus of an utterance in order to understand the import of what the speaker has said. Indeed, other research findings suggest that focussed words actually receive more detailed semantic processing. Thus multiple meanings of homophones are activated if the words are in focus, but not necessarily if the words are not in focus (Blutner and Sommer, 1988). Retention of the surface form of a word in memory is more likely if the word was in focus in a heard sentence than if it was not (Birch and Garnsey, 1995). All this suggests that rapid and effective processing of the accent placement in an utterance contributes to efficient comprehension of meaning.

The present investigation uses the predicted-accent effect and the question-induced focus effect to examine nonnative perceptual processing of the semantic information conveyed by sentence accent. The nonnative listeners tested in our study are native Dutch speakers presented with their second language, English. This comparison allows a strong test of whether nonnative processing is as efficient as native processing, because the prosodic structures of the two languages are very similar (Gussenhoven, 1983; Gussenhoven and Broeders, 1997; Trommelen and Zonneveld, 1999). Lexical stress assignment rules are virtually identical across the two languages (Trommelen and Zonneveld, 1999), and intonational contours have similar structure (though they may be realised within different pitch ranges; de Pijper, 1983). Previous reports of differences between the two languages in the realisation of lengthening (Eefting, 1991; Turk and Sawusch, 1997) have been argued to result from differences in experimental design; when English and Dutch are examined in the same way, accentual realisation is parallel (Cambier-Langeveld and Turk, 1999). Most importantly, in both languages the same rules for accent assignment apply, which "take focus markings as input and give surface structures with sentence accents on particular words as output" (Gussenhoven, 1983, p. 151).

The accenting of focussed words has some claim to universality: Bolinger (1978) lists the highlighting of salient information as one of only two true prosodic uni-

versals (the other being a relationship of prosody to syntactic breaks). Nevertheless, differences across languages in the expression of focus do exist – thus variation in word order in languages such as Italian or Catalan may express the same focus contrasts which result in variation in accent placement in English (see Vallduví, 1992; Ladd, 1996), and in languages such as Korean and Japanese, which do not use intonationally determined pitch accents, other prosodic effects, such as local pitch range expansion and dephrasing, are functionally analogous to accenting and deaccenting in English (Venditti, Jun and Beckman, 1996). Importantly for our study, however, no such differences have been reported for English and Dutch. Thus there is every reason to believe that the Dutch nonnative listeners should have available to them the same routines for processing accent for focus structure as we assume English listeners have, so that we can test nonnative prosodic processing under conditions which are free of influence from L1/L2 mismatches in phonological structure.

Our investigation consisted of two parts. First, we carried out a direct test of the proposal of Cutler and Fodor (1979), described above, that there is a common origin of the two observed effects, whereby listeners direct attention to accented words and show processing advantage for words focussed by a question. This proposal implies that the two effects are not orthogonal, because they both deliver the same information. When one is present, then, the addition of the other should not produce a statistically significant difference. Experiment 1, a much larger experiment than those originally conducted by Cutler (1976) and Cutler and Fodor (1979), thus tested the two effects simultaneously in a single listener group, given that this direct comparison had not previously been undertaken. Experiment 2 was a complete replication of Experiment 1 in Dutch, with Dutch native listeners, in order to establish the processing effects in the native language of our nonnative listeners and thereby rule out any possibility that asymmetry between English listeners' and Dutch listeners' processing of English could arise from inappropriate application of L1 processing strategies in the latter case. The second part of the investigation addressed the relationship between the predicted-accent effect and the question-induced focus effect in nonnative listening; thus in Experiments 3 and 4, the English materials of Experiment 1 were presented to Dutch listeners.

### Experiment 1

The dependent variable in all experiments was reaction time (RT) to the target phoneme. Independent variables were (1) predicted accent on the target-bearing word (+/-), as provided by the prosodic contour surrounding the target; (2) semantic focus on the target-bearing word (+/-), defined as whether the target-bearing word

Table 1. *Example of a sentence in all eight conditions. Each target-bearing word (dinosaur, Cuban) was acoustically identical in each of the four conditions in which listeners should respond to it.*

		Target focussed	Target unfocussed
TARGET EARLY	Target accented	/d/ Which bones were found by the archaeologist? The bones of the DINOSAUR were found by the Cuban archaeologist.	/d/ Which archaeologist found the bones? The bones of the DINOSAUR were found by the Cuban archaeologist
	Target deaccented	/d/ Which bones were found by the archaeologist? The bones of the dinosaur were found by the CUBAN archaeologist	/d/ Which archaeologist found the bones? The bones of the dinosaur were found by the CUBAN archaeologist.
TARGET LATE	Target accented	/k/ Which archaeologist found the bones? The bones of the dinosaur were found by the CUBAN archaeologist.	/k/ Which bones were found by the archaeologist? The bones of the dinosaur were found by the CUBAN archaeologist.
	Target deaccented	/k/ Which archaeologist found the bones? The bones of the DINOSAUR were found by the Cuban archaeologist	/k/ Which bones were found by the archaeologist? The bones of the DINOSAUR were found by the Cuban archaeologist.

provided the answer to a preceding question. The position of the target-bearing word (early vs. late) also varied systematically; however, this comparison, which arose from the need for two accent/focus positions in each sentence, is not itself relevant to the present study.<sup>1</sup>

### Participants

Forty-eight native speakers of British English without reported hearing impairments participated in the experiment, all students at the University of Birmingham. Each was paid a small sum for taking part. The subjects formed eight groups of six, each presented with a different one of the eight sets of materials.

### Materials

Twenty-four semantically unrelated sentences were constructed (and are listed in full in Appendix I). Twenty

of these were taken from Cutler and Fodor (1979), with a few minor adjustments to British English usage and to the number of syllables preceding the first phoneme target. An example sentence is given in Table 1.

Each sentence contained two possible target phonemes, one in the early part (subject NP) and one in the later part (VP) of the sentence. The phonemes /b/, /d/ and /k/ were used as targets. The syllables in which the target sounds occurred were always lexically stressed, and the position of the targets was always word-initial. The target-bearing words varied in length from one to three syllables. The minimum number of syllables preceding the first target was five (this ensured that listeners had enough material on which to base prosodically motivated predictions). This requirement was responsible for one of the structural properties of the material: early targets occurred almost invariably in a prepositional phrase in the subject noun phrase. Target words were not controlled for frequency, as frequency effects of target-bearing words have not been observed in this task (Foss, Harwood and Blank, 1980; Eimas and Nygaard, 1992).

Both early and late targets could occur in two prosodic contexts. In the first, the intonation contour preceding the target-bearing word predicted an accented target; in the second, the preceding intonation contour predicted a deaccented target; but in both, the target-bearing word was the same acoustic token. To achieve this, each sentence was recorded in three versions: (1) the early target-bearing word accented and the late one deaccented; (2) the early target word deaccented and the late one accented – the reverse of (1); and (3) both targets neither accented nor

<sup>1</sup> Across the four experiments, responses were always faster to later targets than to earlier targets; this is an expected finding in phoneme detection experiments with read-speech materials (Mehta and Cutler, 1988). The effect was never significant with the Dutch materials but sometimes was significant across either subjects or items with the English materials; English words are on average shorter than Dutch words, and the early targets in English were in effect earlier (on average 5.43 preceding syllables for the 23 sentences analysed) than the early targets in Dutch (mean 5.92 preceding syllables). The position effect never interacted with the accent effect, and always interacted with the focus effect (in all experiments, the position effect was greater for unfocussed targets than for focussed); the three-way interaction of these effects was never significant.

deaccented. Then the target-bearing words were edited out of all three versions of each sentence, and the accented and deaccented ones were replaced by identical copies of the target word from (3). This ensured that the two versions did not differ in acoustic realisation of the target, but only in the prosodic contour of the stretch of speech preceding it. In each sentence only the word bearing the specified target was replaced, so that the remainder of the sentence (including the word which bore the target in other versions) was prosodically intact.

For each sentence, two alternative questions were constructed: one that focussed on the first potential target-bearing word, and one that focussed on the second. That is, the target-bearing word either constituted the answer to the question or it did not (in which case the other possible target provided the answer). Thus there were eight versions of each experimental sentence, with all possible combinations of two target positions, two questions and two prosodic contexts. See Table 1 for all eight versions of the sentence *The bones of the dinosaur were found by the Cuban archaeologist*.

A further 24 filler sentences were constructed, which either contained target-bearing words differing in type and position from those in the experimental sentences, or contained no occurrence of a specified target. Fillers were also preceded by focussing questions. The fillers were recorded in only two versions: once without contrastive accent, and once with accent (with targets in half the cases on the target-bearing word, in half elsewhere in the sentence). As with the experimental sentences, the target-bearing word from the recording without contrastive accent was spliced into the prosodic context of the other recording. Appendix II gives the complete set of filler materials. All materials were recorded onto Digital Audio Tape in a sound-attenuated booth by a male native speaker of British English. The cross-spliced versions were then made with speech editing software; splices were always made at a zero-crossing on the release of the stop consonant burst, located from both auditory and visual information.

Eight complete sets of materials were constructed, each containing all fillers and a different version of each experimental sentence. The experimental sentences occurred in the same position in each set; target position, focus position and prosodic context were counter-balanced across sets. Further, it was ensured that subjects were presented with no more than three instances in succession of the same phonemic target, the same target position, focus position, prosodic context or type of trial (experimental or filler).

### **Procedure**

The experiment was conducted in the psycholinguistic laboratory of the University of Birmingham's Behavioural Brain Science Center. Subjects were tested individually in

a sound-attenuated booth. Subjects were informed that they were participating in an experiment on sentence comprehension. Written instructions told them to pay careful attention to the content of the sentences, as they would be tested on them at the end of the experiment. In addition, they were asked to listen within the sentences for the occurrence of the target sound specified for that sentence and to press a button as soon as they heard a word beginning with that sound. The sentences were presented binaurally over headphones.

Each sentence was preceded by the target specification (which appeared on the screen for one second), two seconds of silence, one of the two questions for that sentence and another two seconds of silence. After sentence end and response, a new trial started after approximately one second. A timer in a portable computer running NESU experimental control software was automatically started at the beginning of the sentence and was stopped when the subject pressed the button. The computer recorded the time for each subject to respond. Afterwards, the interval between the onset of the sentence and the onset of the target phoneme was subtracted from this reaction time.

Since the subjects had been encouraged to attend to the materials by the warning that a post-experiment test would be administered, such a test was indeed carried out. It consisted of a short written form requiring a choice among four alternatives replacing one word in each of 32 sentences. These were 32 of the 48 experimental sentences; in half of these the subjects were deciding about words that had been early targets, in half they were deciding about words that had been late targets; in half of the cases, the words in question had been target-bearing words, in half they had not. The position of the correct alternative was varied. All subjects were told about the purpose of the experiment after participating.

After data collection it was noticed that in one sentence (*The value of the bonds was altered with the devalued currency*) the speaker had realised the target-bearing word *devalued* in different ways in the "accented" and "deaccented" readings – with stress on the second syllable in the former case, and stress on the first syllable in the latter. Although the target-bearing version of *devalued* was always the same, and these differing words were only present in the versions of the sentence with the first target (/b/ of *bonds*), it was felt that this difference added an unwanted source of variation in the prosodic contour. This sentence was therefore excluded from the results analyses.

### **Results and discussion**

The overall mean of correct answers to the recognition test was 60%. This was lower than expected from previous research, and in fact not significantly different from

chance; however, note that RTs were fast (mean: 394 ms) in comparison to other phoneme detection studies using similar sentence materials (with overall mean RTs of 373 ms (Cutler, 1976), 381 ms (Cutler and Fodor, 1979) – both American English, and 425 ms (Cutler and Foss, 1977), 452 ms (Cutler and Darwin, 1981) and 468 ms (Nix, Mehta, Dye and Cutler, 1993) – all British English). Also, the present test was longer (32 items) than those used in earlier studies (24 items), and it may have been more difficult, in that items that occurred in one sentence were sometimes used as alternatives to choose from in another one.

Mean RTs were computed across conditions for subjects and items, and separate analyses of variance were carried out on these data; an additional factor of subject group (the eight materials sets) was included in the analysis by subjects. Responses shorter than 100 ms or longer than 1500 ms were discarded. No subject was responsible for more than five (out of 23) missed or discarded responses, and no item elicited more than five (out of 48) missed or rejected responses. Missing trials were replaced by subject or item mean for the condition in question.

The subject groups did not differ significantly. There were, however, robust main effects of the two independent variables. Accented targets (mean RT 369 ms) were detected significantly faster than deaccented (mean RT 418 ms;  $F_1 [1,40] = 38.69, p < .001$ ;  $F_2 [1,22] = 24.51, p < .001$ ), and focussed targets (mean RT 372 ms) were detected significantly faster than unfocussed (mean RT 416 ms;  $F_1 [1,40] = 17.12, p < .001$ ;  $F_2 [1,22] = 17.15, p < .001$ ). The focus effect interacted with the predicted-accent effect ( $F_1 [1,40] = 6.29, p < .02$ ;  $F_2 [1,22] = 5.79, p < .025$ ).

Two-tailed *t*-tests examined the components of the focus by accent interaction.<sup>2</sup> The predicted-accent effect was smaller for focussed words (22 ms;  $t_1 [47] = 2.08, p < .05, t_2 [22] = 2.33, p < .03$ ) than for unfocussed words (65 ms;  $t_1 [47] = 5.43, p < .001, t_2 [22] = 4.94, p < .001$ ). Of the 48 participants, 33 showed a larger accent effect for unfocussed than for focussed targets ( $z = 2.45, p < .01$ ).

Thus this study replicated the previously observed advantage in phoneme detection response time of predicted accent on the target-bearing word and of focus on the target-bearing word. Accented targets were responded

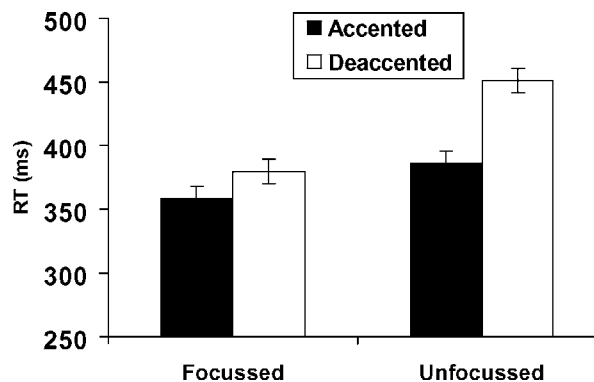


Figure 1. Mean response times (ms) in Experiment 1 (English listeners and English materials) for the effect of predicted accent as a function of focus.

to faster than deaccented ones; as the sentences only differed in the suprasegmental contour prior to the target-bearing word, listeners must have made use of the information in this contour to predict where the sentence accent would fall. Targets in focussed position were detected faster than targets in unfocussed position; this implies that listeners had, as instructed, comprehended the question, since this determined what was new information in the sentence and hence guided them to the sentence focus. Note that further evidence for processing of the question can be seen in the fact that reaction times were faster when the question had focussed upon the earlier part of the sentence (379 ms) than when it had focussed upon the later part (409 ms), irrespective of the target position. This difference may reflect completion of the question-answering task in the former case, freeing processing capacity for other tasks (Cutler and Fodor, 1979, *p.* 55).

The main interest in the present study, however, was in the relationship between the two effects of focus and of predicted accent when they were, for the first time, given the opportunity to interact. Figure 1 depicts the relationship between the two effects. Though both effects were strong, they were not orthogonal: the presence of focus shrank the predicted-accent effect by more than half. In other words, when listeners are given semantic cues as to where to find the new information in an utterance, the search for accent has less to offer. This, in turn, is consistent with the proposal of Cutler and Fodor (1979), that predicting sentence accent on the basis of prosodic information and predicting sentence focus on the basis of semantic information are processes which are directed towards the same goal.

Before examining these two effects in nonnative listening, we asked whether a similar pattern of effects would appear in Dutch. Experiment 2 replicated Experiment 1, except that it was conducted in Dutch, with Dutch listeners.

<sup>2</sup> These *t*-tests assess the crucial interaction, and for theoretical reasons we chose to carry them out on the accent effect as a function of focus. The effect of manipulating focus by means of a question is semantic in nature, and the hypothesis being tested is that the accent effect is also semantic in nature. Although we could in theory have analysed the strength of the focus effect as a function of accent instead, it seems to us much less defensible to argue that the question-determined focus effect could be accentual in nature (i.e. listeners would be searching for the answer to a question in order to direct attention to words which bear accent).

## Experiment 2

### Participants

Forty-nine native speakers of Dutch, students at the University of Nijmegen and all with normal hearing, took part in return for a small payment. The responses of one participant with a very high error rate were not analysed; of the remaining 48, six heard each of the eight materials sets.

### Materials

A new set of sentences was devised in Dutch, patterned as closely as possible in length, plausibility and syntactic structure on the materials of Experiment 1. The same three phonemes were used as targets: /b/, /d/ and /k/; all are highly frequent onset phonemes in Dutch as in English. Again, target-bearing words occurred (a) in either of two positions in the sentence (early vs. late), and (b) in either of two prosodic contexts (one predicting accent on the target, the other deaccentuation on the target as a result of accent on the alternative target), and were (c) preceded by either of two questions (one focussing on the target, the other not focussing on the target), so that each sentence occurred in eight different versions. Again there were eight material sets, with each set containing a different version of each experimental sentence. Appendix III contains the Dutch experimental sentences and Appendix IV the fillers.

The sentences were recorded in the same manner as before, by a male native speaker of Dutch without regional accent. The experimental and filler sentences were again digitised and spliced as in Experiment 1.

### Procedure

The subjects were tested at the Max Planck Institute for Psycholinguistics up to four at a time in individual carrels in a group experiment room. They received instructions in Dutch with the same content as the English instructions of Experiment 1. The materials were presented binaurally over headphones. The timing of events in this experiment was the same as that in Experiment 1. A post-experiment recognition test was again administered, with the same design as in Experiment 1, but containing 20 items rather than 32. Words that had occurred in other sentences of the experiment were not this time used as multiple-choice alternatives; these changes were intended to render the recognition test less difficult than the English test had apparently been.

### Results and discussion

The mean score on the recognition test was 77.5%, suggesting that the shorter test, with its less confusing alternatives, was indeed easier than the test in Experiment 1.

Mean RTs across subjects and across items were calculated in the same manner as for Experiment 1. No subject

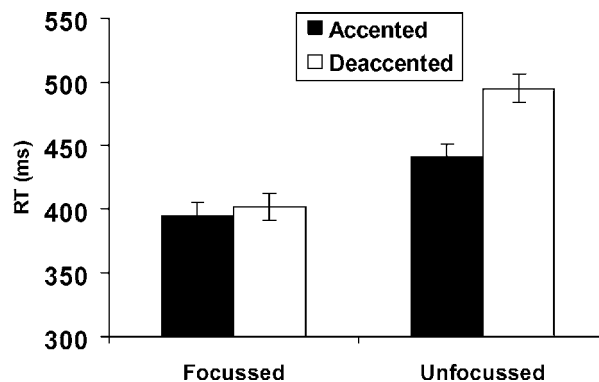


Figure 2. Mean response times (ms) in Experiment 2 (Dutch listeners and Dutch materials) for the effect of predicted accent as a function of focus.

was responsible for more than four (out of 24) missed or discarded responses, and no item elicited more than six (out of 48) such responses. Missing responses (5.6% of all data points) were replaced as before, and the data analysed in the same manner as before.

As in Experiment 1, the subject groups did not differ significantly, and both main effects of interest were significant (focussed 398 ms vs. unfocussed 468 ms:  $F_1 [1,47] = 52.92$ ,  $p < .001$ ,  $F_2 [1,23] = 23.18$ ,  $p < .001$ ; predicted accent 418 ms vs. deaccent 449 ms:  $F_1 [1,47] = 14.99$ ,  $p < .001$ ,  $F_2 [1,23] = 4.75$ ,  $p < .04$ ), and the crucial interaction between them was also significant across subjects ( $F_1 [1,47] = 4.59$ ,  $p < .04$ ,  $F_2 [1,23] = 3.67$ ,  $p < .07$ ). The predicted-accent effect was 54 ms in the unfocussed condition but only seven ms under focus. T-tests showed the former difference to be significant ( $t_1 [47] = 3.44$ ,  $p < .001$ ;  $t_2 [23] = 3.66$ ,  $p < .001$ ) but the latter difference not (both  $t_s < 1$ ). Thirty-three of the 48 participants showed a larger accent effect in unfocussed than in focussed position ( $z = 2.45$ ,  $p < .01$ ).

Experiment 2 thus suggests that the aspects of sentence processing which are at issue in this study pattern very similarly in English and in Dutch. Response times were once again faster to accented than to deaccented words, implying that the Dutch subjects, too, made use of the information provided by the prosody of the sentence to direct their attention to the location of the sentence accent. Words in focussed position, as determined by the preceding question, also elicited faster response times than words in unfocussed position, suggesting that the subjects' processing of sentence semantics was driven by the question context, and that they directed attention to the location of the sentence focus. Further, RTs were again faster (431 ms) when focus occurred early rather than late (467 ms), regardless of target position. And, just as in Experiment 1, the presence of focus reduced the predicted-accent effect to a fraction of its size without focus, again in accord with the suggestion that the accent prediction effect involves a search for new information (see Figure 2).

English and Dutch listeners are very similar with respect to the way they process accent and focus information during sentence comprehension in their native language. On the basis of this parallelism, the third experiment examined the processing of accent and focus information in nonnative listening. To provide the strongest possible comparison of nonnative with native listening, we tested the same subject group for whom we had collected native listening data in Experiment 2.

### Experiment 3

#### Participants

The participants in Experiment 3 were the same as those who had taken part in Experiment 2. Note that no test of proficiency in English was administered, as the participants were undergraduates and thus necessarily had a level of English proficiency adequate for listening to English sentences of the kind used in the study. For admission to Dutch university, ability to follow lectures in English is required. Most Dutch students are exposed to spoken English, e.g. through the media, on a daily basis.

#### Materials and procedure

The materials and recognition test were those used for Experiment 1; the procedure and testing environment were as for Experiment 2, except that instructions were delivered in English. All participants had first completed the Dutch experiment, then returned after an interval of on average 7.5 days to take part in the English experiment. Participants were assigned to materials sets in order of arrival and no attempt was made to match set participation across the Dutch and English experiments.

#### Results and discussion

The mean score on the recognition test was 72%. No subject was responsible for more than five (of 23) missed or discarded responses, and no item for more than five (of 48) such responses. As in Experiment 1, the sentence *The value of the bonds . . .* was excluded from the analysis. Missing responses (4.9% of all data points) were replaced as before, and the data analysed in the same manner as for Experiments 1 and 2. Figure 3 displays the condition means.

Again there was no significant difference between groups hearing different materials sets. However, although the main effects of interest were in the same direction as in Experiments 1 and 2, in fact neither here reached significance (focussed 455 ms vs. unfocussed 474 ms:  $F_1 [1,47] = 2.88, p = .09, F_2 [1,23] = 2.85, p > .1$ ; predicted accent 456 ms vs. deaccent 473 ms:  $F_1 [1,47] = 2.46, p > .1, F_2 [1,23] = 2.45, p > .1$ ); the crucial interaction

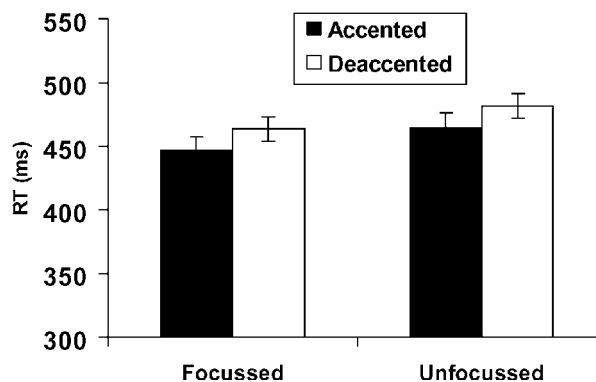


Figure 3. Mean response times (ms) in Experiment 3 (Dutch listeners and English materials) for the effect of predicted accent as a function of focus.

between them did not approach significance (both  $F_s < 1$ ). The predicted-accent effect was 17 ms in both focussed and unfocussed conditions, and significant on t-tests in neither condition (all  $t_s$  between 1 and 2). Twenty-three of the 48 participants showed a larger accent effect in unfocussed than in focussed, 25 did not.

A joint (within-subjects) analysis of Experiments 2 and 3 revealed a main effect of Experiment ( $F_1 [1,47] = 7.55, p < .01, F_2 [1,45] = 6.79, p < .02$ ), indicating that the present group of subjects responded more rapidly in their native than in their nonnative language. Any practice effect for these subjects across the two experiments was thus insufficient to compensate for the fact that their second experiment involved nonnative listening. In the joint analysis the effects of accent and focus were again significant; the accent effect did not interact with Experiment, but the focus effect did ( $F_1 [1,47] = 10.46, p < .01, F_2 [1,45] = 6.53, p < .02$ ). The accent-focus interaction was not itself significant ( $F_1 [1,47] = 3.87, p < .06, F_2 [1,45] = 2.34, p > .1$ ), and nor was the three-way interaction of accent, focus and Experiment ( $F_1 [1,47] = 2.22, p > .1, F_2 [1,23] = 1.0$ ).

The results of this experiment are both surprising and disappointing. No significant effect either of predicted accent or of focus was observed when these subjects were listening to a nonnative language, although in their native language the same listeners had shown significant effects of both factors. This could mean that nonnative listening is in many ways much less efficient than native listening. However, the performance of these listeners was not so poor: the RTs (grand mean 465 ms) would not have been considered slow for a native listener group, the error rate was low, and the performance on the recognition test was better than the native English listeners achieved. We suspect that an alternative conclusion is warranted: namely that the fact that the English and Dutch experiments were essentially the same, except for the form and content of the stimulus materials, played a



role in the pattern of responses in Experiment 3. Even though some time intervened between administration of the two experiments, the subjects seem to have learned from their first experiment and applied this learning when participating in their second experiment. Specifically, they seem to have learned that neither of the two experimental tasks – detecting the target phonemes, and correctly identifying in the recognition test words they had indeed heard – in fact required attention to the question preceding each test sentence. The insignificance in Experiment 3 of the effect of focus, highly robust in Experiments 1 and 2, as well as in predecessor experiments involving this manipulation, strongly suggests that in Experiment 3 the listeners in large part ignored the question.

The absence of significant focus effects in turn means that there is no scope for such effects to modulate other aspects of sentence processing – in other words, the data of Experiment 3 effectively fail to address the hypothesis under test. It is apparently not possible to collect exactly comparable data in the current task in two languages from the same listener group; it would be necessary to alter some part of the experimental design, thus losing direct comparability, and in any case performance in the second experiment would be subject to influence in many ways from knowledge acquired in the first.

Accordingly, we chose to carry out the study as a between- rather than within-subjects comparison of nonnative with native listening. In Experiment 4, the materials of Experiment 1 were presented to a new group of listeners from the same population as used in Experiment 3.

## Experiment 4

### *Participants*

Forty-eight native speakers of Dutch participated, all students at the University of Nijmegen. All had normal hearing and none had taken part in Experiments 2 or 3. They were paid a small sum for their participation. Six heard each materials set.

### *Materials and procedure*

The materials and recognition test of this experiment were again those used in Experiment 1. The procedure and testing environment were as for Experiment 3, except that the subjects were instructed as in Experiment 2, i.e. in their native language (although all examples in the instructions were of course given in English).

### *Results and discussion*

The overall mean score on the recognition test was 60% correct, the same score as that of the English listeners.

Mean RTs were calculated per condition across subjects and items and analyses of variance performed as before. RTs shorter than 100 or longer than 1500 ms were excluded. No subject was responsible for more than 5 (of 23) missed or discarded responses, and no item for more than 7 (of 48) missed or rejected responses.

Again the subject groups did not significantly differ. Both the critical independent variables reached significance: Accented targets (mean RT 465 ms) were again responded to faster than deaccented (mean RT 506 ms;  $F_1 [1,40] = 13.76, p < .001$ ;  $F_2 [1,22] = 17.95, p < .001$ ) and focussed targets (mean RT 457 ms) were detected faster than unfocussed (mean RT 514 ms;  $F_1 [1,40] = 22.46, p < .001$ ;  $F_2 [1,22] = 14.54, p < .001$ ). The crucial interaction between focus and predicted accent did not approach significance (both  $F_s < 1$ ). The predicted-accent effect was 36.16 ms under focus and 45.65 ms for unfocussed targets, a ratio of one to one and a quarter, far lower than the one to more than two ratio of the two native-listener experiments. For comparison with the earlier experiments, we analysed the predicted-accent effect separately for the two focus conditions via t-tests; in both, the effect was significant ( $t_1 [47] = 2.57, p < .02$ ,  $t_2 [22] = 2.63, p < .02$  under focus,  $t_1 [47] = 2.94, p < .01$ ,  $t_2 [22] = 2.47, p < .025$  unfocussed). Of the 48 participants, 27 showed a larger accent effect for unfocussed than for focussed targets and 21 showed the reverse (a nonsignificant difference).

Although the RTs were again slower than those of the native English listeners with the same materials (a grand mean of 485 ms, about 90 ms slower than in Experiment 1), the results again showed evidence of high English proficiency on the part of these nonnative listeners: error rates were again low (6.0%), RTs again fell within a range normal for native speakers in such experiments, and performance on the recognition test in this case paralleled that of the native English listeners.

As expected from Experiments 1 and 2, RTs were faster when targets were focussed rather than unfocussed. For the purposes of locating the answer to a question, semantic cues to focus thus can be exploited effectively by both native and nonnative listeners. Also, RTs were faster when targets were in accented rather than deaccented position. The ability to exploit the prosodic structure of speech input, and direct attention to accented words, may carry over well from the native language to a prosodically similar nonnative tongue.

What was different for this group of listeners (though in this case the same as for the nonnative group of Experiment 3) was that the presence of focus did not significantly influence the size of the accent effect; the relevant comparison is shown in Figure 4. The processing advantage for accented words was as significant with as without focus. Because listeners from the same population showed a reduction in the size of the accent effect when

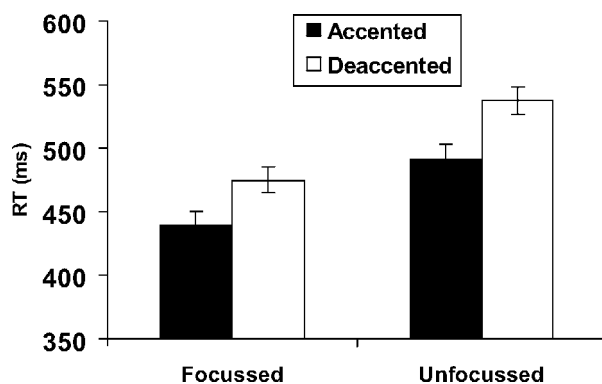


Figure 4. Mean response times (ms) in Experiment 4 (Dutch listeners and English materials) for the effect of predicted accent as a function of focus.

focus was present in Experiment 2, the lack of such a reduction in the present experiment must be the result of the subjects' comprehending a language that is not their own. Apparently, the construction of semantic structure does not proceed as efficiently for nonnative as for native listeners.

A joint analysis of Experiments 3 and 4 showed no main effect of Experiment: participants in Experiment 3 responded more rapidly (grand mean 465 ms) than those in Experiment 4 (485 ms), but not to a significant extent. The main effects of focus and of predicted accent were again both significant; the latter did not interact with the factor Experiment, but the focus effect did ( $F_1 [1,94] = 5.99, p < .02, F_2 [1,22] = 5.94, p < .03$ ), showing that the 57 ms effect of focus in Experiment 4 represented a significant increase over the 19 ms effect shown by the Experiment 3 group. The interaction of focus and predicted accent was insignificant, as was the three-way interaction of these two factors with the factor Experiment (all  $F_s < 1$ ). The participants in Experiment 4 thus seem to have produced the same pattern of performance as the earlier nonnative group listening to English, except in respect of their semantic processing. Note that the semantic processing at issue here is the on-line construction of a discourse-relevant semantic representation; the simple WORD RECOGNITION performance as measured by performance on the recognition test was better for the subjects of Experiment 3 than for the listeners in Experiments 1 and 4. This is in itself not surprising since in Experiment 3 the subjects were able to draw on prior experience with Experiment 2 to inform them as to what the recognition test would be like; of course, they would hardly have been able to apply this information had they been unable to recognise the words in the sentences. The difference in the focus effect between Experiments 3 and 4 supports our suggestion that in Experiment 3 the listeners simply did not attend to the questions.

Given that both sets of native listeners reacted more rapidly than the nonnative listeners, it might be argued that response speed overall underlies the different result patterns. For example, perhaps only with extra time is there an opportunity for both focus and predicted-accent effects to be fully operative. To test this possibility, we examined the pattern of results in the faster and slower half of the response distribution for each of the experiments separately.<sup>3</sup> In no case was there an indication of a stronger interaction in the faster responses than in the slower. The different pattern shown by the nonnative listeners in comparison with the two native groups therefore seems to reflect not simply their response speed per se, but characteristics of the processing which they apply to speech input; the speed with which they can exploit prosodic cues to semantic structure, and integrate these with other focus-related information, is less than they can achieve in their own language.

### General discussion

In our experiments we have observed highly efficient processing of prosodic structure for semantic information. Nevertheless, the pattern observed with native listeners of English in Experiment 1 was not fully replicated in Experiments 3 and 4 in which nonnative listeners were presented with the same materials, despite the evidence from Experiment 2 that Dutch listeners in principle show the same pattern of effects as English listeners. The asymmetry is consistent with reduced efficiency on the part of the nonnative listeners in the mapping of prosodic information to semantics.

Our results motivate two major conclusions. Most fundamentally, the native listening results of Experiments 1 and 2 support the proposal of Cutler and Fodor (1979) that listeners' active search for accented words has the same motivation as the more rapid processing of focussed words; both serve the interests of efficient apprehension of an utterance's semantic structure. From Cutler and Fodor's proposal we derived the prediction that the focus effect they reported, and the predicted-accent effect originally discovered by Cutler (1976), would, if manipulated in a single experiment, likely prove not to be statistically orthogonal. Experiment 1 confirmed this expectation.

Neither predicted-accent effects nor effects of question-induced focus had previously been established for Dutch, but in Experiment 2 both were seen to hold also for this language, and the relationship between them paralleled that found for English.

<sup>3</sup> In fact, this analysis showed a somewhat larger tendency for the accent effect to differ in the two focus conditions in slower responses than in faster responses, in all of Experiments 1 to 4; however, in no case was a difference between the patterns of the faster versus the slower set statistically significant. We are grateful to Dan Swingley for suggesting this analysis.

The second conclusion is that nonnative listeners cannot equal native efficiency in this mapping of accent to semantics. In Experiments 3 and 4, the English materials of Experiment 1 were heard by Dutch listeners, and with these nonnative listeners the results patterned differently. In Experiment 3, strategic factors most probably vitiated the crucial comparison, but no trace of modulation of accentual processing by semantic processing could be discerned. The absence of such modulation is consistent with the claim that nonnative listeners perform the computations necessary to determine the semantic structure of an utterance less efficiently than native listeners do. In Experiment 4, although both the predicted-accent and focus main effects were significant, there was again no modulation of one by the other – they were statistically orthogonal.

This result must be viewed in the context of the Dutch listeners' overall good performance with the English materials. First, the grand mean of response times in Experiment 3, in which listeners had knowledge of the experimental design to help them, was 465 ms with a standard deviation of 88 ms. In Experiment 4, the slowest of all, the mean RT was 485 ms, with a standard deviation of 103 ms. None of these values would be remarkable in a phoneme detection experiment with native listeners.<sup>4</sup> The grand mean of Experiment 1 was 394 ms, and of Experiment 2 433 ms, both within one standard deviation of the means of Experiments 3 and 4.

Second, the target detection rate of the nonnative listeners differed little from that of the native listeners; in Experiment 1, 4.43% of responses were missed or were outside the analysed range, in Experiment 2, 5.6%, in the experiments with nonnative listeners, 5.9% and 4.9%, respectively. These figures further strengthen the impression that the nonnative listeners had little difficulty processing the English sentences.

Third, the Experiment 4 main effect of focus clearly indicates that the nonnative listeners competently processed the sentences for meaning. The effect of focus consists in faster RTs to targets which form part of the answer to the preceding question than to targets which occur in parts of the sentence presupposed by the question. A significant effect of this variable in the RTs can only occur if the listeners both understand the question and rapidly identify which part of the sentence constitutes the required answer.

And fourth, the main effect of predicted accent in Experiment 4 likewise shows processing competence by the nonnative listeners. Here they could of course benefit from the fact that, as Experiment 2 attested, their native Dutch encourages the same type of processing as English does. In both languages, accent is an expression of semantic focus, and in both languages, cues in the preceding prosodic contour can be exploited to locate in advance where accent will fall. As Experiment 4 showed, the competence of these Dutch subjects was such that those cues could be exploited in the nonnative input to an extent quite parallel with native performance.

Thus when two languages share relevant aspects of phonological structure, second-language listening can be very competent. As we described in the introduction, the mapping of prosodic structure to sentence semantics is highly similar in English and Dutch. Both languages should thus encourage exactly the same types of processing; and indeed, Experiments 1 and 2 showed that native speakers of the two languages produced similar response patterns given parallel materials in their respective mother tongues. Nonetheless, the listening efficiency of nonnative listeners has its limits. A difference with native listening appeared in the very aspect of processing under study here, namely the relationship of the prediction of accent to the computation of focus. In both native listening experiments, the effect of predicted accent was less than half the size under focus than in unfocussed position. In nonnative listening, significant effects of accent under focus were not decreased to a statistically significant extent in comparison to the effect size in unfocussed position.

Our results do not allow us to isolate exactly why the native pattern did not surface in nonnative listening. We see at least three alternative explanations. One is that the nonnative listening proficiency of our subjects varied, with some listeners attaining near-native proficiency and patterning also in respect of the focus-accent relationship like native listeners. The remaining listeners would then simply be poor at listening to English in all respects, including in the processing of prosody and sentence semantics. Since we have no independent measure of English proficiency for the listener group, we cannot rule this explanation out. However, there are grounds to find it unsatisfactory, since we have no reason to believe that our listeners varied across a substantial range of listening proficiency – as described above, their response times were not particularly slow, the variance in the nonnative group was not significantly different from that in the native groups, and their performance on the recognition test was no worse than that of the native listeners. One might predict that less proficient listeners might respond more slowly in phoneme detection; to test this possibility, we carried out an additional analysis comparing the subject-by-subject mean response time in Experiment 4 with the

<sup>4</sup> By comparison, American listeners in the comparable experiment with cross-spliced sentences by Cutler (1976) produced a grand mean RT of 398 ms, American listeners in Cutler and Fodor's (1979) experiment, with unspliced sentences, produced a grand mean of 381 ms, American listeners in another experiment with unspliced sentences by Cutler and Foss (1977) a grand mean of 425 ms, and British listeners in a comparable cross-splicing experiment by Cutler and Darwin (1981) a grand mean of 452 ms.

focus/accnt asymmetry (i.e., the difference in the size of the accent effect for focussed vs. unfocussed targets; a significant relationship would here show up as a high negative correlation, higher mean RT being associated with lesser difference between the accent effect size in the two focus conditions). There was no such relationship ( $r = .025$ ; there was also no such relationship in the other experiments, incidentally).

A second possibility is that prosodic processing cannot be usefully exploited until lower-level processing is completed, and that lower-level processing (phonetic processing, lexical access) proceeds more slowly for nonnative listeners, so that their prosodic processing skills have no chance to be visible in our experiments. This also seems to us unlikely, given evidence from native listening that prosodic processing actually assists phonetic identification and lexical access (see Cutler, Dahan and Donselaar, 1997; Nooteboom, 1997; Cutler, 1998, for reviews).

The third possibility, then, is that prosodic processing itself, and the interface of prosodic to semantic processing, differs in native versus nonnative listening. As noted in the introduction, Vanlancker-Sidtis (2003) discovered that even highly proficient nonnative listeners had difficulty exploiting the prosodic cues which distinguished English idioms from non-idiomatic versions of the same word sequences. Likewise, Pennington and Ellis (2000) found poorer memory for prosodically signalled information, including focus contrasts, in nonnative listeners. Our study suggests that this memory asymmetry may have its roots in an earlier processing asymmetry: that is, that the initial processing of prosodic information for semantic structure during sentence comprehension is less efficiently accomplished by nonnative than by native listeners. This claim is consistent with the findings of more detailed semantic processing of focussed material (Blutner and Sommer, 1988; Birch and Garnsey, 1995). Thus comparative inefficiency of nonnative accentual processing could easily carry through to relative depth of processing of the accented words, and their retention in memory.

It could also lead to delay in overall sentence comprehension, which in native listeners is sensitive to accentual structure. Response time to signal comprehension of an utterance is shorter when new information is accented and given information is not, compared with the reverse accent assignment (Bock and Mazzella, 1983). When accent assignment is reversed in this way, listeners judge accenting of given information to be more acceptable than deaccenting of new information (Nooteboom and Kruyt, 1987); however, the presence of an accent on given information can delay sentence comprehension (Terken and Nooteboom, 1987). These findings suggest that efficiency in processing accentual

information brings the native listener substantial payoff in comprehension of semantic structure.

The predicted-accent effect itself is also evidence of highly adept processing of prosodic structure, and, as our present results have attested, this is again apparently in service of semantic processing. Note that the predicted-accent effect is a measure solely of the listeners' ability to exploit cues in preceding prosody to where accent will fall; it is not a measure of the relative ease of processing of accented versus deaccented words themselves. The target words in these cross-spliced sentences were always acoustically identical whether they occurred in a position which had originally held an accented or a deaccented word. Only the prosodic structure of the words surrounding them differed, and it is to these prosodic differences in the surrounding context that the response differences must be attributed. If acoustic correlates of accent are indeed present, the effect on phoneme-detection responses is of course very noticeable: the RT advantage of originally spoken accented over deaccented targets is significantly larger than the advantage of cross-spliced targets in positions predicted to be accented over identical targets predicted to be deaccented (Cutler, 1976), and the RT advantage of originally spoken accented targets over deaccented is also robust under focus (Cutler, 1982).

Our nonnative listeners did show the predicted-accent effect, so they can exploit prosodic structure in their second language; and they did show the focus effect, so they can efficiently process sentence semantics in their second language. What they cannot do is rapidly map between these levels of processing – even though they must, by any other criterion, be reckoned to be highly proficient in that second language, and even though the two languages in question map prosody to semantics in a similar way. The deficiency in mapping between prosody and semantics may reside simply in slower semantic integration speed, itself resulting from such factors as low lexical familiarity and reduced automaticity in multi-word string processing in the second language; if native processing of semantic structure proceeds significantly faster than processing of prosodic structure, so that the second can be switched off where the first has already delivered a result, the asymmetry we observed could imply that nonnative semantic processing cannot outstrip prosodic processing in this way. Alternatively, our result may imply a fail-safe, belt-and-braces approach by nonnative listeners, with two processes delivering the same information nevertheless being allowed to continue in parallel even though one of them may effectively be redundant. In either case, it is clear that reduced efficiency and robustness of nonnative compared with native listening in part involves higher-level processing such as the semantic evaluation of prosodic information.

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4. The mother of two daughters wrote to the boarding school. Which mother was it that wrote to the school? Which school was it that the mother wrote to?
  5. The bones of the dinosaur were found by the Cuban archaeologist. Which bones were found by the archaeologist? Which archaeologist found the bones?
  6. The rising price of boxes worried the dog food manufacturer. Which rising price worried the manufacturer? Which manufacturer was worried at the rising price?
  7. The remains of the camp were found by the deer hunter. Which remains were found by the hunter? Which hunter found the remains?
  8. The group of tourists from Denmark photographed the crocodile wrestler. Which group of tourists photographed the wrestler? Which wrestler was it that the group of tourists photographed?
  9. The attitudes of the businessman aroused his colleagues' anger. Whose attitudes aroused anger? Whose anger did the attitudes arouse?
  10. The watcher on the balcony saw the driver's escape. Which watcher was it that saw the escape? Whose escape was it that the watcher saw?
  11. The company of dancers negotiated with the Broadway agent. Which company negotiated with the agent? Which agent was it that the company negotiated with?
  12. The young man on the corner was wearing the blue hat. Which young man was wearing the hat? Which hat was the young man wearing?
  13. The programme about the Brontes interested the common viewers. Which programme interested the viewers? Which viewers did the programme interest?
  14. The chauffeur of the diplomat refused to pick up the Kenyan representative. Which chauffeur refused to pick up the representative? Which representative was it that the chauffeur refused to pick up?
  15. The owner of the bookshop refused to go to the councillor's party. Which owner refused to go to the party? Which party did the owner refuse to go to?
  16. The flavour of the coffee was ruined by the dirty water. Which flavour was ruined by the water? Which water ruined the flavour?
  17. The woman with the bag went into the dentist's office. Which woman went into the office? Which office was it that the woman went into?
  18. The member of the cabinet was involved in the bombing incident. Which member was involved in the incident? Which incident was the member involved in?
  19. The value of the bonds was altered with the devalued currency. Which value was altered with the currency? Which currency altered the value?
  20. The residents of the district were annoyed at the building plans. Which residents were annoyed at the plans? Which plans were the residents annoyed at?
  21. The manager of the dairy will check on his bank account. Which manager will check on his account? Which account will the manager check on?
  22. The personnel officer of the company interviewed the basketball player. Which personnel officer interviewed the player? Which player was it that the personnel officer interviewed?

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### **Appendix I: English experimental sentences**

1. The villa with the carport must belong to the doctor's widow. Which villa must belong to the widow? Which widow must the villa belong to?
2. The actions of the crew focussed on the dangerous situation. Which actions focussed on the situation? Which situation was it that the actions focussed on?
3. The statement of the crown witness led to the burglar's arrest. Which witness's statement led to the arrest? Which arrest was it that the statement led to?

23. The reporter from the daily paper was responsible for the candid story. Which reporter was responsible for the story? Which story was the reporter responsible for?
24. The suspension of the boy was protested at the college meeting. Whose suspension was protested at the meeting? Which meeting protested the suspension?

### Appendix II: English distractor sentences

1. The army officer was not happy about his posting to the desert war. Which posting was it that the officer was not happy about?
2. The ambassador's wife wanted to order a new dinner table. Whose wife wanted to order a new table?
3. The old folks' club had gone on its regular Friday afternoon bus trip. Which club had gone on its regular trip?
4. The victim of the gang's vicious attack had cuts on his back. Where was it that the victim had cuts?
5. His old Volvo broke down while he was on holiday in Kent. What was it that broke down while he was on holiday?
6. The geology student decided to buy the second-hand car. What was it that the student decided to buy?
7. The ducklings in the pond were fighting for the bread-crumbs. Which crumbs were the ducklings fighting for?
8. The demonstrators at the South African embassy were arrested by the riot police. Who was arrested by the police?
9. The bridge nearest the town was sabotaged by the Libyan terrorists. Which terrorists sabotaged the bridge?
10. The brain surgeon was unable to remove the smallest of the tumours. Who was unable to remove the tumours?
11. The captain of the expedition refused to turn back to the nearest harbour. Which harbour was it that the captain refused to turn back to?
12. The cricket grounds of the village were maintained by the former test match player. What was maintained by the former player?
13. The checking of the ballots was interrupted when the computer failed. Which failure interrupted the checking?
14. The paintings in the gallery turned out to be forgeries. Which paintings turned out to be forgeries?
15. The university vice-chancellor's opinion was reported on the evening news. Which news was it that the vice-chancellor's opinion was reported on?
16. The Member of Parliament was angry about the newspaper's allegation. Which allegation was it that the member was angry about?
17. The Californian senator proposed the motion to dismiss. Which senator proposed the motion?
18. The association of consumers objected to the new delivery procedure. Which new procedure was it that the association objected to?
19. The voice of the caller was hard to hear on the defective telephone. Which voice was hard to hear on the telephone?
20. The road to the Cape was washed out in the tropical rains. Which rains washed out the road?
21. The personnel manager of the department store fired the lazy salesman. Which personnel manager fired the salesman?

22. The rich playboy spent most of his time on his luxury yacht. Which yacht was it that the playboy spent most of his time on?
23. The graffiti in the underground greatly amused the Japanese tourist. Which graffiti greatly amused the tourist?
24. The president of the United States established peace between the Arab nations. Which president established peace between the nations?

### Appendix III: Dutch experimental sentences

1. De mensen van de Bantoestam leefden van de koffiehandel. Welke mensen leefden van de handel? Van welke handel leefden de mensen?
2. De hoogleraar in de biowetenschappen onderzocht het gedrag van knaagdieren. Welke hoogleraar onderzocht het gedrag? Van welke dieren onderzocht de hoogleraar het gedrag?
3. De man met de bril werd onderzocht door de keelarts. Welke man werd onderzocht door de arts? Welke arts onderzocht de man?
4. De dader van de bomaanslag was lid van het Koeweitse leger. Welke dader was lid van het leger? Van welk leger was de dader lid?
5. Het groepje toeristen uit Bern kreeg uitleg over het Deltaplan. Welk groepje toeristen kreeg uitleg over het plan? Over welk plan kreeg het groepje toeristen uitleg?
6. Het clubje archeologen uit België ging graven in het dennenwoud. Welk clubje archeologen ging graven in het woud? In welk woud ging het clubje archeologen graven?
7. Het personeelshoofd van het bankfiliaal kampte met een dollartekort. Welk personeelshoofd kampte met een tekort? Met welk tekort kampte het personeelshoofd?
8. Het artikel over borstkanker kreeg veel kritiek van het damestijdschrift. Welk artikel kreeg veel kritiek van het tijdschrift? Van welk tijdschrift kreeg het artikel veel kritiek?
9. Het gezelschap van dominees ging naar het kloosterfeest. Welk gezelschap ging naar het feest? Naar welk feest ging het gezelschap?
10. Het erelid van het dichtgenootschap schreef over Keltische mythen. Welk erelid schreef over mythen? Over welke mythen schreef het erelid?
11. Het horloge van het dienstmeisje werd aangetroffen op het kermisterrein. Welk horloge werd aangetroffen op het terrein? Op welk terrein werd het horloge aangetroffen?
12. Het statenlid uit Drenthe was niet aanwezig bij het kerstontbijt. Welk statenlid was niet aanwezig bij het ontbijt? Bij welk ontbijt was het statenlid niet aanwezig?
13. Het materiaal van het duikpak werd getest in het Balatonmeer. Welk materiaal werd getest in het meer? In welk meer werd het materiaal getest?
14. Het personeel van het doveninstituut kreeg instructies over het blusapparaat. Welk personeel kreeg instructies over het apparaat? Over welk apparaat kreeg het personeel instructies?
15. Het wielrennersteam uit Denemarken ging op trainingskamp in het bergstadje. Welk wielrennersteam ging op trainingskamp in het stadje? In welk stadje ging het wielrennersteam op trainingskamp?

16. Het actieplan van het dorpscomité richtte zich op bijstandsgezinnen. Welk actieplan richtte zich op gezinnen? Op welke gezinnen richtte het actieplan zich?
17. Het ongeval met het kernafval had rampzalige gevolgen voor het duingebied. Welk ongeval had rampzalige gevolgen voor het gebied? Voor welk gebied had het ongeval rampzalige gevolgen?
18. Het goudgeld uit het koningsgraf werd tentoongesteld in het Delfts museum. Welk goudgeld werd tentoongesteld in het museum? In welk museum werd het goudgeld tentoongesteld?
19. Het ministerie van justitie van Canada nam een voorbeeld aan het Nederlandse dopingbeleid. Welk ministerie van justitie nam een voorbeeld aan het Nederlandse beleid? Aan welk Nederlands beleid nam het ministerie van justitie een voorbeeld?
20. Het programma over krijgswapens was bestemd voor het Duitse televisiestation. Welk programma was bestemd voor het televisiestation? Voor welk televisiestation was het programma bestemd?
21. De inwoners van Kampen ergerden zich aan de bouwplannen van de gemeente. Welke inwoners ergerden zich aan de plannen van de gemeente? Aan welke plannen van de gemeente ergerden de inwoners zich?
22. De eerstejaars studenten kunstgeschiedenis gingen naar de beeldtentoonstelling. Welke eerstejaars studenten gingen naar de tentoonstelling? Naar welke tentoonstelling gingen de eerstejaars studenten?
23. De leden van de Kamer stelden vragen over de beursfraude. Welke leden stelden vragen over de fraude? Over welke fraude stelden de leden vragen?
24. De uitlatingen van de kroongetuige wezen naar de bendeleider. Welke uitlatingen wezen naar de leider? Naar welke leider wezen de uitlatingen?
6. Het Braziliaanse kunstschaatspaar verloor het wereldkampioenschap. Welk Braziliaans paar verloor het kampioenschap?
7. Het schuurtje bij het boswachtershuis was gemaakt van berkenhout. Van welk hout was het schuurtje gemaakt?
8. Het verslag van het skiongeluk was op het avondnieuws. Welk verslag was op het nieuws?
9. De demonstranten op het Binnenhof werden gearresteerd door de oproerpolitie. Door welke politie werden de demonstranten gearresteerd?
10. De leden van de vrouwenvereniging hielden een inzameling voor de slachtoffers van de watersnood. Welke leden hielden een inzameling voor de slachtoffers?
11. De burgemeester van Groningen werd aangehouden voor een snelheidsovertreding. Welke burgemeester werd aangehouden voor een overtreiding?
12. De generaal van de landmacht sneuvelde tijdens de burgeropstand. Tijdens welke opstand sneuvelde de generaal?
13. De Baskische terroristen waren verantwoordelijk voor de moordaanslag. Welke terroristen waren verantwoordelijk voor de aanslag?
14. De blonde vrouw won de schoonheidswedstrijd. Welke wedstrijd won de vrouw?
15. Het dwarsfluitensemble trad op in het schoolgebouw. In welk gebouw trad het ensemble op?
16. Het dameselftal werd achtste op het voetbaltoernooi. Welk elftal werd achtste op het toernooi?
17. Het kustgebied werd getroffen door zware onweersbuien. Welk gebied werd getroffen door zware buien?
18. De kippenboeren protesteerden tegen het nieuwe mestbeleid van de minister. Tegen welk nieuw beleid van de minister protesteerden de boeren?
19. De eenden in de vijver vochten om de restjes brood. Welke eenden vochten om de restjes?
20. De leerlingen van de technische school luisterden naar het vioolconcert van Beethoven. Naar welk vioolconcert luisterden de leerlingen?
21. Het bestuur van het gezondheidscentrum ging naar het congres over donornieren. Naar welk congres ging het bestuur?
22. Het publiek van het safaripark kwam kijken naar het jong van het dwergnijlpaard. Welk publiek kwam kijken naar het jong?
23. De leden van het parlement waren verontwaardigd over de beschuldigingen van de krant. Welke leden waren verontwaardigd over de beschuldigingen?
24. De inwoners van het dorp waren tegen de uitbreiding van de camping. Tegen welke uitbreiding waren de inwoners?

#### **Appendix IV: Dutch distractor sentences**

1. De afdelingschef van het warenhuis ontsloeg de schoenenverkoper. Welke afdelingschef ontsloeg de verkoper?
2. De deelnemer aan de hardloopestafette verrekte zijn kniegewricht. Welk gewricht verrekte de deelnemer?
3. De ondernemers in de transportsector werden de dupe van de oliecrisis. Van welke crisis werden de ondernemers de dupe?
4. De directeur van het chemieconcern wist niets af van het omkoopschandaal. Welke directeur wist niets af van het schandaal?
5. Het trommeltje met het smokkelgoed was verstopt in het graanpakhuis. In welk pakhuis was het trommeltje verstopt?