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The modulation of lexical competition by segment duration

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In an eye-tracking study, we examined how fine-grained phonetic detail, such as segment duration, influences the lexical competition process during spoken word recognition. Dutch listeners' eye movements to pictures of four objects were monitored as they heard sentences in which a stop-initial target word (e.g., *pijp* "pipe") was preceded by an [s]. The participants made more fixations to pictures of cluster-initial words (e.g., *spijker* "nail") when they heard a long [s] (mean duration, 103 msec) than when they heard a short [s] (mean duration, 73 msec). Conversely, the participants made more fixations to pictures of the stop-initial words when they heard a short [s] than when they heard a long [s]. Lexical competition between stop- and cluster-initial words, therefore, is modulated by segment duration differences of only 30 msec.

One of the major objectives of current psycholinguistic research is to unravel the processes involved in the understanding of spoken language. More specifically, how do people recognize words from the speech they hear? Speech is a continuous signal; explicit physical cues to word boundaries are not always available. Nevertheless, even in the absence of explicit word boundary markers, listeners will rapidly identify the discrete words in the speech stream.

Current models of spoken word recognition seek to explain this behavior. An established finding is that as the speech signal unfolds over time, words that are fully or partially consistent with the available acoustic-phonetic information become activated and compete among one another (see McQueen, 2005, for a review). The activation of a given word is thus determined by both its goodness of fit with the input and the activation of other competitors. The outcome of the competition is a parse of the spoken utterance in which each speech sound is attributed to only one word, yielding a sequence of nonoverlapping words. The aim of the present study was to examine whether fine-grained phonetic detail in the speech signal can modulate this lexical competition process.

A growing body of evidence suggests that even very subtle acoustic information can have an impact on lexical activation levels (see McQueen, 2005, for a review). One type of such fine-grained information is segment duration. This has been shown by both off- and online measures to influence lexical interpretation. For example, listeners' offline segmentation judgments of ambiguous sequences are influenced by individual segment duration (Kemps, 2004; Quené, 1992). Using online priming measures, Gow and Gordon (1995) observed evidence for the activation of both *tulips* and *lips* when the listeners heard *two lips*, but no evidence for the activation of *lips* when the listeners heard *tulips*. The word-initial consonants (e.g., the [l] in *two lips*) had longer durations than did the noninitial consonants (e.g., the [l] in *tulips*); the authors concluded, therefore, that segment duration was guiding the listeners' segmentation. Similarly, Spinelli, McQueen, and Cutler (2003) have shown, in a cross-modal priming task, that even though French sequences such as *dernier oignon* ("last onion") and *dernier rognon* ("last kidney") are phonemically identical, French listeners appear to segment such ambiguous phrases correctly—that is, as intended by the speaker. The consonants in liaison environments (e.g., [ʁ] in *dernier oignon*) were shorter than genuine word-initial consonants (e.g., [ʁ] in *dernier rognon*), suggesting once more that fine-grained acoustic details bias the lexical competition in the correct direction.

These studies did not show, in fact, that individual segment duration, and not some other acoustic information, influenced ambiguity resolution. A recent eye-tracking study (Shatzman & McQueen, 2006) showed specific effects of segment duration, however. Dutch listeners' eye movements were monitored as they heard sentences and saw four pictured objects. The participants were instructed to click on the object mentioned in the sentence. In the critical sentences, a stop-initial target (e.g., *pot* "jar") was preceded by an [s], thus causing ambiguity regarding whether the sentence referred to a stop-initial or a cluster-initial word (e.g., *spot* "spotlight"). In these trials, the visual display contained, in addition to the target object, a cluster-initial object, which overlapped with the first two phonemes of the target's cluster-initial counterpart (e.g., *spin* "spider"). The participants made fewer fixations to target pictures (e.g., a jar) when the target and the preceding [s] were replaced by a recording of the target's cluster-initial counterpart than when they were spliced from another token of the target-bearing sentence. Acoustic analyses revealed several differences between the two

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recordings, but only [s] duration correlated with the listeners' fixations (more target fixations for shorter [s]s). In a second experiment, the participants made more fixations to target pictures when the [s] was shortened than when it was lengthened. However, the long [s] did not elicit more cluster-initial word (e.g., *spin*) interpretations: Although the participants in the long-[s] condition looked more often at the cluster-initial objects (in comparison with the short-[s] condition), they also looked more often at the distractors. A long [s] before a stop was, thus, a poorer match for the stop-initial target, but not a better match for the cluster-initial competitor. Because the effect was observed only with the stop-initial words, these data do not show that segment duration directly influences the competition between stop-initial and cluster-initial words.

In the present study, a design was used similar to that in Shatzman and McQueen (2006), except that the critical stimuli were no longer fully ambiguous (e.g., *eens pot/een spot*) and that the overlap of the cluster-initial object with the signal included the vowel following the cluster. For example, the Dutch word *pijp* ("pipe") was preceded by an [s], so that it was temporarily congruent with the cluster-initial word *spijker* ("nail"). The duration of the [s] was manipulated so that it was either short (one standard deviation shorter than the mean duration of [s] in, e.g., *eens pijp* "once pipe") or long (one standard deviation longer than the mean natural duration of [s] in, e.g., *een spijker* "one nail"). If [s] duration modulates the lexical competition process, the proportion of looks to *spijker* (but not to the distractors) should increase, and looks to *pijp* should decrease, for the longer relative to the shorter [s]. In addition, we examined the influence of segment duration on the time course of word recognition.

METHOD

Participants

Thirty Max Planck Institute participant pool volunteers, all native Dutch speakers, were paid for their participation.

Materials

Twenty-six stop-initial Dutch nouns referring to picturable objects (e.g., *pijp* "pipe") were selected as targets. Each target was paired with a cluster-initial picturable noun (henceforth, the *competitor*). The competitor always started with an [s], and the following stop and vowel overlapped with the target word's onset (e.g., *spijker* "nail"). Two additional picturable nouns that were phonologically unrelated to the target and the competitor were assigned to each target/competitor pair. There were no semantic or morphological relationships between the words within each quadruple. The full set of items is presented in the Appendix.

Recording contexts were constructed so that the target was always preceded by an [s] (always in the word *eens*), and the sequences preceding the target or the competitor were otherwise identical (e.g., *ik zou ooit eens pijp willen roken*, "I would like to smoke a pipe some time" and *ik zou ooit een spijker willen kopen*, "I would like to buy a nail"). All the sentences were produced by a female native Dutch speaker in a sound-attenuated booth and were recorded directly onto computer (sampling at 44.1 kHz with 16-bit resolution). Acoustic measurements showed that the average duration of the [s] was 88 msec ($SD = 15$) when it was in word-final position (target context) and 95 msec ($SD = 9$) when it was in word-initial position (competitor context). These values are comparable, albeit with a somewhat smaller difference, to those reported in Shatzman and McQueen (2006), in which a different speaker was recorded. In that study, the average durations of the [s] were 87 and 108 msec in word-final and a word-initial position, respectively. In the present study, the stimuli were created by manipulating the duration of the [s] in the target sentences. For each sentence, two spliced versions were created: In the short-[s] version, the duration of the [s] was approximately one standard deviation lower than its average duration in word-final position, whereas in the long-[s] version, [s] duration was one standard deviation higher than its average duration in word-initial position.

The stimuli were edited using Xwaves speech-editing software. In each sentence, the steady state phase of the fricative was excised, leaving approximately 20 msec of the initial and final portions of the frication noise (subject to small variation due to the restriction of splicing at zero crossings). The steady state phase was replaced by a fragment of steady state [s] frication (from another token), which was either 30 or 60 msec long, resulting in fricatives that had average durations of 73 msec (short version) and 103 msec (long version), respectively. Average duration of the ambiguous sequence (i.e., the [s] and the following stop and vowel) was 260 msec in the short-[s] condition and 289 msec in the long-[s] condition. Average target duration was 360 msec.

Forty-four filler trials were constructed, in which the target was phonologically unrelated to all three distractors. Sentences mentioning the filler targets were produced by the same speaker and were recorded at the same time as the experimental sentences. Line drawing pictures associated with the experimental and filler items were selected from various picture databases.[1]

Procedure and Design

The participants were tested individually. They were first familiarized with the 280 pictures, to ensure that they identified them as intended. The pictures appeared on a computer screen in a randomized order, one at a time, along with their printed names. The participants pressed a response button to proceed to the next picture. After familiarization, the eyetracker (an SMI EyeLink system, sampling at 250 Hz) was mounted and calibrated. The experiment was controlled by a Compaq 486 computer. The pictures were presented on a ViewSonic 17PS screen, and the auditory stimuli were presented over headphones, using NESU software (www.mpi.nl/world/tg/experiments/nesu.html).

Each trial was structured as follows. A central fixation dot appeared on the screen for 500 msec. Then a spoken sentence was presented, and simultaneously, a 5×5 grid with pictures appeared on the screen (see Figure 1). Prior to the experiment, the participants were instructed to use the computer mouse to move the object mentioned in the spoken sentence above or below the geometrical shape adjacent to it. Once the picture had been moved, the experimenter pressed a button to initiate the next trial.

Two lists were created, each containing 26 experimental and 44 filler trials. The lists varied in which of the two versions (i.e., the short-[s] or the long-[s] version) was presented for each of the experimental trials. Within each list, 13 experimental trials were assigned to each condition. Fifteen random orders were created for the lists. There was always at least 1 filler trial between 2 experimental trials. Five filler trials were presented at the beginning of the experiment to familiarize the participants with the task. The participants were randomly assigned to one list.

RESULTS

Using graphical software, the locations of the participants' fixations were displayed as dots superimposed on the four line drawings for each trial and each participant. The timing of the fixations was established relative to the acoustic onset of the [s] preceding the target word. Fixa-

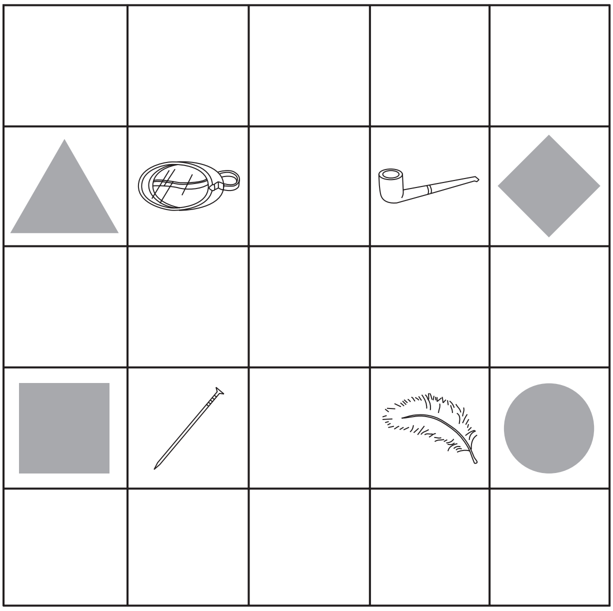

Figure 1. Example of stimulus display presented to the participants. Clockwise from top left corner: *duikbril* "diving mask," *pijp* "pipe," *veer* "feather," and *spijker* "nail."

tions on the line drawings were coded as pertaining to the target, the competitor, one of the two distractors, or anywhere else on the screen. For each trial, fixations were coded from the onset of the [s] until the participant had clicked on the target picture. Three trials were removed from the analysis because the participants erroneously selected a nontarget picture. The proportion of fixations to each picture type was computed by summing trials in which each type was fixated (in each 10-msec slice, in each condition) and dividing the sum by the total number of trials (in the same time interval) in which any picture or location was fixated.

Figure 2 presents the average proportions of fixations to the target, competitor, and distractor pictures, averaged over participants. Fixation proportions to the two distractors were averaged. Fixation proportions are shown in 20-msec time slices from the onset of the [s] preceding the target word to 1,200 msec thereafter.

In both conditions, fixation proportions to the target and competitor pictures began to differ from those to the averaged distractors at around 250 msec after the onset of the [s]. The proportion of fixations to the target began to increase rapidly at 400 msec in the short-[s] condition and 450 msec in the long-[s] condition. Fixation proportions to the competitor rose until 400 msec into the short-[s] condition and 500 msec in the long-[s] condition and then started decreasing, with a shallower slope in the long-[s] condition.

Fixation proportions to each picture type were calculated over a time window extending from 200 to 1,100 msec after the onset of the [s]. Fixation proportions started reflecting significant events in the speech stream after approximately 200 msec (Saslow, 1967). The duration of the window corresponded to the time interval during which fixation proportions to the competitor were higher than fixation proportions to the distractors. ANOVAs on the fixation proportions to the targets were computed by subjects (F_1) and by items (F_2). The average fixation proportion to the target picture was 54% in the short-[s] condition and 49% in the long-[s] condition [$F_1(1,29) = 12.05$, $p < .005$; $F_2(1,25) = 7.63$, $p < .05$]. To compare fixation proportions to the competitors and distractors without violating the assumption of independence between observations, the mean difference between fixation proportions to the competitor and distractor pictures—averaged over participants or items—was computed and compared with zero in one-sample *t* tests. Over the 200- to 1,100-msec interval, the participants looked more at the competitors than at the distractors, in both the short-[s] condition [mean difference, 4%; $t_1(29) = 3.72$, $p < .005$; $t_2(25) = 3.06$, $p < .01$] and the long-[s] condition [mean difference, 8%; $t_1(29) = 7.04$, $p < .001$; $t_2(25) = 3.93$, $p < .005$]. ANOVAs on the mean difference values showed that the difference between the conditions was significant only by participants [$F_1(1,29) = 5.1$, $p < .05$; $F_2(1,25) = 2.69$, $p = .11$].

To study the time course of the influence of segment duration on the competitor's activation, fixation proportions were examined for the interval in which fixations reflected the processing of the target word and in the interval after word offset. The average offset of the target word was roughly 450 msec (433 and 463 msec in the short-[s] and long-[s] conditions, respectively). Allowing 200 msec for saccadic latency, the analyses were therefore performed in the 200–650 and 650–1,100 msec intervals. As the target word unfolded (200–650 msec interval), the participants fixated the competitor more than the distractor in both conditions [6% in the short-[s] condition, $t_1(29) = 2.23$, $p < .05$, and $t_2(25) = 2.68$, $p < .05$; 8% in the long-[s] condition, $t_1(29) = 4.39$, $p < .001$, and $t_2(25) = 3.07$, $p < .01$], but the difference between the conditions was not significant (Fs < 1). In the period after word offset (650–1,100 msec), the competitor was fixated more than the distractor in the long-[s] condition [mean difference, 7%; $t_1(29) = 5.00$, $p < .001$; $t_2(25) = 2.61$, $p < .05$], but only slightly so in the short-[s] condition [mean difference, 2%; $t_1(29) = 2.23$, $p < .05$; $t_2(25) = 1.59$, $p = .13$], yielding a significant difference between the conditions [$F_1(1,29) = 7.67$, $p < .05$; $F_2(1,25) = 4.91$, $p < .05$].

These analyses confirm the impression given by Figure 2 that the activation of the competitor is longer lasting in the long-[s] condition than in the short-[s] condition. Since [s] duration was 30 msec longer in the long-[s] condition, it could be argued that the differences between the conditions were due to the delay in the onset of the target in that condition. However, a reanalysis of the data that corrected for this durational difference did not change the pattern of results.

DISCUSSION

This study demonstrates that fine-grained acoustic detail, such as segment duration, differentially favors lexi-

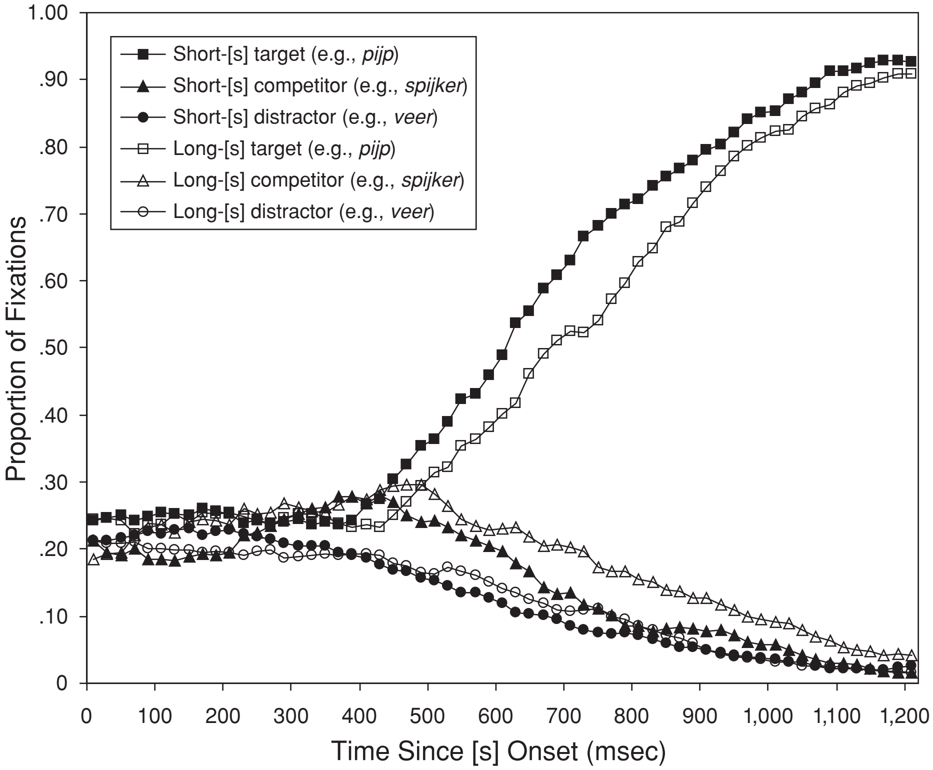

Figure 2. Fixation proportions over time to the target, the competitor, and averaged distractors, in the short-[s] and the long-[s] conditions.

cal candidates, thereby biasing the competition process. The participants' eye movements to four displayed objects were tracked as they listened to sentences in which stop-initial target words (e.g., *pijp* "pipe") were preceded by an [s]. The participants made more fixations to pictures of cluster-initial words, which partially overlapped with the signal (e.g., *spijker* "nail"), when they heard a long [s] than when they heard a short [s]. Conversely, the participants made more fixations to pictures of the stop-initial words when they heard a short [s] than when they heard a long [s].

The present study extends the findings of previous studies (Shatzman, 2004; Shatzman & McQueen, 2006) that have indicated that the interpretation of a fully ambiguous sequence involving an [s] followed by a stop can be influenced by the duration of the [s]. Whereas those studies showed that the interpretation containing a stop-initial word is disfavored when the [s] is long, the present results also show that when the [s] is long, the cluster-initial word interpretation is favored. Furthermore, by using temporarily ambiguous phrases, the present study revealed that the influence of segment duration was detectable long after disambiguating information had been heard. By modulating the competition process, segment duration winnows down the set of candidate words, thus affecting how and when the competition is resolved.

The fact that the effect of segment duration lasted for a relatively long time period can be attributed to two reasons. First, segment duration, being a temporal cue, is likely to be interpreted relative to other durational information in the signal. That is, segment duration is not evaluated in absolute terms, but in relation to both the preceding context and the unfolding signal. Consequently, the effects of a segment's duration may occur only after an amount of information has accrued sufficient for its relative duration to be evaluated. A second, not mutually exclusive, possibility is that the long-lasting effect is due to the dynamics of the lexical competition process. Before disambiguating information is heard, the signal is a better match for the cluster-initial words in the long-[s] than in the short-[s] condition. Lexical activation levels for the cluster-initial words are, therefore, likely to be higher in the long-[s] condition. Once disambiguating information is heard, its effect is immediate, in that fixation proportions to the cluster-initial picture begin to drop in both conditions. However, it takes time for lexical activation levels to return back to baseline, and the higher the activation levels were, the more time is required (assuming that the decay rate is independent of activation levels). Consequently, the difference between the conditions is spread over time, resulting in a long-lasting effect.

One way to incorporate the accumulating evidence regarding listeners' sensitivity to fine-grained acoustic detail involves the notion of prosodic hierarchy: the view that spoken utterances are hierarchically organized, with large prosodic constituents, or domains, consisting of smaller constituents (e.g., Beckman & Pierrehumbert, 1986; Nespor & Vogel, 1986; see Shattuck-Hufnagel & Turk, 1996, for a review). Acoustic-phonetic research has shown that initial segments and syllables in higher level constituents are different, articulatorily and acoustically, from initial segments and syllables in lower domains. Consequently, within a prosodic domain, a domain-initial segment or syllable has different fine-grained phonetic properties from a domain-medial one (e.g., Fougeron, 2001; Fougeron & Keating, 1997; Turk & Shattuck-Hufnagel, 2000). For example, segments in word-initial position tend to be longer than those in word-medial or word-final position (e.g., Klatt, 1974; Oller, 1973; Umeda, 1977). This finding is a result of the fact that a word-initial segment tends to be articulatorily stronger than a word-medial segment, a phenomenon known as domain-initial strengthening.

In a recent cross-modal priming experiment in which domain-initial strengthening was examined (Cho, McQueen, & Cox, in press), listeners heard sentences containing a temporary lexical ambiguity (e.g., the phrase *bus tickets*, containing the embedded word *bust*) and had to make lexical decisions to visual targets. The onset of the phrase's second word (e.g., /tɪ/) was spliced either from a word-initial position or from an intonational-phrase-initial position. When the target was the first word in the phrase (e.g., *bus*), there was more priming when the second word came from an intonational-phrase-initial position than when it came from a word-initial position, demonstrating that listeners may use the acoustic consequences of prosodic strengthening during word recognition. The present results could also be interpreted as indicating that listeners are sensitive to the acoustic correlates of domain-initial strengthening and use these in the segmentation process: A longer [s] provides the listener with evidence that a word boundary is more likely to occur before that [s].

Recent research also suggests that listeners exploit other aspects of the prosodic structure of utterances in the online segmentation of continuous speech (e.g., Davis, Marslen-Wilson, & Gaskell, 2002; Salverda, 2005; Salverda, Dahan, & McQueen, 2003). For example, in a French study (Christophe, Peperkamp, Pallier, Block, & Mehler, 2004), listeners were presented with sentences containing a local lexical ambiguity, such as the phrase *chat grincheux* ("grumpy cat") containing the word *chagrin* ("sorrow"). The listeners were delayed in recognizing the word *chat* in these sentences, in comparison with sentences in which there was no lexical ambiguity, but not if there was a phonological phrase boundary between the two words containing the ambiguity.

The principal finding of the present research is the direct evidence that segment duration modulates the lexical competition process. Furthermore, this effect is quite long-lasting: Fixations to the competitor remained higher in the long-[s] condition for a considerable amount of time. Thus, a 30 msec difference in segment duration resulted in an ongoing effect on lexical competition. The effect of prosodically dependent acoustic detail, therefore, is congruent with the view that spoken word recognition is cascaded: Information percolates continuously to higher level representations and modulates the activation levels of those representations.

REFERENCES

Beckman, M. E., & Pierrehumbert, J. B. (1986). Intonational structure in Japanese and English. In C. Ewen & J. Anderson (Eds.), *Phonology yearbook* (Vol. 3, pp. 255-309). Cambridge: Cambridge University Press.

Cho, T., McQueen, J. M., & Cox, E. A. (in press). Prosodically driven phonetic detail in speech processing: The case of domain-initial strengthening in English. *Journal of Phonetics*.

Christophe, A., Peperkamp, S., Pallier, C., Block, E., & Mehler, J. (2004). Phonological phrase boundaries constrain lexical access: I. Adult data. *Journal of Memory & Language*, **51**, 523-547.

Davis, M. H., Marslen-Wilson, W. D., & Gaskell, M. G. (2002). Leading up the lexical garden path: Segmentation and ambiguity in spoken word recognition. *Journal of Experimental Psychology: Human Perception & Performance*, **28**, 218-244.

Fougeron, C. (2001). Articulatory properties of initial segments in several prosodic constituents in French. *Journal of Phonetics*, **29**, 109-135.

Fougeron, C., & Keating, P. A. (1997). Articulatory strengthening at edges of prosodic domains. *Journal of the Acoustical Society of America*, **101**, 3728-3740.

Gow, D. W., & Gordon, P. C. (1995). Lexical and prelexical influences on word segmentation: Evidence from priming. *Journal of Experimental Psychology: Human Perception & Performance*, **21**, 344-359.

Kemps, R. J. J. K. (2004). *Morphology in auditory lexical processing: Sensitivity to fine phonetic detail and insensitivity to suffix reduction*. Doctoral dissertation, Radboud University Nijmegen (MPI Series in Psycholinguistics, Vol. 28). Wageningen: Ponsen & Looijen.

Klatt, D. (1974). Duration of [s] in English words. *Journal of Speech & Hearing Research*, **17**, 51-63.

McQueen, J. M. (2005). Speech perception. In K. Lamberts & R. Goldstone (Eds.), *The handbook of cognition* (pp. 255-275). London: Sage.

Nespor, M., & Vogel, I. (1986). *Prosodic phonology*. Dordrecht: Foris.

Oller, D. K. (1973). Effect of position in utterance on speech segment duration in English. *Journal of the Acoustical Society of America*, **54**, 1235-1247.

Quené, H. (1992). Durational cues for word segmentation in Dutch. *Journal of Phonetics*, **20**, 331-350.

Salverda, A. P. (2005). *Prosodically-conditioned detail in the recognition of spoken words*. Doctoral dissertation, Radboud University Nijmegen (MPI Series in Psycholinguistics, Vol. 33). Wageningen: Ponsen & Looijen.

Salverda, A. P., Dahan, D., & McQueen, J. M. (2003). The role of prosodic boundaries in the resolution of lexical embedding in speech comprehension. *Cognition*, **90**, 51-89.

Saslow, M. G. (1967). Latency for saccadic eye movement. *Journal of the Optical Society of America*, **57**, 1030-1033.

Shattuck-Hufnagel, S., & Turk, A. E. (1996). A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research*, **25**, 193-247.

Shatzman, K. B. (2004). Segmenting ambiguous phrases using phoneme duration. In *Proceedings of the Eighth International Conference on Spoken Language Processing* (pp. 329-332). Seoul: Sunjin Printing.

Shatzman, K. B., & McQueen, J. M. (2006). Segment duration as a cue to word boundaries in spoken-word recognition. *Perception & Psychophysics*, **68**, 1-16.

Spinelli, E., McQueen, J. M., & Cutler, A. (2003). Processing resyllabified words in French. *Journal of Memory & Language*, **48**, 233-254.

Turk, A. E., & Shattuck-Hufnagel, S. (2000). Word-boundary-related duration patterns in English. *Journal of Phonetics*, **28**, 397-440.

Umeda, N. (1977). Consonant duration in American English. *Journal of the Acoustical Society of America*, **61**, 846-858.

NOTE

1. The pictures are available on request from the first author.

APPENDIX

Target	Competitor	Distractor	Distractor
paard (horse)	spaarvarken (piggy bank)	bezem (broom)	mand (basket)
pak (package)	spar (fir)	kasteel (castle)	tomaat (tomato)
paling (eel)	spatel (spatula)	auto (car)	zaag (saw)
peddel (paddle)	speld (pin)	bok (goat)	radijs (radish)
pen (pen)	specht (woodpecker)	varen (fern)	wekker (alarm)
perzik (peach)	sperzieboon (green bean)	trap (stairs)	vleermuis (bat)
piano (piano)	spion (spy)	gieter (watering can)	rok (skirt)
pijp (pipe)	spijker (nail)	duikbril (diving mask)	veer (feather)
pinguin (penguin)	spinneweb (spider’s web)	lamp (lamp)	raket (rocket)
pizza (pizza)	spier (muscle)	cactus (cactus)	bel (bell)
poes (cat)	spoel (spool)	tulp (tulip)	ei (egg)
poort (gate)	spook (ghost)	anker (anchor)	hooivork (hayfork)
python (python)	spiegel (mirror)	knuppel (bat)	emmer (bucket)
tafel (table)	stadion (stadium)	kikker (frog)	radio (radio)
tas (bag)	stang (rod)	ballon (balloon)	kam (comb)
teckel (sausage dog)	stempel (stamp)	fee (fairy)	piramide (pyramid)
tennisracket (tennis racket)	stekker (plug)	boterham (sandwich)	jurk (dress)
thermometer (thermometer)	ster (star)	pan (pot)	rits (zipper)
toekan (toucan)	stoel (chair)	penseel (paintbrush)	mijter (miter)
ton (barrel)	stofzuiger (hoover)	chocolade (chocolate)	bus (bus)
tor (beetle)	stoplicht (traffic light)	zadel (saddle)	wortel (carrot)
trein (train)	strijkplank (ironing board)	moer (nut)	fopspeen (pacifier)
trommel (drum)	stropdas (necktie)	giraf (giraffe)	kerk (church)
troon (throne)	stroopwafel (syrup waffle)	beker (mug)	koffer (suitcase)
trui (sweater)	struisvogel (ostrich)	fototoestel (camera)	kraan (tap)
tuba (tuba)	stuur (handlebar)	kleed (rug)	libel (dragonfly)

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