How Acoustically Reduced Forms Activate the Lexicon: Evidence from Eye-tracking

Susanne Brouwer[1], Holger Mitterer[2], & Mirjam Ernestus[3]

[1]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, susanne.brouwer@mpi.nl
[2]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, holger.mitterer@mpi.nl
[3]Radboud University & Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, mirjam.ernestus@mpi.nl

Most research on spoken word comprehension has focused on carefully articulated speech that is read aloud by selected speakers (Cutler, 1998). But the type of speech we most often encounter is spontaneous speech, in which no attention is paid to careful pronunciation. The production of a word shorter than its citation form is called reduction, which is highly frequent in casual speech (Ernestus, 2000; Johnson, 2004). The challenge for models of word comprehension is to explain how listeners recognize reduced forms such as [pjutər] which deviate drastically from their canonical counterpart [kɔmpjutər] 'computer'.

Several mechanisms have been proposed to explain the recognition of reduced forms. All reduced forms of a word may have their own lexical representations and recognition just consists of mapping the form on the right representation ([pjutər]) mapped on /pjutər/, Johnson, 2004). In contrast, every word may be lexically represented by just one form, indicating the word's citation form. The reduced form may then be reconstructed to the word's citation form at the pre-lexical level on the basis of fine phonetic detail in the signal (Mitterer & Blomert, 2003). In this study, we investigated the mechanisms involved in the recognition of reduced forms.

Crucially, the two accounts differ in their prediction which lexical candidates act as serious competitors for reduced forms in the recognition process. The exemplar-based account predicts competition especially from words sharing their pronunciation with the reduced form (e.g., [pjupɪl] 'pupil' for [pjutər]). The reconstruction account predicts that the most important competitors are those that are phonologically similar to the word's citation form (e.g., [kɔmpɛnjən] 'companion' for [kɔmpjutər]). We investigated the relevance of the different competitors using the visual-world paradigm (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995), which measures participants' eye movements to printed words closely time-locked to the unfolding speech signal. This eye-tracking paradigm provides a sensitive, continuous measure of competition effects in spoken word recognition.

We created two types of competitors: "underlying" competitors which were similar in pronunciation to the word's citation form and "surface" competitors which were similar to the pronunciation of the reduced form of the target word. For the experimental trials, we displayed an underlying competitor (*competent*, /kɔmpətɛnt/), a surface competitor (*poetsen* 'to clean', /putsə/) and two phonologically unrelated distractors (*juweel* 'jewel', *vakantie* 'holiday') on the computer screen, while participants listened to spontaneous utterances from the Spoken Dutch Corpus (Oostdijk, 2000) containing reduced ([pjutər]) and non-reduced forms ([kɔmpjutər]). Thus, for the critical trials, the target word was never present on the screen. Subsequently, the participants' task was to click in the center of the screen. For the filler trials, one of the written words was present in the utterance. Participants were then asked to click on the word they heard in that utterance.

Figure 1 presents the fixation proportions from target onset (0 ms) to 1400 ms thereafter for the (A) Non-reduced and (B) Reduced forms of the target words. The results for the non-reduced forms show, unsurprisingly, that the underlying competitor, which is most similar to the presented pronunciation of the target word, is overall significantly more activated than the surface competitor. More importantly, during the presentation of the reduced forms, the surface competitors were significantly more strongly activated in the early time window (400-800 ms) than the underlying competitors. This activation reflects an inability to immediately reconstruct the reduced forms to their canonical forms. That is, information in the fine phonetic

detail is not strong enough to block the activation of the surface competitor. In the late time window (800-1200 ms), we observe a strong rise of the underlying competitor. This indicates that restoration of the reduced form based on phonetic detail might occur, but that the process is time-consuming.

In conclusion, the clear activation of both competitors suggests that the comprehension process involves the activation of both the citation form and reduced representations, whereas previous studies have only been able to document a role for the citation form (e.g., Ernestus, Baayen & Schreuder, 2002). This study is the first to show that surface competitors also contribute to the recognition process.
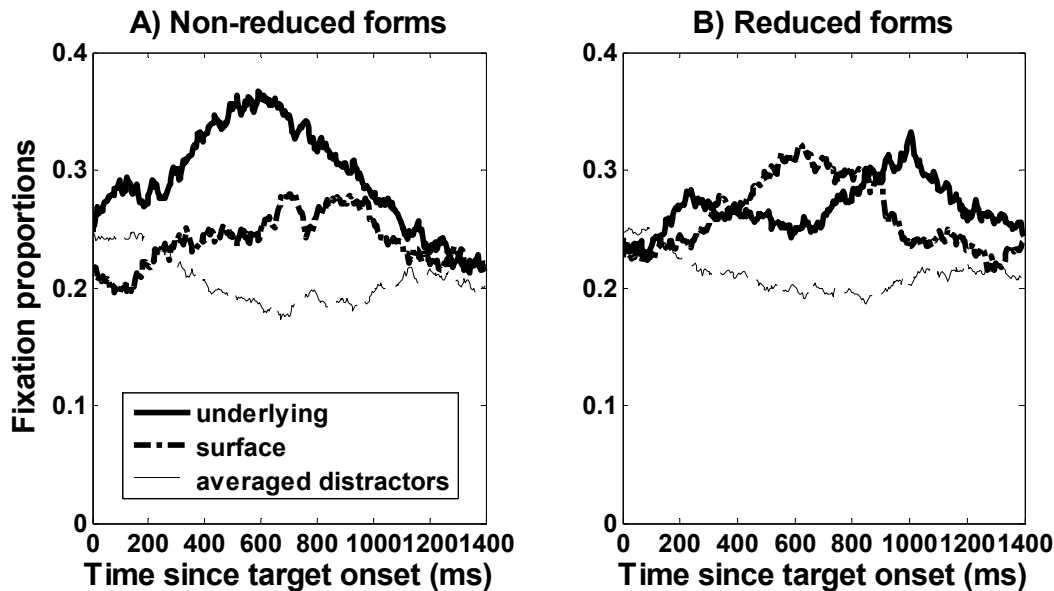

Figure 1: Fixation proportions to the underlying competitor, the surface competitor and the two averaged distractors for (A) Non-reduced forms and (B) Reduced forms.

References

Cutler, A. (1998). The recognition of spoken words with variable representation. In Danielle Duez (Ed.) *SPoSS - Sound Patterns of Spontaneous Speech* (pp. 83-92)*.* Aix-en-Provence, France.

Ernestus, M. (2000). *Voice assimilation and segment reduction in casual Dutch. A corpus-based study of the phonology-phonetics interface.* Utrecht: LOT.

Ernestus, M., Baayen, H., & Schreuder, R. (2002). The recognition of reduced word forms. *Brain and Language,* 81, 162-173.

Johnson, K. (2004). Massive reduction in conversational American English. In K. Yoneyama & K. Maekawa (Eds.). *Spontaneous Speech: Data and Analysis. Proceedings of the 1st session of the 10th International Symposium* (pp. 29-54)*.* Tokyo, Japan.

Mitterer, H., & Blomert, L. (2003). Coping with phonological assimilation in speech perception: Evidence for early compensation*. Perception and Psychophysics,* 65(6), 956-969.

Oostdijk, N. (2000). The Spoken Dutch Corpus project. *The ELRA Newsletter*, 5, 4-8.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science*, 268, 1632-1634.