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Letters don't matter: No effect of orthography on the perception of conversational speech ☆

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ABSTRACT

It has been claimed that learning to read changes the way we perceive speech, with detrimental effects for words with sound–spelling inconsistencies. Because conversational speech is peppered with segment deletions and alterations that lead to sound–spelling inconsistencies, such an influence would seriously hinder the perception of conversational speech. We hence tested whether the orthographic coding of a segment influences its deletion costs in perception. German glottal stop, a segment that is canonically present but not orthographically coded, allows such a test. The effects of glottal-stop deletion in German were compared to deletion of /h/ in German (grapheme: *h*) and deletion of glottal stop in Maltese (grapheme: *q*) in an implicit task with conversational speech and explicit task with careful speech. All segment deletions led to similar reduction costs in the implicit task, while an orthographic effect, with larger effects for orthographically coded segments, emerged in the explicit task. These results suggest that learning to read does not influence how we process speech but mainly how we think about it.

Introduction

Our thinking about speech is massively influenced by our ability to read, and we are not aware of this influence. Readers find it natural to think of speech in terms of letter-like segments and often assume that this is universal. It hence came as a big surprise when Morais, Cary, Alegria, and Bertelson (1979) showed that awareness of phonemes does not arise spontaneously. They tested adults that, for social reasons, had not learned to read at a typical school age. One half of these adults was enrolled in a reading class at adult age, the other not. Critically, only participants following the reading class were able to manipulate words at a phoneme level (e.g., perform tasks as "bread minus b is . . . ? " → "red"). Later research revealed a reciprocal relationship between learning to read and phoneme awareness using simpler tasks that also pre-school children can solve to some degree[1]: Bradley and Bryant (1983) devised an "odd-one out" task, in which the question was which word does not fit in a series like "pin, pat, hill, pit". They found that those pre-reading children who perform well in such tasks turned out to be good readers. This has given rise to the idea that spoken and written language processing influence each other.

The link from spoken to written language is obvious. Normal-hearing children invariably learn to speak a

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[1] Attempts to do phoneme-deletion tasks with pre-schoolers can lead to frustration. It has happened, for instance, that the question "what is bread minus b" leads the child to answer "then my lunch is gone" and burst into tears.

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language before they learn to write it. The better the oral language is processed, the easier it is to link written language to it (Melby-Lervåg, Lyster, & Hulme, 2012). The link in the other direction is somewhat less straightforward and more controversial. In this paper, we will present data that may force a re-interpretation of the relation between learning to read and speech perception. As a consequence of the paper by Morais et al. (1979), it has become an underlying assumption that learning to read makes us better at perceiving speech—where "better" means "more segmental". This far-reaching interpretation of the phoneme-awareness data is evident when Dehaene et al. (2010, p. 1362) spoke of "the enhanced phonemic processing that accompanies reading acquisition" or when Pattamadilok et al. (2009, p. 169) argue "Thus it is possible that learning to read is crucially involved in developing fine-grained phonological representations." It has even been suggested that orthographic representations are activated online during speech perception (Ziegler & Ferrand, 1998). Contrasting with this theme, we will argue that in everyday speech processing, confronted with conversational speech in a natural task setting, the role of orthography is negligible. Based on the present finding we suggest that learning to read may only influence meta-linguistic thinking about speech and in fact make us "deaf" to the properties of normal conversational speech.

In the literature, there have been proposals of "on-line" and "off-line" influences of learning to read on speech perception. Off-line, or indirect, influences may arise due to exposure to stylistic language variation that comes with reading. More experience with a wider variety of texts, for instance, seems to influence a listener's ability to predict upcoming words (Mishra, Singh, Pandey, & Huettig, 2012). It has also been argued that reading is important for the expansion of the mental lexicon during elementary school (Stanovich & Cunningham, 2001). Reading is considered important here because infrequent words are more likely to occur in texts than in spoken language (Hayes, 1988). As a consequence, infrequent words are more often encountered during reading than during oral language use. As such, reading will influence listening by expanding the lexicon and changing the number of candidate words that may fit a given input.

Extending this line of thought, it has even been claimed that only with sufficient vocabulary growth through reading do children gain access to phoneme-like units in speech perception (Metsala & Walley, 1998). Following this lead, Dehaene et al. (2010) tested the brain activation patterns of literate and illiterate participants, matched on socio-economic status, during various tasks. They found that literate participants showed an increase of brain activation during listening in the superior posterior temporal gyri compared to illiterate participants. This was interpreted as "enhanced phonemic processing which accompanies alphabetization" (p. 5). Interestingly they cited Morais et al. (1979) as additional evidence for a more phonemic processing of speech although Morais et al. (1979) only showed that *meta-linguistic abilities* change drastically with reading acquisition. In this context, it is also important to note that in models of speech processing in the brain the superior posterior temporal cortex is not part of the core speech perception system but a secondary path that seems to be involved in linking speech sound to articulation (Scott & Wise, 2004). Moreover, recent evidence suggests that the implicit processing of speech does not get "more phonemic" with reading. McQueen, Tyler, and Cutler (2012) showed that pre-school children, before they had learned to read, are able to make use of phoneme-like units in speech perception: When they learn that a given speaker produces /f/ in slightly /s/-like way, they are able to generalize this to new words, which necessitates the assumption of a pre-lexical phoneme-sized unit. Moreover, it has also been shown that dyslexics also show no deficit in such phonemic processing (Groen & McQueen, 2014; Mitterer & Blomert, 2003). This suggests that phoneme-like units are not the consequence of learning to read but are used for speech perception independently of reading experience.

Another off-line influence of reading on speech perception can arise when exposure to written words influences the lexical–phonological representations of specific words. Racine, Bürki, and Spinelli (2014) investigated the processing of French words in which the written form suggests the presence of a schwa vowel that, in spoken form, can be deleted either optionally or obligatorily. When these words were presented auditorily with and without schwa to pre-readers in a recognition task, the results showed a simple spoken-word frequency effect: For the words with optional deletion, reactions were faster to the version with schwa; for words with obligatory deletions, reactions were faster to words without the schwa – in both cases matching the respective more frequent spoken form. However, in contrast to these effects for pre-reading children, for beginning readers (aged 9–10 years) the results showed an overall "boost" for the schwa-bearing forms – matching the orthographic representation. This provides evidence that reading a word can influence the phonological representation (Bürki, Ernestus, & Frauenfelder, 2010; Bürki & Gaskell, 2012; Connine, Ranbom, & Patterson, 2008). This may not be surprising, if one assumes that reading actually involves phonological recoding, so that reading a word with a schwa leads to "implicitly hearing" the same word with a schwa. The reading experience may hence influence the phonological representation of this word, since independent evidence indicates that phonological representations are sensitive to input frequencies of variants (Connine et al., 2008; Pitt, 2009). Implicitly hearing a word during reading may thereby also influence listening by changing the phonological representation but without necessarily activating an orthographic representation during listening. This possibility gains credibility given the evidence that words learned during reading also seem to be added to the mental lexicon for spoken words (Bakker, Takashima, van Hell, Janzen, & McQueen, 2014).

A similar influence of the orthographic form on developing lexical representations has been shown for second language learners (Escudero, Hayes-Harb, & Mitterer, 2008). Escudero et al. trained Dutch learners of English to associate a set of novel English (nonsense) words containing either /æ/ or /ɛ/ with novel shapes. Critically, the sound contrast between /æ/ and /ɛ/ is difficult to distinguish for Dutch learners. This was reflected in the results, as participants