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## Does sound structure affect word learning? An eye-tracking study of Danish learning toddlers

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### ABSTRACT

Previous research has shown that Danish-learning children lag behind in early lexical acquisition compared with children learning a number of other languages. This delay has been ascribed to the opaque phonetic structure of Danish, which appears to have fewer reliable segmentation cues than other closely related languages. In support of this hypothesis, recent work has shown that the phonetic properties of Danish negatively affect online language processing in young Danish children. In this study, we used eye-tracking to investigate whether the challenges associated with processing Danish also affect how Danish-learning children between 24 and 35 months of age establish and learn novel label–object mappings. The children were presented with a series of novel mappings, either ostensibly (one novel object presented alone on the screen) or ambiguously (one novel object presented together with a familiar one), through carrier phrases with different phonetic structures (more vs less opaque). Our results showed two main trends. First, Danish-learning children performed poorly on the task of mapping novel labels onto novel objects. Second, when learning did occur, accuracy was affected by the phonetic opacity of the speech stimuli. We suggest that this finding results from the interplay of a perceptually challenging speech input and a

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slower onset of early vocabulary experience, which in turn may delay the onset of word learning skills in Danish-learning children.

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## Introduction

Cross-linguistic studies of the trajectories of early vocabulary acquisition have shown that different languages are learned at different rates, with children's average vocabulary sizes differing by as much as 60% across language groups during their first 2 years of life (Bleses et al., 2008a, 2008b). This variability in learning rate is likely to be driven by, among other things, structural differences across languages (Bates, Devescovi, & Wulfeck, 2001; Stoel-Gammon, 2011). Children learning Danish, for example, show a slower lexical development rate than children learning a number of other languages, possibly as a consequence of the opaque phonetic structure that characterizes Danish speech (Bleses, Basbøll, Lum, & Vach, 2011; Bleses, Basbøll, & Vach, 2011; Bleses et al., 2008b). The opaque nature of the Danish speech signal has been argued to make the language especially hard to process and, as a consequence, to delay lexical acquisition in Danish-learning children (Bleses & Basbøll, 2004; Bleses & Trecca, 2016; Bleses et al., 2008b).

The idiosyncratic sound structure of Danish results mainly from the interplay of two pervasive phonological processes (see Basbøll (2005) and Grønnum (2003), for detailed accounts). First, and most important, a number of Danish consonants undergo extensive weakening (or lenition) in unstressed syllables. Weakening is manifested as loss of aspiration/affrication (e.g., [k<sup>h</sup>] → [ç]), loss of closure (e.g., /b g/ → [u], /d/ → [ð]), and, more generally, in many consonants being realized as semivowels (e.g., /r/ being consistently realized as [ɐ] word-finally as in *biler*, [ˈbiːlə], “cars”). As a result, Danish speech is characterized by frequent uninterrupted sequences of *vocoids* (phonetically defined vowels [i.e., vowels and semivowels] vs *contoids* [phonetically defined consonants]), both word-internally and across word boundaries. Second, the neutral vowel /ə/ (schwa), occurring in unstressed syllables, is commonly assimilated to neighboring phonemes (e.g., *gade*, street, [ˈç æːðə] → [ˈç æːðð]). Together, consonant weakening and schwa assimilation give Danish speech an unusually monotonous sonority profile (i.e., the distance in acoustic saliency between different segments in a syllable is typically less marked than in other related languages) and frequently lead to the loss of entire syllables (Grønnum, 2003).

This combination of segmental and syllabic reductions results in a speech signal in which syllable and word boundaries are often less explicitly marked than in other closely related languages (Basbøll, 2005; Bleses et al., 2008b). The effect becomes evident when comparing Danish words or sentences with cognates from other Scandinavian languages, as shown in Fig. 1. The long speech sequences with few or no contoids that characterize Danish—which are manifested acoustically as speech sequences with few or no interruptions in voicing—have been hypothesized to be harder to segment than sequences of alternating contoids and vocoids (e.g. Gooskens, van Heuven, van Bezooijen, & Pacilly, 2010; Grønnum, 2003). This is because the alternation of contoids and vocoids makes syllable and word boundaries perceptually more salient (e.g. Oller, 2000; Wright, 2004,) and arguably because it is easier to segment speech by computing statistics over contoids than vocoids (e.g. Bonatti, Peña, Nespor, & Mehler, 2005). Furthermore, prosodic cues are significantly less prominent in Danish than in other closely related languages, mainly because of the lack of compulsory sentence accents, which may contribute to making Danish speech particularly hard to process (Grønnum, 2003; see also Gooskens et al., 2010).

The hypothesized difficulty of segmenting Danish received support from a recent eye-tracking study of speech processing in Danish-learning 2-year-olds. The study found that children needed a longer time to orient to a known target object on the screen (*abe* [monkey], *and* [duck], *bamse* [teddy bear], *bil* [car]) when prompted to do so by a sentence that was highly vocalic/reduced as a consequence of the phonological processes described above (*Her er \_\_\_\_!*, [ˈheː æ], “Here is the \_\_\_\_!” with

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