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Brief article

Listen up! Developmental differences in the impact of IDS on speech segmentation

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ABSTRACT

While American English infants typically segment words from fluent speech by 7.5-months, studies of infants from other language backgrounds have difficulty replicating this finding. One possible explanation for this cross-linguistic difference is that the input infants from different language backgrounds receive is not as infant-directed as American English infant-directed speech (Floccia et al., 2016). Against this background, the current study investigates whether German 7.5- and 9-month-old infants segment words from fluent speech when the input is prosodically similar to American English IDS. While 9-month-olds showed successful segmentation of words from exaggerated IDS, 7.5-month-olds did not. These findings highlight (a) the beneficial impact of exaggerated IDS on infant speech segmentation, (b) cross-linguistic differences in word segmentation that are based not just on the kind of input available to children and suggest (c) developmental differences in the role of IDS as an attentional spotlight in speech segmentation.

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1. Introduction

One of the critical aspects of acquiring a language is the ability to segment the fluent speech stream into its constituent units, i.e., words. In first language acquisition, this ability seems to be in place by approximately 7.5-months, at least for American English infants (Jusczyk & Aslin, 1995), with some studies showing even earlier evidence of segmentation (e.g., Bortfeld, Morgan, Golinkoff, & Rathbun, 2005). However, it has proved difficult for studies examining infants learning other native languages to replicate such findings at the same ages. For instance, one recent study finds that German 9-month-olds familiarized (in the laboratory) with words embedded in fluent speech, do not differentiate these familiarized from unfamiliar control words (Schreiner, Altvater-Mackensen, & Mani, 2016). Studies with Dutch (Kooijman, Hagoort, & Cutler, 2005) and French infants (Nazzi, Mersad, Sundara, Iakimova, & Polka, 2014) find similar inconsistencies with the pattern of results reported with American English infants. Thus, French 8-month-olds familiarized with words in isolation seem unable to recognize the same words in fluent speech, while German 9-month-olds perform successfully in this task so long as the words tested are highly frequent function words (Höhle & Weissenborn, 2003). In contrast, French 8-month-olds do recognize words in isolation when previously familiarized with the same words in fluent speech. Thus, there appears to be considerable variation in the circumstances under which infants successfully segment words from fluent speech across languages.

Why do we find such differences? While there are likely to be considerable cross-cultural phenomena that may underlie such behavioral differences, we focus here on one possible explanation for the differences found across language cultures, namely, the differences in the kind of speech presented to infants in the studies, and in their native language, at large. Importantly, the speech presented to infants in the Jusczyk and Aslin (1995) study, and indeed, in most studies on speech segmentation, was in the infant-directed speech register (hereafter, IDS), the speech register typically used in communication with young infants. It differs from speech used in normal communication between adults, i.e., adult-directed speech (hereafter, ADS): Speech addressed to infants is slower, higher in pitch, with longer pauses between words, and greater pitch variation within utterances (Kuhl et al., 1997).

The use of IDS in studies with infants is well-grounded: Not only do infants show a preference for IDS from birth onwards (Cooper, Abraham, Berman, & Staska, 1997; Werker, Pegg, & McLeod, 1994) but they also seem to be better in extracting words from fluent IDS compared to ADS (Singh, Nestor, Parikh, & Yull, 2009; Thiessen, Hill, & Saffran, 2005). Furthermore, IDS appears to facilitate word learning (Graf Estes & Hurley, 2013; Song,

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Demuth, & Morgan, 2010), and its use in communication with infants can predict vocabulary growth (Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013; Weisleder & Fernald, 2013). However, it is important to note that most of this research has been conducted with American English infants using American English IDS.

There is considerable variation in the prosodic characteristics of IDS across languages, with different studies finding that American English IDS is the most modified compared to ADS amongst the languages tested (Cooper et al., 1997; Fernald et al., 1989; Shute & Wheldall, 1989). Against this background, is it possible that the above-mentioned studies with infants of other languages (e.g., French, Dutch, German) fail to replicate the pattern of segmentation reported in American English infants due to the characteristics of IDS in the different languages? Or to put it differently, given that infants show improved segmentation of fluent speech from IDS relative to ADS (Singh et al., 2009; Thiessen et al., 2005) and that American English IDS is more exaggerated relative to IDS in other languages (Cooper et al., 1997; Ferguson, 1964), would we find similar segmentation abilities in infants learning other languages if the speech input presented to them is as exaggerated as American English IDS?

One recent study testing speech segmentation in British English infants offers considerable support for this possibility (Floccia et al., 2016): Only one of 13 experiments found successful word segmentation, and only when the stimuli were presented to 10.5-month-old infants in exaggerated IDS. This suggests that the different styles of IDS used to address infants of different dialects and different languages critically impacts their performance in segmentation tasks.[1] Nevertheless, this study finds successful segmentation in infants three months later than similar findings have been reported with American English infants. The possibility remains, therefore, that infants of other languages, e.g., German, may not be able to segment words at this younger age even given more exaggerated IDS.

Examining this possibility is critical for the following reason. On the one hand, were infants learning other languages, e.g., German, able to segment words from fluent speech at 7.5-months given exaggerated IDS, this would suggest that the differences between the studies reported to-date with infants learning other languages and American English infants come down to the input presented. In other words, infants from different language backgrounds would be able to segment words from fluent speech at the same age as American English infants as long as the input is adequately exaggerated and engaging. While this might have consequences for lexical development in infants hearing such less engaging input on a regular basis, this would at least suggest that there is no long-term cognitive impact of hearing such less exaggerated IDS on day-to-day language processing. Conversely, were we to find that infants learning German are unable to segment words at 7.5-months, even given exaggerated input, this would suggest that merely exaggerated input is inadequate to drive successful segmentation, at least in German infants. This would further imply that there may be other cross-cultural (including cross-linguistic) differences between infants from different language backgrounds that induce more long-term differences in the language behavior of these infants. Against this background, the current study sets out to explore German 7.5- and 9-month-olds' segmentation abilities given exaggerated IDS resembling that heard by American English infants.

[1] Note that the lack of segmentation abilities in 9-month-old British English tested with American English IDS suggests that exaggeration might not be sufficient but that the native accent is required to succeed in segmenting speech.

2. Method

2.1. Participants

Twenty-two 7.5-month-old, and 22 9-month-old monolingual German infants participated in the study (Appendix A).

2.2. Material and design

Four passages with one of four phonotactically legal German monosyllabic pseudowords, *Jopp [ˈjɔp]*, *Riel [ri:l]*, *Mauf [mauf]*, and *Lenn [lɛn]*, were recorded in an exaggerated speech register resembling American English IDS (Table 1; Appendix B). The same female speaker recorded five different isolated tokens of each pseudoword which were repeated three times to form lists of 15 tokens. Stimuli were selected for their acoustic properties to match those of American English IDS (Fig. 1).

2.3. Procedure

A trained experimenter controlled the experiment from the adjacent room using the stimulus-presenting software Look (Meints & Woodford, 2008). During each trial, infants were presented with a blinking checkerboard on screen whilst simultaneously being presented with an auditory stimulus. Using silent video images of the infant, the experimenter initiated a trial when the infant looked towards the screen and continued to indicate throughout the remainder of the trial whether the infant was looking towards the screen or away by pressing a corresponding button on the keyboard. The auditory and visual stimulus continued to play either until the trial was complete or until the infant looked away for more than 2 s (see Mani & Pätzold, 2016, for an identical procedure). The experimenter was blind to the experimental condition as no information on the stimuli being presented was provided by the computer and the stimuli played in the adjacent booth were masked by music.

Familiarization Phase. Infants listened to alternating blocks of two passages in exaggerated IDS. Passages were either repeated for a total of 12 times or until the child had accumulated 100 s of listening time for both passages.

Test Phase. Infants were presented with isolated tokens of the words they had heard embedded in passages during the familiarization phase and control words they had never heard before. Each infant received three trials of isolated tokens of either the two familiarized, or the two control words, i.e., totalling 12 trials. Trial order within test blocks was randomized.

3. Results

Test Phase. A repeated-measures ANOVA with the within-subject factor familiarity (familiarized vs. control word) and the between-subject factor age (7.5 vs. 9 months) revealed a significant interaction of familiarity and age ($F(1,42) = 4.11$, $p = 0.049$, $\eta_p^2 = 0.09$) and a significant main effect of age ($F(1,42) = 4.70$, $p = 0.036$, $\eta_p^2 = 0.10$). There was no significant main effect of familiarity ($F(1,42) = 1.13$, $p = 0.293$, $\eta_p^2 = 0.03$). Hence, we ran planned contrasts within each age-group to further examine infants' segmentation abilities. For the 7.5-month-olds, there were no significant differences between listening times to familiarized and control items ($t(43) = -0.93$, $p = 0.357$, $d = -0.14$). However, 9-month-olds listened significantly longer to the familiarized relative to the control words ($t(43) = 2.99$, $p = 0.005$, $d = 0.45$) indicating successful word segmentation (Fig. 2; Appendix C). Thus, our results suggest that German infants at 9-months benefit from exaggerated speech in segmenting the speech stream, whereas 7.5-month-olds did not show a similar benefit.

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