DRAFT – SEE JOURNAL FOR FINAL VERSION

The following article has been accepted by The Journal of the Acoustical Society of America Express Letters. After it is published, it will be found at http://asa.scitation.org/journal/jel.

.

Input matters: Multi-accent language exposure affects word form recognition in infancy

Marieke van Heugten

Department of Psychology, University at Buffalo, The State University of New York

Buffalo, NY 14260

mariekev@buffalo.edu

Elizabeth K. Johnson

Department of Psychology, University of Toronto

3359 Mississauga Road, Mississauga, Ontario, Canada, L5L 1C6

elizabeth.johnson@utoronto.ca

Corresponding author

Correspondence should be addressed to Marieke van Heugten, Department of Psychology, University at Buffalo, The State University of New York, Buffalo, NY 14260, United States. E-mail: mariekev@buffalo.edu.

Abstract

Early language input is far from uniform, even among children learning the same language. For instance, while some children are exposed to a single accent in their linguistic environment, others have routine exposure to multiple accents. Nonetheless, few studies have taken this into account when examining word recognition, and none has examined this issue in infants prior to the emergence of phonological constancy (~18 months). This study demonstrates that daily exposure to multiple accents strongly impacts infants' performance in a laboratory word form recognition task. Accent variability in the input thus needs to be carefully considered when studying speech development.

Keywords: infant speech perception, word recognition, multi-accent language input

1. Introduction

To become mature communicators, infants must learn to recognize words across contexts. This can be particularly difficult when confronted with speakers of unfamiliar accents. Indeed, laboratory studies suggest that infants initially struggle in such situations[1–3] What does that mean for children who are routinely exposed to multiple variants of their native language? Imagine, for instance, a child born to an American English-speaking mother and an Irish English-speaking father. While her mother may label the yellow vehicle that takes her big brother to school as a *bus*, her father's pronunciation will sound more like *boss*, leaving the child to deduce that mother's *bus* and father's *boss* refer to the same object even though her mother's pronunciation of *bus* and *boss* label two separate referents. How does language development in this child differ from that in a child growing up in a family where both parents speak in the same accent?

Unfortunately, we currently have very little data to assess this question. Most developmental word recognition studies to date have focused on linguistically homogeneous populations, and those studies testing more heterogeneous populations typically do not consider variation as a predictive factor. The few existing studies examining the impact of accent variation on early word recognition have tested children around their second birthday.[4,5] By this age, however, children's vocabularies are rapidly expanding and phonological constancy (presumably a prerequisite to coping with accents) already appears to be present.[1] Hence, the greatest impact of accent variability is likely to be observed earlier in infancy. It is thus crucial to evaluate younger infants' word form recognition abilities as a function of their exposure to different accents.

Although theories of early speech perception differ in their perspectives regarding the mechanics underlying word recognition, all predict that variability in the input should affect early word form recognition.[6] That is, whether due to more fine-grained word representations[7,8]

or to more sophisticated signal-to-word mapping skills,[2] exposure to greater variation in word forms should enhance children's ability to recognize novel word tokens.[9,10] At the same time, however, greater distances between word tokens might lead to greater difficulty extracting commonalities. As a result, infants may require exposure to more tokens to start treating them as the same word. By extrapolation, then, extensive exposure to variability early in life might have a dramatic effect on the developmental trajectory of children's word recognition capabilities.

This Headturn Preference study tests the impact of accent variation on 12.5-month-olds' word form recognition. Infants listen to known and nonsense words spoken in the local accent. Past work using this design has revealed preferences for known over nonsense words.[1,2,11,12] Here, we test monolingual children who either consistently receive Canadian English language input (low variability group) or a mixture of Canadian English and a second accent (high variability group). We predict that the amount of accent variability an infant experiences at home will impact the developmental trajectory of word form recognition in the lab.

2. Experiment 1

Two groups of typically developing monolingual English-learning 12.5-month-olds were recruited from the Greater Toronto Area, all receiving at least 90% of their language input in English. Infants in the low variability group (N=20, age range: 373 – 395 days, mean age: 383 days, 9 boys) listened almost exclusively to the dominant regional variant (on average ~96% Canadian-accented English), whereas infants in the high variability group (N=20, age range: 363 – 403 days, mean age: 383 days, 12 boys) listened to multiple variants of English (on average only ~33% Canadian-accented English, ~65% other variants of English). The additional variant, spoken by either their parent(s) or a caregiver with whom they spent at least 32 hours a week, could either be a native (e.g., Irish) or a foreign (e.g., Polish) accent. Importantly, however, the

total input of English did not differ between the two groups (99% vs. 98% respectively), as established by a detailed language questionnaire. Groups were further matched on maternal education level (as a proxy for socioeconomic status) as well as reported vocabulary size (see Table 1).[13] An additional 3 infants were tested, but excluded from the analysis due to experimenter error (1) or fussiness (2). All infants received a small toy.

Eight word lists (described elsewhere[2] in detail) were used, four containing words typically known by 12.5-month-olds (*daddy, bottle, diaper, mommy, grandma, kitty, ball, dog, bath, kiss, cup, shoe*), and four containing unknown words (*koddy, dimma, dapper, mitty, guttle, shammy, bog, bap, deuce, kie, koth, brall*). Words were recorded by a female Canadian English speaker who had exclusively lived in the Greater Toronto Area. Word types were matched for average word length (known words: 559 ms; nonsense words: 579 ms) and average pitch (known words: 358 Hz; nonsense words: 378 Hz). Within each list, all words were presented twice. Word order differed between lists. All lists lasted 34.5 s.

Experiment	Exposure to English	Exposure to Canadian English	Additional accent types	Maternal education	Receptive/ Productive vocabulary	Number of items understood/ produced
12.5 months (single accent)	.99	.96		5.7 (N=19)	112.1 / 7.5	8.8 / 1.7
12.5 months (multi-accent)	.98	.34	native: N=13 foreign: N=6 mixed: N=1	5.8 (N=18)	98.3 / 6.9	8.0 / 1.3
14.5 months (multi-accent)	.96	.38	native: N=10 foreign: N=9 mixed: N=1	6.1 (N=20)	104.3 / 13.7	9.5 / 2.4
18 months (multi-accent)	.96	.43	native: N=9 foreign: N=9 mixed: N=2	5.6 (N=20)	173.0 / 42.0	9.7 / 4.3

Table 1. Participant characteristics broken down by language background and age. Measures include proportion of exposure to both English and Canadian English, accent type, maternal education level (measured on a scale from 1 (some high school) to 7 (postgraduate degree)), vocabulary scores as per parental report on the MacArthur-Bates Communicative Development Inventories, and the number of experimental words reported to be known. 12.5-month-olds were closely matched on maternal education level ($U = 155.5$; $p = .641$), receptive vocabulary ($t(38) = 533$; $p = .597$), productive vocabulary ($t(38) = .163$; $p = .872$), number of understood test items ($t(38) = .993$; $p = .327$), and number of produced test items ($t(38) = .969$; $p = .339$).

Infants were tested in the Headturn Preference Procedure. Children sat on their parents' lap in a three-sided area inside a dimly-lit double-walled IAC booth. Attached to the pegboard panels in front and to the side were three lights at eye level. Loudspeakers were positioned behind the side lights, out of view from the infants. A camera just above the center light allowed the experimenter to monitor the infant's behavior from outside the booth. A center light flashed at experiment onset. Once the infant oriented towards this light, the experimenter pressed a button ceasing the light, and one of the side lights was triggered. A head turn toward the flashing light initiated a word list, which played until the infant looked away for two seconds or until the maximum trial length of 34.5 s was reached. Infants listened to all eight lists, presented randomly with the restriction that lists of the same type could not occur more than twice in a row. Presentation side was randomized and not associated with list type. To limit parental influence, parents wore closed headphones playing masking music. The experiment lasted 2-3 minutes.

Mean orientation time to lists of known and nonsense words was computed (see Figure 1). As accent type (native vs. foreign) did not yield any main effects or interactions in Experiment 1 or 2, this factor was excluded from further analyses. A 2 x 2 Analysis of Variance (ANOVA) with word status (known vs. nonsense words) as a within-participant factor and accent exposure group (low vs. high variability) as a between-participant factor revealed a main effect of word status ($F(1,38) = 4.971$; $p = .032$; $\eta_p^2 = .116$), which was modulated by an interaction between word status and exposure group ($F(1,38) = 4.492$; $p = .041$; $\eta_p^2 = .106$). Two-tailed dependent samples *t* tests were conducted to further examine this interaction. The effect of word status reached significance for the low-variability group ($t(19) = 3.174$, $p = .005$, Cohen's $d = .710$, mean difference = 4.38 s, 95% CI [1.49, 7.28]), but not for the high-variability group ($t(19) = .76$, $p = .941$, mean difference = .11 s, 95% CI [-2.97, 3.18]). That is, only infants with exposure

predominantly to Canadian English listened longer to known than to nonsense words. Language input outside the lab thus clearly affects infants' recognition of familiar word forms in the lab. Given that multi-accent input is so common, claims that children recognize regionally-accented words in this test paradigm by the end of their first year of life may only be true for a subset of language learners (i.e. those with relatively uniform input). Experiment 2 examines when multi-accent infants start to recognize word forms spoken by a Canadian-accented speaker.

3. Experiment 2

An additional two groups of typically developing English-learning children were tested. All met the same language criteria as the high variability group in Experiment 1. The younger group were 14.5-month-olds (N = 20, age range: 431-459 days, mean age: 447 days, 12 boys), and the

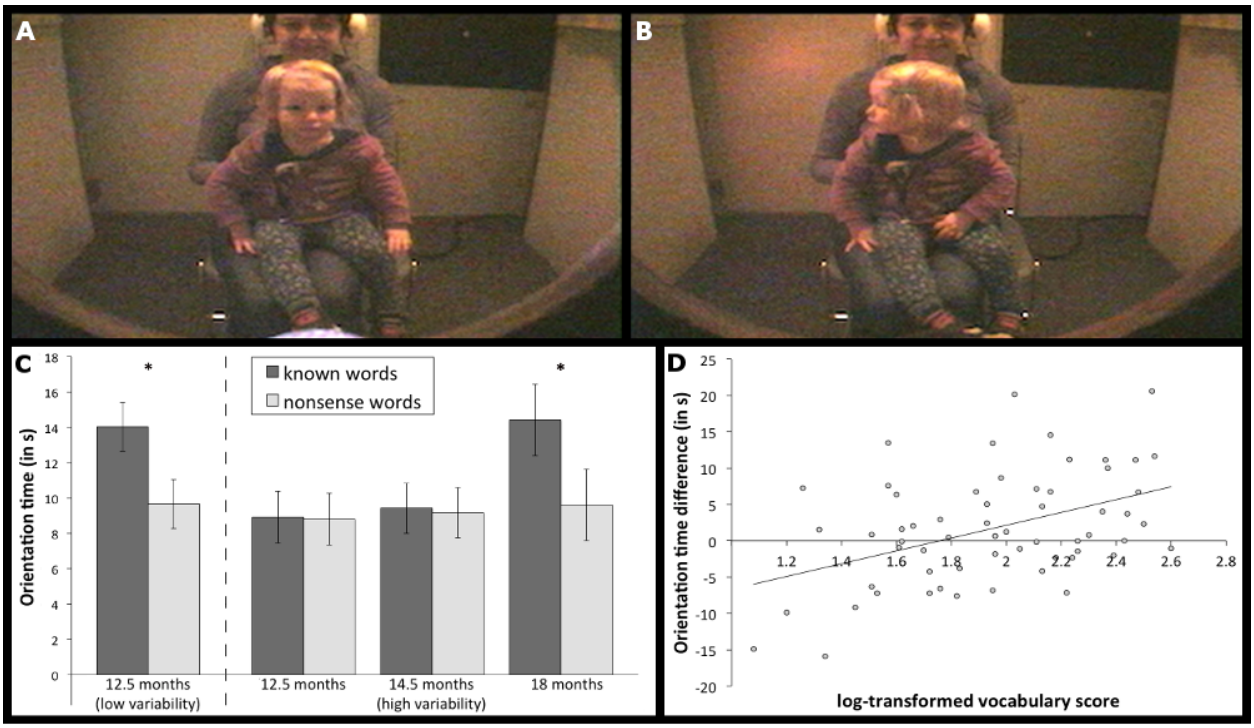

Figure 1. a and b (upper left and right): An infant participating in the study. c (bottom left): Infants' orientation times (in seconds) to known and nonsense words in Experiments 1 and 2, broken down by accent background (low variability vs. high variability) and age. Error bars indicate standard errors of the mean difference scores. d (bottom right): Difference in orientation time between known and nonsense words (in seconds) as a function of infants' log-transformed receptive vocabulary scores. Each dot represents an infant from the high variability group.

older group were 18-month-olds (N=20, age range: 530-566 days, mean age: 550 days, 11 boys). An additional 8 infants were tested, but excluded from the analysis due to parental interference (1), experimenter error (1), or fussiness (6). All infants received a small toy.

The materials, design, procedure, and questionnaires were identical to Experiment 1. To best assess when infants with mixed accent input learn to recognize word forms in the Canadian accent, orientation times to known and nonsense word lists from all age groups (including the 12.5-month-olds from Experiment 1) were analyzed. A repeated measures ANCOVA with word status (known vs. nonsense word) as a within-participant factor and age (in days) as a covariate was conducted on these data. This revealed a marginally significant main effect of word status ($F(1,58) = 3.281$; $p = 0.075$; $\eta_p^2 = .054$), as well as a main effect of age ($F(1,58) = 7.671$; $p = 0.008$; $\eta_p^2 = .117$), but more importantly, an interaction between word status and age ($F(1,58) = 5.159$; $p = 0.027$; $\eta_p^2 = .082$), suggesting infants' looking preference changed over time (see Figure 1). Two-tailed dependent samples *t*-tests analyses conducted for each of the older age groups revealed that only the older infants recognized the words ($t(19) = 2.378$; $p = .028$; Cohen's $d = .532$; mean difference = 4.80 s, 95% CI .57, 9.03] for the 18-month-olds and $t(19) = .178$; $p = .861$; mean difference = 0.25 s, 95% CI [-2.73, 3.23] for the 14.5-month-olds. Thus, not until around 18 months of age do infants exposed to substantial accent variation in their language input begin recognizing the locally dominant versions of word forms in this test paradigm. This aligns with findings from lab studies, showing that 18-month-old (but not younger) infants' word recognition benefits from experience with multiple accents in the lab prior to test.[14]

To examine what drives this development, a standard multiple linear regression analysis was carried out to predict the difference in orientation time between known and nonsense words based on age (in days), log-transformed receptive vocabulary scores, the proportion of exposure

to Canadian English, and maternal education level. Although age and log-transformed vocabulary size both correlated with this difference score ($r(58) = .286$; $p = .027$ and $r(58) = .438$; $p < .001$, respectively), only the log-transformed vocabulary scores added significantly to the model ($F(4,57) = 4.335$; $p = .004$; $R^2 = .25$). Thus, vocabulary score ($\beta = .374$; $p = .005$) was a better predictor than age ($\beta = .143$; $p = .282$), proportion of exposure to Canadian English ($\beta = .180$; $p = .145$), and maternal education ($\beta = .094$; $p = .437$), suggesting that the ability to recognize words in the local accent may develop as a function of receptive vocabulary size.

4. General discussion

Research on infant speech perception differentiates between children learning one versus multiple languages, but rarely considers how exposure to accents might influence language acquisition. Here, we examined how accent variability affects infants' language development by testing two groups of monolinguals: one with routine exposure to primarily Canadian English and one with exposure to Canadian English as well as at least one other variant of English. Our results demonstrate a dramatic influence of home accent exposure on infants' word form recognition in the lab. Infants with little accent variation in their home environment readily recognized familiar word forms in Canadian English by 12.5 months of age, but infants exposed to variable accents failed to show a reliable preference for words over non-words spoken in Canadian English until 18 months of age. This performance difference was observed despite our mono- and multi-accent groups being well-matched in vocabulary size and socioeconomic status.

How can we explain this finding? One possibility is that children receiving more accent variability in their home environment may simply be approaching our task differently than the children receiving less accent variability. Perhaps infants accustomed to hearing more variability are interested both in words they recognize and in words they do not, rendering preference

studies inappropriate to study their word form recognition abilities. However, there are two reasons that call this explanation into question. First, these children *do* show a preference, just not until 18 months. And second, bilinguals (who might logically be expected to react similarly to our mixed-accent group) have been found to display looking preferences in studies using similar procedures as early as 11 months of age.[15]

Alternatively, only the amount of exposure to Canadian English might contribute to infants' recognition of Canadian-accented words. As infants from the high variability group receive less exposure to Canadian English, they might not have reached the required threshold enabling them to recognize words in the Canadian accent. This, too, seems unlikely. First, if this were the case, the proportion of Canadian accent exposure within this multi-accent group should have predicted infants' performance in this task (which it did not). Second, as 15-month-olds have been shown to accommodate unfamiliar accents after as little as two minutes of exposure,[2] it seems extremely improbable that monolingual 14.5-month-old infants who receive an average 38% of their language input in Canadian English have not yet passed that minimum.

A final explanation for our findings then, is that children with more exposure to accent variation in their daily environment create word representations[7,8] (or signal-to-word mapping strategies[2]) that are qualitatively different from those of infants who receive less variable input. Due to differences in the pronunciation of words across accents, the initial word representations of infants with multi-accent language exposure may, for instance, be less precise than those of their single-accent peers. While this may not prevent infants from recognizing words under naturalistic listening conditions (e.g., understanding their Canadian-accented mother as well as their Irish-accented father, and potentially even a less familiar neighbor), coping with unfamiliar speakers in the absence of any context (as is characteristic of the paradigm employed here) might

be too difficult.[16] Note that if this were the case, then the fully-developed word recognition skills of (older) infants hearing multiple accents will likely be more flexible than those of similarly-aged infants receiving uniform accent input. As a result, children with exposure to accent variability might later excel in situations where they need to cope with unfamiliar accents.

Taken together, this study demonstrates a clear impact of daily accent variability on word form recognition in the regionally dominant accent for infants 12.5 to 14.5 months of age. This suggests that even very early on in life, monolingual infants do not form a homogeneous group. Discrepancies in experimental findings among labs in different locations could hence be due to the specific language environments experienced by children in their home settings. Thus, accent exposure may not only have profound implications for theories of early language processing, but with the infant speech perception community moving toward conducting large-scale cross-lab replications,[17] it should also be included as a predictor of infants' early linguistic abilities.

Acknowledgements

This work was supported by grants from NSERC and SSHRC awarded to EKJ. Part of this work was presented at the 2013 SRCD meeting, Seattle, WA and at the 2013 WILD workshop, Donostia – San Sebastián, Spain. We thank Melissa Paquette-Smith for assistance with testing.

References and links

1. Best, C. T., Tyler, M. D., Gooding, T. N., Orlando, C. B. & Quann, C. A. Development of phonological constancy: Toddlers' perception of native- and Jamaican-accented words. *Psychological Science* **20,** 539–542 (2009).
2. Van Heugten, M. & Johnson, E. K. Learning to contend with accents in infancy: Benefits of brief speaker exposure. *Journal of Experimental Psychology: General* **143,** 340–350 (2014).

3. Van Heugten, M., Krieger, D. R. & Johnson, E. K. The developmental trajectory of toddlers' comprehension of unfamiliar regional accents. *Language Learning and Development* **11,** 41–65 (2015).
4. Floccia, C., Delle Luche, C., Durrant, S., Butler, J. & Goslin, J. Parent or community: Where do 20-month-olds exposed to two accents acquire their representation of words? *Cognition* **124,** 95–100 (2012).
5. Van der Feest, S. V. H. & Johnson, E. K. Input-driven differences in toddlers' perception of a disappearing phonological contrast. *Language Acquisition* **23,** 89–111 (2016).
6. Johnson, E. K. Constructing a proto-lexicon: an integrative view of infant language development. *Annual Review of Linguistics* **2,** 391–412 (2016).
7. Jusczyk, P. W. *The discovery of spoken language*. (MIT press, 1997).
8. Werker, J. F. & Curtin, S. PRIMIR: A developmental framework of infant speech processing. *Language Learning and Development* **1,** 197–234 (2005).
9. Rost, G. C. & McMurray, B. Speaker variability augments phonological processing in early word learning. *Developmental Science* **12,** 339–349 (2009).
10. Singh, L. Influences of high and low variability on infant word recognition. *Cognition* **106,** 833–870 (2008).
11. Hallé, P. A. & De Boysson-Bardies, B. Emergence of an early receptive lexicon: Infants' recognition of words. *Infant Behavior and Development* **17,** 119–129 (1994).
12. Swingley, D. 11-month-olds' knowledge of how familiar words sound. *Dev Sci* **8,** 432–443 (2005).
13. Note that recent census data show that education level among immigrants is, on average, higher in Canada than in the US. This makes it easier to disentangle the effects of accentedness and socioeconomic status on word recognition in our Canadian sample than in a

229 sample in which accent variability and socioeconomic status are more strongly related.
230 14. Potter, C. E. & Saffran, J. R. Exposure to multiple accents supports infants' understanding of
231 novel accents. *Cognition* **166,** 67–72 (2017).
232 15. Vihman, M. M., Thierry, G., Lum, J., Keren-Portnoy, T. & Martin, P. Onset of word form
233 recognition in English, Welsh, and English–Welsh bilingual infants. *Applied*
234 *Psycholinguistics* **28,** 475–493 (2007).
235 16. Van Heugten, M. & Johnson, E. K. Infants exposed to fluent natural speech succeed at cross-
236 gender word recognition. *Journal of Speech, Language and Hearing Research* **55,** 554–560 (2012).
237 17. Frank, M. C. *et al.* A collaborative approach to infant research: Promoting reproducibility,
238 best practices, and theory-building. *Infancy* (in press).
239