DEVELOPMENTAL DIFFERENCES IN INTELLIGIBILITY OF UNFAMILIAR ACCENTS

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ABSTRACT

Early school-aged children have more difficulty understanding speech produced with unfamiliar accents than adults. However, little is known about the development of these abilities. Furthermore, most investigations use one or two unfamiliar talkers, limiting generalizability of the findings. We examined younger (5-7 years; n=304) and older children's (11-13 years; n=147) perception of English sentences spoken by two unfamiliar native, one bilingual, five non-native, and one familiar native (Midland American English) accented speakers in quiet and noise-added conditions. In quiet, both groups were near ceiling for familiar and unfamiliar native accents but showed performance decrements for some non-native and bilingual accents. In noise, younger children's word recognition accuracy declined across all accents whereas the older children maintained high accuracy for the unfamiliar native accents and one non-native accent. Thus, children's word recognition with unfamiliar accents improves during middle childhood but may continue to mature into adolescence, particularly in noise.

Keywords: Speech perception, intelligibility, children, non-native accents, unfamiliar accents

1. INTRODUCTION

Both adults and children are sensitive to the social-indexical variability present in speech due to speaker accent [1-3]. This sensitivity emerges in infancy [4-6] and continues to develop through childhood [2,7-10] and, likely, into adolescence [11-14]. Some research suggests that young children and even toddlers can understand unfamiliar accented speech [15-16], consistent with findings that certain fundamental perceptual skills that likely contribute to accent perception are in place early in development, including the observation that young children show lexically guided retuning of phoneme boundaries [17] and toddlers can learn phoneme mappings of artificial accents [18]. However, other research suggests that accent perception follows a protracted developmental trajectory certainly through the early elementary years [3,7,19,20] and well into adolescence [11-14]. Data supporting a protracted developmental trajectory are consistent with findings that some general auditory and speech perception skills are developing into adolescence, including auditory perceptual learning [21], understanding speech in the presence of competing noise [22], and phoneme categorization [23]. Differences in tasks and task demands, the number of accents studied, whether the accents are regional or non-native, and how the accents differ from the listener's home accent likely contribute to the disparate developmental findings.

Several recent investigations on the perception of regional American English varieties suggest that sociolinguistic abilities continue to develop through middle childhood and possibly into adolescence. Using a free classification paradigm with four regional American English dialects, monolingual American English listeners ranging in age from 4-86 years completed two experiments [12]. In the first, 8- to 86-year-olds classified sentence recordings from five females and five males of each regional dialect from the TIMIT Corpus [24] based on their perceived region of origin. The youngest children were less accurate than children 12 years of age and older, as well as the adults, at placing talkers from the same regional dialect into the same group. It was not until children were 16 years of age that their accuracy was adult-like. A second experiment reduced the number of sentences to make it more child-friendly and included children between 4-11 years. The 4- to 5-year-olds produced fewer talker groups than the older children, and children between 4-7 years performed less accurately than children between 8-11 years. These results suggest that classification of these regional dialects by monolingual American English speakers incrementally improves through childhood and adolescence, with more substantial growth in middle (7-8 years) and late childhood (11-12 years), with adult-like performance appearing by 16 years.

Two related studies [13-14] employed different tasks to examine dialect perception of monolingual English speakers ranging from 4-70+ years. The stimuli were TIMIT sentences spoken by 12 females with three from each of the same regional American English dialects as [12]. In the first study [13], listeners completed two tasks: dialect identification using ad-hoc labels and dialect discrimination. The discrimination task was easier for the younger children than the identification task, which would be predicted based on well-known foundations of auditory perceptual development [25]. Specifically, 4- to 5-year-olds could discriminate New England talkers from Midland and Northern talkers but could not identify them with ad-hoc labels until 10-11 years of age. Reliable discrimination was achieved across all four dialects by 12-13 years of age, whereas ad-hoc labelling of all four dialects was adult-like by 14-15 years of age. These results suggest that the cognitive capacity to discriminate some of these regional dialects is present in preschool, but it takes more than 10 years of exposure to linguistic variation in their native language to reliably discriminate and identify these four regional dialects. The second study [14] examined the development of language attitudes and talker regional background using rating scales of locality, status, and solidarity. A fundamental understanding of dialect perception based on locality judgements was observed in children as young as 6 years for some of the dialects; adult-like performance was achieved by 8 years of age, which is earlier than was observed on the discrimination and ad-hoc labelling tasks in [13].

Together, these investigations suggest that (1) task demands influence when sociolinguistic abilities with regional accents appear to fully mature, and (2) while early underpinnings of sensitivity to accent variability appear before children enter school, other dimensions of accent perception likely take more than 10 years to fully mature. Although these studies have revealed important insights into the development of accent perception skills with a focus on regional accents, they have not tested whether listeners understand the linguistic content of speech. While there is evidence that young children struggle to understand talkers with unfamiliar nonnative and regional accents [2,7-9], few have examined the development of this ecologically important skill. One of the only studies to include adolescents [11] employed a single non-native accent of English (Japanese). Word recognition accuracy was evaluated in quiet and speech-shaped noise for children 5 to 15 years and young adults. Accuracy significantly improved with age for the native accent in noise and for the non-native accent in quiet and noise; accuracy for the native accent in quiet was at ceiling for all age groups. The age at which children achieved adult-like performance varied with accent and noise condition: 8-9 years and 11-12 years for the native talker in quiet and noise, respectively, and 14-15 years for non-native talker in quiet; the oldest children (15 years) did not achieve adult-like performance for the non-native talker in noise. The inclusion of a single non-native accent limits the generalization of these findings. Because of its importance to functioning in everyday life in a global world, the current study examines intelligibility of eight unfamiliar native and non-native accents in school-age children through adolescents to examine differences in accent intelligibility development more fully.

2. METHOD

2.1. Participants

Two groups of children participated. The younger group consisted of 304 children between 5 to 7 years (mean age = 6.5 years, SD = 0.8 years; 163 female, 141 male, 0 nonbinary). The older group consisted of 147 children between 11 and 13 years (mean age = 12.4 years, SD = 0.9 years; 74 female, 72 male, 1 nonbinary). All children's caregivers reported typical hearing, speech, and language development. All children were monolingual American English-speaking and had minimal to no exposure to the unfamiliar accent varieties to which they were assigned. Testing took place in the Midland dialect region of the United States, so all children had extensive exposure to Midland American English.

2.2. Materials

The stimuli were 60 English sentences from the Hearing In Noise Test for Children (HINT-C) [26]. HINT-C sentences are simple, declarative sentences containing words familiar to children. The sentences were recorded from nine adult females representing each the following English accents: Midland American, Southern Standard British, Scottish, Bilingual Hindi, German, Mandarin, French, Japanese, and Spanish. Root Mean Square amplitude was equalized across the sentences to equate sound pressure level. To create the noise-added condition, sentences were mixed with 8-talker babble [from 27] at a signal-to-noise ratio (SNR) of +4 dB. Each sentence was centered on a random selection of babble that was 1-second longer than the sentence.

2.3. Procedure

Children were recruited from the Center of Science and Industry (COSI) in Columbus, OH, United States and tested in a quiet lab within the museum. Caregivers completed a demographic questionnaire about their child's language background. The study was approved by the local IRB.

Sentences were presented at a comfortable listening level under Audiotechnica headphones (model 8TH-770COM). Children were randomly assigned to either quiet or +4 dB SNR, and to one of four accent conditions all of which contained Midland: 1) German and Scottish, 2) Mandarin and Bilingual Hindi, 3) British and Japanese, or 4) French and Spanish. Prior to testing, children completed nine practice trials representing three sentences from each accent of their assigned condition. Twenty test sentences were contributed by each talker per condition (60 total). Sentences were randomly blocked by accent and randomized within each block. They were asked to repeat each sentence as best they could and guess when necessary. An experimenter recorded each response in real time and scored responses offline. Words were scored as incorrect if they included added or deleted phonemes. Only a(n)/the, has/had, have/had, are/were, and is/was were exceptions to this rule, consistent with the HINT-C scoring method.

Note that some of the data from the younger group have been reported previously: British and Japanese [28], and Mandarin, Bilingual Hindi, German, and Scottish [29]. All data were collected on a Dell Optiplex 790 Desktop Computer using Pavlovia (http://pavlovia.org/) or E-Prime 2.0 [30]. Data not reported elsewhere include all conditions from the older group and the French and Spanish condition from the younger group. Data were combined across studies to more fully understand developmental differences in accent intelligibility across many accent varieties.

3. RESULTS

Mean accuracy and standard error are presented across all 9 accents as a function of age group in Figure 1. Word recognition accuracy was analyzed using a generalized linear mixed effects model with a logit link function (see Table 1). Random effects included age group (older vs. younger, which was the reference) and accent (9 levels, dummy coded with Midland as the reference). Listening condition (noise vs. quiet, which was the reference) was included as a fixed effect. Participant and item (word) were included as random intercepts.

As expected, older children had better word recognition accuracy than younger children (χ^2 = 58.44, $p < .001$) and word recognition accuracy was better in quiet than in noise (χ^2 = 159.32, $p < .001$). The random effect of accent was also significant (χ^2 = 798.46, $p < .001$). Accuracy was better for Midland than all other accents (*ps* < .001) except German ($p = .418$), a non-native accent that, like English, is a Western Germanic language. Four accents interacted with age, reflecting that relative to older children, younger children had poorer word recognition with one unfamiliar, native accent (British), two non-native varieties (Mandarin and Spanish), and Bilingual Hindi. The seven two-way interactions between accent and listening condition suggest that children overall have more difficulty with the majority of the accents tested in noise relative to quiet. Two three-way interactions were significant (age, listening condition, and Mandarin; age, listening condition, and Spanish) indicating that

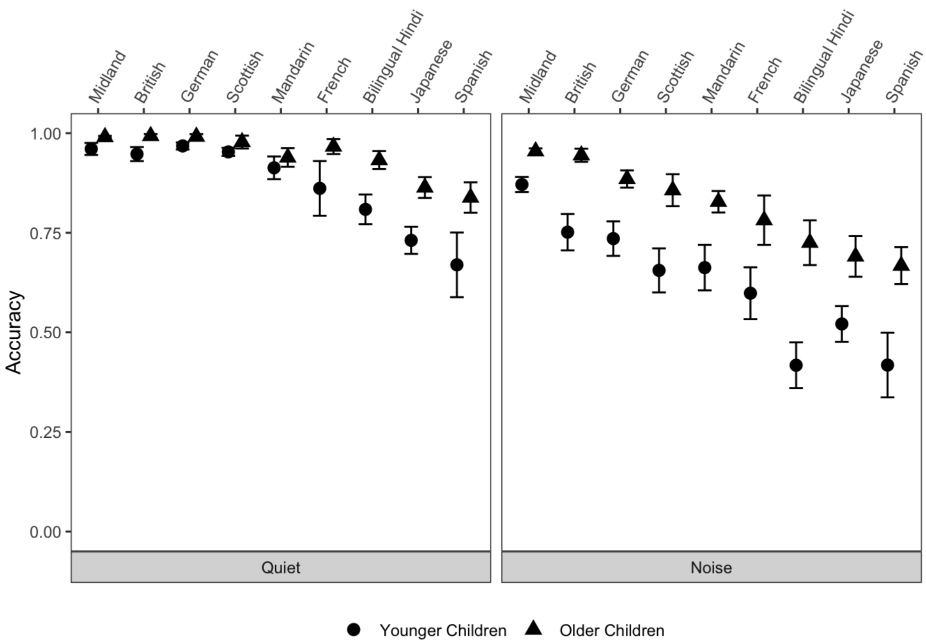

Figure 1: Mean word recognition accuracy (proportion correct) +/- 1 standard error across all 9 accents as a function of age group. Circles reflect younger children's performance and triangles that of the older children. Accuracy in quiet is shown in the left-hand panel and accuracy in +4 dB SNR is shown in the right-hand panel.

noise influences younger and older children's word recognition differently for two of the non-native varieties relative to Midland.

	Estimate	SE	*z*-value	*p*-value
Intercept (Midland)	4.25	.12	36.30	< .001
Age (Older)	1.25	.16	7.64	< .001
Condition (Noise)	-1.64	.13	-12.62	< .001
Acc (British)	-.47	.13	-3.47	< .001
Acc (Scottish)	-.70	.16	-4.77	< .001
Acc (Mand)	-.96	.12	-8.21	< .001
Acc (French)	-.53	.16	-3.40	< .001
Acc (BL Hin)	-2.06	.12	-16.88	< .001
Acc (Japanese)	-2.75	.14	-20.28	< .001
Acc (Spanish)	-2.43	.16	-15.28	< .001
Age x Acc (British)	.85	.33	2.58	.010
Age x Acc (Mand)	-.83	.19	-4.29	< .001
Age x Acc (BL Hin)	.40	.19	2.05	.040
Age x Acc (Spanish)	-.53	.21	-2.52	.012
Acc (British) x Cond	-.77	.13	-6.14	< .001
Acc (German) x Cond	-1.08	.14	-7.48	< .001
Acc (Scottish) x Cond	-1.11	.14	-8.19	< .001
Acc (Mand) x Cond	-.60	.11	-5.39	< .001
Acc (French) x Cond	-1.23	.16	-7.58	< .001
Acc (BL Hin) x Cond	-1.06	.11	-9.78	< .001
Acc (Spanish) x Cond	-.43	.15	-2.83	.005
Age x Mand x Cond	.73	.23	3.15	.002
Age x Spanish x Cond	.73	.25	2.85	.004

Table 1: Significant results of the mixed effects model, which included fixed effects for listening condition, and random effects for age group and accent, as well as all two- and three-way interactions. *Note:* Acc = Accent, Mand = Mandarin, BL = Bilingual, Cond = Condition, Hin = Hindi.

4. DISCUSSION

This study is the first to include both a relatively large number of unfamiliar native and non-native accents in a spoken word recognition task and a large group of adolescent participants to examine developmental differences in accent intelligibility cross- sectionally. Intelligibility of accents is important to study developmentally because understanding speech of people with different language and dialect histories is a real-life, everyday skill needed to communicate in a global society. Including many unfamiliar accent varieties, both native and non-native, is valuable for generalizability, as well as for allowing a more nuanced understanding of accent perception development.

The results suggest that in quiet both groups maintain relatively high spoken word recognition accuracy with a variety of unfamiliar accents but show slightly poorer word recognition with a subset of the non-native talkers. The younger children also showed some decrement in word recognition with the bilingual talker. These results contrast with previous findings for adults showing that adult listeners tend to show high word recognition accuracy with unfamiliar native and non-native accents in quiet and only show decrements in noise-added conditions [1,19]. For both groups of children, the addition of noise resulted in substantial decrements in word recognition accuracy relative to performance in quiet for most of the unfamiliar accents. There was some evidence that word recognition for Spanish- and Mandarin-accented English talkers are influenced differently by noise for the two age groups of children. The underlying causes for why listening condition and age interact with these two accents but not the others should be explored in future research. In particular, the contribution of factors such as the acoustic-phonetic characteristics of the accents, children's prior familiarity with the accents, and sociolinguistic variables should be investigated.

These results suggest that word recognition for talkers with unfamiliar accents improves during early and middle childhood, particularly in noise, which is a more common listening environment than quiet, and that improvement from early childhood to later childhood does not occur to the same degree across accents. Moreover, while non-native accents tend to be more difficult to understand than native ones, there is no evidence of a native/non-native divide. For example, the German-accented talker was one of the easier speakers to understand for both age groups.

Future research should examine adults' word recognition of these materials to determine if, when, and under what conditions adolescents attain adult-like intelligibility scores with these accents. Still, these data support previous studies [11-14] that accent perception has a protracted period of development. Further, it builds on prior work by investigating both unfamiliar native and non-native varieties in the same paradigm. Follow-up work should examine the acoustic-phonetic characteristics of the accents that contribute to the intelligibility differences between the younger and older listener groups to provide insight into the developmental changes underpinning the improvements observed with development.

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