Toddlers’ Word Recognition in an Unfamiliar Regional Accent: The Role of Local Sentence Context and Prior Accent Exposure

Marieke van Heugten
Department of Psychology, University at Buffalo, State University of New York, USA

Elizabeth K. Johnson
Department of Psychology, University of Toronto, Canada

Abstract
Adults are generally adept at recognizing familiar words in unfamiliar accents. However, studies testing young children’s abilities to cope with accent-related variation in the speech signal have generated mixed results, with some work emphasizing toddlers’ early competence and other work focusing more on their long-lasting difficulties in this domain. Here, we set out to unify these two perspectives and propose that task demands may play a crucial role in children’s recognition of accented words. To this end, Canadian-English-learning 28-month-olds’ looks to images on a screen were recorded while they were presented with a Scottish-accented speaker instructing them to find a depicted target object. To examine the effect of task demands, both local sentence context and prior accent exposure were manipulated. Overall, Canadian toddlers were found to recognize Scottish-accented words successfully, showing above-chance performance in the identification of words produced in an unfamiliar accent, even when target labels were presented in isolation. However, word recognition was considerably more robust when target words were presented in sentence context. Prior exposure to the unfamiliar Scottish accent in the laboratory did not modulate children’s performance in this task. Taken together, these findings suggest that at least some task-related factors can affect children’s recognition of accented words. Understanding unfamiliar accents, like understanding familiar accents, is thus not an isolated skill but, rather, is susceptible to contextual circumstances. Future models of spoken language processing in toddlerhood should incorporate these early effects of task demands.

Keywords
Accent adaptation, child speech perception, sentence context, word recognition, language acquisition

Corresponding author:
Marieke van Heugten, Department of Psychology, University at Buffalo, State University of New York, Buffalo, NY 14260, USA.
Email: mariekev@buffalo.edu
Introduction

Speaker-related variation in the realization of words results in a myriad of possible pronunciations of the same word. Nonetheless, comprehension of spoken language under everyday listening conditions is remarkably efficient. Although Americans watching *Downton Abbey* or *Monty Python* may initially be challenged when trying to understand the British pronunciations, such difficulties coping with the actors’ accents appear to abate over time, and generally seem to have resolved by the end of the first episode. The intuition that we rapidly adapt to accents that are initially difficult to understand has been confirmed in experimental work. That is, while listeners may initially be somewhat slower and less accurate when they process speech spoken in an unfamiliar accent (Adank, Evans, Stuart-Smith, & Scott, 2009; Floccia, Goslin, Girard, & Konopczynski, 2006; Munro & Derwing, 1995) these additional processing demands tend to rapidly decline once people have gained experience with the speaker or the accent (Bradlow & Bent, 2008; Dahan, Drucker, & Scarborough, 2008; Maye, Aslin & Tanenhaus, 2008). In fact, as little as a few sentences of speaker exposure can sometimes be sufficient for listeners to overcome these initial difficulties (Clarke & Garrett, 2004; Floccia, Butler, Goslin, & Ellis, 2009). This ability to accommodate accented speech efficiently reveals the incredible flexibility of human speech perception; but when and how do such malleable signal-to-word mapping skills first develop?

Research examining early speech perception has suggested that young children, like adults, process spoken language much more efficiently when they listen to someone whose accent matches their own native accent rather than someone whose accent is unfamiliar. Within the first year of life, for example, infants experience less difficulty extracting and recognizing word forms from native-accented speech than from speech produced in an unfamiliar accent (Nazzi, Mersad, Sundara, Iakimova, & Polka, 2014) and generalization of word forms across speakers of the same accent is more easily achieved than generalization across accents (Schmale, Cristià, Seidl, & Johnson, 2010; Schmale & Seidl, 2009). Unlike adults, however, increased processing demands associated with unfamiliar accents often block children’s word recognition altogether, at least early in life. For example, although North-American and Australian 15-month-olds experience little difficulty recognizing frequently occurring words in their own native accent, recognizing the same words in an unfamiliar Jamaican accent remains challenging at this age (Best, Tyler, Gooding, Orlando, & Quann, 2009; Mulak, Best, Tyler, Kitamura & Irwin, 2013; van Heugten & Johnson, 2014). However, over time, with increased vocabulary size, and with experience with the accent, children learn to map accented pronunciations of words onto their underlying representation (Best et al., 2009; Mulak et al., 2013; Schmale, Cristia, & Seidl, 2012; Schmale, Hollich, & Seidl, 2011; van Heugten & Johnson, 2014; van Heugten, Krieger, & Johnson, 2015; White & Aslin, 2011).

Despite the mounting body of research on children’s ability to understand accented speech (Cristia et al., 2012), many details regarding the scope of children’s abilities to understand accented speech remain unresolved. For example, while some work has postulated that children understand words produced in an unfamiliar accent by 19 months of age (Best et al., 2009; Mulak et al., 2013), other studies have suggested that children require more time to acquire this ability (Floccia, Delle Luche, Durrant, Butler, & Goslin, 2012; Schmale et al., 2011; van Heugten et al., 2015) and that this acquisition process is still ongoing during the preschool and early school-age period (Bent, 2014; Nathan, Wells, & Donlan, 1998; Newton & Ridgway, in press). What could explain these seemingly contrasting results? One explanation might be that toddlers’ varying degree of success at different ages in different studies is due to the differences in stimulus characteristics (e.g., low vs. high phonological complexity of the target words, isolated words vs. sentences) and testing procedures (e.g., word comprehension vs. word repetition) across tasks. Given that adults’ speech perception can suffer tremendously in adverse conditions (Mattys, Davis, Bradlow, & Scott, 2012),
it seems reasonable that processing demands incurred by the listening conditions can similarly affect speech perception in children. This may be particularly pertinent for unfamiliar accents, which are initially challenging to understand to begin with.

Previous developmental work has tested children under highly variable conditions without systematically controlling (or manipulating) many of the parameters that differ from one study to the next. In particular, studies differ in their presentation of the target word, with some studies presenting children with isolated word tokens (Best et al., 2009; Floccia et al., 2012; van Heugten & Johnson, 2014), yet others presenting them with words embedded in full sentences (Mulak et al., 2013; Schmale et al., 2011, 2012; van der Feest & Johnson, in press; van Heugten et al., 2015; White & Aslin, 2011). However, due to additional differences in accents, age groups, populations, and tasks, the exact ramifications of sentence context remain unclear. Similarly, past work differing in its use of children’s prior experience with the speaker’s accent has resulted in mixed findings. That is, brief exposure to the accented speaker has been found to help toddlers recognize accented words in some situations (Schmale et al., 2012; van der Feest & Johnson, in press; van Heugten & Johnson, 2014; White & Aslin, 2011), but not in others (van Heugten et al., 2015), and even routine exposure to a minority accent at home through at least one parent is not always sufficient for efficient word recognition in the minority accent (Floccia et al., 2012; though see van der Feest & Johnson, in press). If children’s ability to recognize accented words depends so critically on the precise conditions under which they are tested, this could have pronounced consequences for understanding accented speakers in the real world, where listening conditions are not always optimal. To understand better toddlers’ perception of accented speech in everyday life, it is thus important to establish the conditions necessary for recognizing familiar words in unfamiliar accents and to examine the extent to which proficiency in this task is dependent on stimulus characteristics and task difficulty. In this study we therefore start assessing the contribution of factors affecting the ease of word recognition (henceforth: ‘task demands’) by systematically manipulating local sentence context and prior exposure to the relevant accent.

Using the Preferential Looking Procedure, Canadian English 28-month-olds were presented with a Scottish-accented speaker who asked children to look at a target object. We chose to test 28-month-olds because although children at this age have begun to develop the ability to recognize accented words in at least some tasks (Best et al., 2009; Mulak et al., 2013; Schmale et al., 2012; van Heugten & Johnson, 2014; van Heugten et al., 2015; White & Aslin, 2011), they are still in the process of fine-tuning this skill (Nathan et al., 1998; Newton & Ridgway, in press). This makes them an optimal age group for observing potential effects of task demands. The Scottish-accented test words were presented either in sentence frames or in isolation and were preceded by a video of The Very Hungry Caterpillar story (Carle, 1969), recorded by the same Scottish speaker, a distinctly different Australian English speaker, or a distinctly different native Canadian English speaker. These three exposure versions were included not only to test for effects of familiarity with the Scottish accent all children heard at test, but also to examine the consequences of prior exposure to unfamiliar accents unrelated to the test accent, thereby allowing us to disentangle potential benefits of experience with accents in general from benefits of experience with the specific accent at hand. Note that previous work has suggested that both sentence context (DePaolis, Vihman, & Keren-Portnoy, 2014; Fennell & Waxman, 2010; Fernald & Hurtado, 2006) and knowledge of the speaker’s pronunciation of words (Barker & Newman, 2004) can assist language processing during childhood. Such factors, clearly affecting task difficulty when perceiving speech in the native accent, could thus mean the difference between successful lexical access and the complete failure to recognize words when listening to an accented speaker. Recognition of the Scottish-accented words is therefore hypothesized to be conditional upon the presence of both factors. That is, only children presented with words in sentences preceded by the story in Scottish English are expected to succeed in this task, although it is also conceivable that...
either sentence context alone or exposure to the relevant accent alone could facilitate the ease of recognition compared to cases where neither is present.

2 Method

2.1 Participants

Seventy-two normally developing 27- to 29-month-old toddlers from the Greater Toronto Area were tested (age range: 822–894 days; 35 boys). According to parental reports, all children were raised in households where English was the only language spoken and where at least one parent had a North-American accent. None of the toddlers had any regular exposure to Australian or Scottish English and no hearing problems or recent ear infections were reported. An additional 21 toddlers were tested but excluded from the analyses due to extreme fussiness or failure to complete the study (16); equipment failure (1); history of language problems (2); or extended exposure to Scottish English through family members (2). All participating children received a certificate and a small toy.

2.2 Stimuli

Sixteen high-frequency nouns were used as target words in the test phase. To rule out the possibility that prior exposure would cause children to rely solely on words they had heard the speaker produce during exposure, rather than on a more general adaptation to the speaker’s sound structure, these nouns included both words that occurred in the story (henceforth: ‘story words’ — butterfly, cake, cheese and strawberry) and words that had not been used in the story (henceforth: ‘generalization words’ — ball, boat, book, car, cat, cup, cow, dog, duck, fork, soup and toast; see Table 1 for a narrow transcription). These words are generally well known by 28-month-olds, as indicated by an average target word production rate of 89.9% (range 69%–98.3%) at this age in the Lexical Development Norms for English (Dale & Fenson, 1996). Moreover, past work using these same test items has shown that even 25-month-olds have no difficulty understanding them (van Heugten et al., 2015). Each noun was represented by an image and the images were matched for approximate size and interest.

Nouns were either presented in isolation (e.g., Ball! or Boat!) or as the final word in a sentence frame (e.g., Look at the ball! or Where is the boat?). Both versions were recorded by a female native English speaker born and raised in Scotland, UK. The speaker was instructed to talk in a child-directed fashion. Target words in sentences lasted on average 759 ms. The average pitch level measured on the steady part of the vowel was 229 Hz and the average pitch peak was 252 Hz. Target words in isolation lasted on average 711 ms, with an average pitch level on the steady part of the vowel of 371 Hz, and an average pitch peak of 399 Hz. Note that the relatively low pitch levels of the words in sentence context (which always occurred in final position) were at least partially due to a naturally declining pitch contour over the course of a sentence (Cooper & Sorensen, 1981). In addition to these target words and phrases, auditory attention attractors (aww, hey, look, wow) were recorded to guide children’s attention to the screen prior to word onset. To increase local contextual information in the sentence frame condition, the speaker also recorded positive statements about the stimuli (e.g., Fantastic, eh? or How cute!).

On each test trial, a target and a distracter picture were presented side-by-side against a white background. Pictures loomed simultaneously to retain the child’s interest. The auditory attention getter was presented 400 ms after the appearance of the two pictures. This was either followed by
the target word in the isolated word condition or by the sentence containing the target word in the sentence frame condition. Regardless of the condition, the target word always started three seconds into the trial. In the sentence frame condition, target words were followed by a positive comment about the stimuli (e.g., Fantastic, eh? or How cute!). This comment was not included in the isolated word condition. Images were displayed on the screen for a total of seven seconds and trials were interceded by a colorful looming star accompanied by short auditory cartoon boings (see Figure 1 for a visual representation of these test trials).

We further recorded three versions of *The Very Hungry Caterpillar* story, one read by the same Scottish speaker who also spoke at test, one by a female Australian-accented speaker, and the remaining one by a female Canadian-accented speaker (van Heugten et al., 2015). Because children have previously been shown to adapt to speakers after concurrent presentation of accented words and their referents (White & Aslin, 2011), the video displayed the illustrations from the storybook. All three exposure videos lasted approximately two minutes and 21 seconds

### Table 1. Target words, broad transcriptions of their typical Canadian-accented pronunciations and narrow transcriptions of our Scottish-accented items.

<table>
<thead>
<tr>
<th>Target word</th>
<th>Typical Canadian-accented pronunciation (broad transcription)</th>
<th>Scottish-accented stimulus pronunciation (narrow transcription)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ball</td>
<td>bɔːl</td>
<td>b̩ɑʊ</td>
</tr>
<tr>
<td>boat</td>
<td>bɔut</td>
<td>b̩oʔət</td>
</tr>
<tr>
<td>book</td>
<td>bʊk</td>
<td>b̩ʊk</td>
</tr>
<tr>
<td>butterfly</td>
<td>bɔɾəflai</td>
<td>ˈbɛrəflai</td>
</tr>
<tr>
<td>cake</td>
<td>keik</td>
<td>k̩eik</td>
</tr>
<tr>
<td>car</td>
<td>kɑːj</td>
<td>k̩ɑːj</td>
</tr>
<tr>
<td>cat</td>
<td>kæt</td>
<td>k̩æt</td>
</tr>
<tr>
<td>cheese</td>
<td>tʃiːz</td>
<td>tʃiːz</td>
</tr>
<tr>
<td>cow</td>
<td>kɑʊ</td>
<td>k̩æʊ</td>
</tr>
<tr>
<td>cup</td>
<td>kɑp</td>
<td>k̩ɑːp</td>
</tr>
<tr>
<td>dog</td>
<td>dɑːg</td>
<td>d̩ɑːg</td>
</tr>
<tr>
<td>duck</td>
<td>dʊk</td>
<td>d̩ʊk</td>
</tr>
<tr>
<td>fork</td>
<td>fɔːk</td>
<td>fɛːk</td>
</tr>
<tr>
<td>soup</td>
<td>suːp</td>
<td>s̩ʊp</td>
</tr>
<tr>
<td>strawberry</td>
<td>stəaˈbeʃi</td>
<td>s̩təaˈbeʃi</td>
</tr>
<tr>
<td>toast</td>
<td>tʊst</td>
<td>t̩ʊst</td>
</tr>
</tbody>
</table>

![Figure 1](image-url). Visual representation of the audiovisual materials presented during test trials: analyses were conducted on the two-second time window starting 300 ms after target word onset.
2.3 Design

By manipulating both sentence context (words in isolation, words in sentence frames) and exposure accent (Scottish, Australian, Canadian), six conditions were created. Toddlers either listened to target words presented in sentences or in isolation and, within each of these two groups, toddlers heard the same Scottish speaker, a different Australian speaker, or a different Canadian speaker read the story prior to test. For each of these six conditions, four orders were designed. Each order featured four story word trials (for which both the target word and the distracter had been heard during exposure) and twelve generalization trials (for which neither the target word nor the distracter had been heard in the context of the current experiment).

Each of the selected images was presented twice throughout the test phase: once as target and once as distracter. This ensured that each of the sixteen experimental trials within a given order contained a unique target word. The order in which a picture was presented as target and as distracter was counterbalanced across orders, as was the location of the picture (left or right) on the screen. Within each video, targets occurred equally often on left and right.

2.4 Procedure

Children were seated on their parent’s lap in a double-walled, sound-attenuated test booth approximately one meter in front of a Sony LDC TV screen. An experimental session started with the child orienting toward the screen. Once a session had been initiated, it continued consecutively until the end of the test phase. The sessions were videotaped using a remotely controlled camera located directly underneath the screen. These video recordings were used to code the toddlers’ eye movements off-line. To avoid biases, parents wore closed headphones delivering masking music. Each experimental session lasted approximately five minutes.

2.5 Off-line coding

Sessions were coded off-line using SuperCoder, on a frame-by-frame basis. For each 33-ms frame a trained coder indicated whether the toddler looked toward the left picture, the right picture or neither of the two pictures. The coder was blind to both the auditory and the visual components of a trial. Four sessions were recoded by a second coder. The agreement on individual fixation durations was consistently high (mean correlation across videos = 0.996).

3 Results

Following previous work employing a similar paradigm (Mulak et al., 2013; Swingley, 2007; van Heugten et al., 2015; Zangl & Fernald, 2007), we used the proportion of fixations to the target picture as the dependent variable. This proportion of target fixations was computed by dividing the fixation times to the target by the sum of the fixation times to the target and the distracter. Fixations away from the screen and shifts between the two images were hence not taken into account. A value higher than 0.5 suggests a looking preference for the target word, while a value lower than 0.5 would reveal a looking preference for the distracter.

To examine word recognition in this study, the proportion of target fixations was analyzed in a two-second window starting 300 ms after target word onset (see Figure 2). A 2 × 3 × 2 mixed factorial Analysis of Variance with sentence context (sentences vs. isolated words) and exposure story speaker (Scottish vs. Australian vs. Canadian) as between-subject factors and word type (story words vs. generalization words) as a within-subjects factor conducted on these fixation proportions...
revealed a main effect of sentence context, $F(1,66) = 12.533; p = 0.001; \eta^2_p = 0.160$. Thus, children who were given carrier phrases recognized the Scottish-accented target words better than those who heard the words presented in isolation. There was an additional main effect of word type, $F(1,66) = 5.999; p = 0.017; \eta^2_p = 0.083$, indicating that story words were easier understood than generalization words (probably due to the story priming the story words) but, crucially, this main effect did not interact with any other factor. No other main effects or interactions were observed (all $p$-values $> 0.114$). Furthermore, closer inspection of the data revealed that, surprisingly and despite the effect of sentence context, the overall proportion of target fixations consistently exceeded chance level. Thus both words in sentences $t(35) = 9.114; p < 0.001; d = 1.083$ and words in isolation $t(35) = 4.564; p < 0.001; d = 0.877$ were recognized, albeit with greater precision for words in sentence frames than for words in isolation.

4 Discussion

To become mature language users, children need to learn to contend with accented speakers. Previous work has suggested that this capacity to flexibly map phonetically variable pronunciations of the same word onto the same underlying representation starts to develop within the second year of life (Best et al., 2009; Mulak et al., 2013; Schmale et al., 2012; van Heugten & Johnson, 2014; van Heugten et al., 2015; White & Aslin, 2011), but continues to be refined in the years

![Graph showing proportion of fixations to target images for Scottish-accented words in sentence and isolation conditions.](image-url)
thereafter (Bent, 2014; Nathan et al., 1998; Newton & Ridgway, in press). Here, we have proposed that children’s variable success at identifying words in unfamiliar accents early in life can, in part, be attributed to stimulus characteristics and task demands. To test this hypothesis, Canadian-English learning 28-month-olds’ ability to recognize Scottish-accented words was examined, while systematically varying sentence context and prior accent exposure – two factors known to affect processing difficulty in native-accented speech. Surprisingly, our results showed that children generally identified words in an unfamiliar Scottish accent with above-chance accuracy, regardless of whether words were presented in sentences or in isolation, and regardless of which accent was heard during exposure. In addition, children’s accuracy levels did not appear to be affected by exposure to the accented test speaker. Nonetheless, the use of sentence context did modulate ease of recognition; that is, in line with our predictions, children recognized words more reliably when they were embedded in sentences as opposed to when they were presented in isolation. Thus, although neither the use of sentence carriers nor access to the speaker’s pronunciation of words was a prerequisite for lexical access at this age, the presence of a sentence frame appeared to be beneficial for this purpose. This finding suggests that task difficulty can – at least to some extent – affect the efficacy with which accented words are identified, and demonstrates that the ability to cope with accents is not immutable but, rather, can vary as a function of cognitive demand.

What would underlie the advantage for recognizing words in sentence frames compared to words in isolation? Hearing words in sentence frames rather than in isolation may have contributed to the recognition of familiar words in at least three ways. First, sentence frames may allow toddlers to deduce the syntactic structure of the unfolding sentence, which in turn may help them anticipate the syntactic category of the final word in the sentence (e.g., Cauvet et al., 2014). As such, it may have been easier for toddlers to recognize words as the predicted noun than to recognize words in the absence of any syntactic prediction. Second, sentence context may have highlighted the referential status of the target word and, as such, may have enhanced children’s recognition of the target item. One possible consequence of this strategy would be that children might dedicate more effort to finding the correct picture and may therefore spend more time looking towards the screen. However, an analysis of children’s looking times provided no evidence for such an effect – the cumulative amount of time fixating on either picture in our two-second window of analysis was consistently high and did not differ depending on whether words were presented in sentences (on average 1859 s, SEM: 22.6 s) or in isolation (on average 1817 s, SEM: 28.4 s; t(70) = 1.139; p = 0.259). While this result does not exclude the possibility that the referential status may have been more transparent in the case of sentence context, the sentence carrier, at the very least, did not appear to increase children’s attention towards the screen. Finally, sentence frames can also be advantageous for identifying accented words in particular, because they may provide listeners with a ‘frame of reference’ for understanding subsequent words. In other words, the speaker information extracted from the sentence frame may help toddlers accommodate the previously unfamiliar accent.

Although the benefit of sentence context may be large enough to explain why the exposure accent did not modulate children’s recognition of words embedded in sentence frames, it does not explain why it did not affect children’s recognition of words in isolation. Based on just the comparison between children exposed to the Scottish- and children exposed to the Australian-accented speaker, one may posit that the lack of a difference between the two groups could have been due to toddlers simply relaxing their signal-to-word mappings after brief exposure to an unfamiliar accent (Schmale et al., 2012; Schmale, Seidl, & Cristia, 2015). That is, because the exposure speaker speaks in an unfamiliar accent, toddlers may have learned to put less weight on the exact pronunciations, allowing subsequent words produced in a non-regional accent to be recognized better,
regardless of whether this accent matches the one heard during exposure. However, given that the results remained unchanged even when the story was read in children’s own native Canadian accent, it is unlikely that experience with the exposure speaker involved any boosting of children’s performance in this task. A more plausible account for the absence of an exposure effect may therefore be that sentence context constrains the recognition of accented words to a greater extent than prior speaker exposure and that children’s performance in this task under the current listening conditions may have reached the highest level possible for word tokens presented in isolation. Had the task been harder (e.g., by using speech in noise, by delaying the presentation of the pictures until target word onset, or by adding additional images to the display), and baseline recognition levels lower, toddlers might have used exposure to the accent characteristics to help them reach the current level of success.

The question of how task demands affect word recognition is particularly relevant for difficult cognitive activities – for instance, those involving language comprehension in the context of unfamiliar accents. In comparison to most other speaker-related information affecting the acoustic–phonetic variability in the speech signal (e.g., gender, age, mood), unfamiliar accents can be notoriously challenging to cope with because, depending on the population, children may have far less experience with this type of variation early on in life. Perhaps, as a result, children continue to experience difficulty with unfamiliar accents long after they have learned to recognize words produced by unfamiliar speakers of their own regional background (Best et al., 2009; Floccia et al., 2012; Mulak et al., 2013; van Heugten & Johnson, 2014; van Heugten et al., 2015). In other words, accented speech remains appropriately susceptible to task demands in toddlerhood. Had we tested younger children, however, or used a more taxing procedure, similar effects may have been observed for other types of speaker variability. Similarly, we observed here an effect of sentence context; but other factors – such as the distance between the native and the unfamiliar accent, the familiarity of the test items, and the task – could also have substantial effects on lexical access. Because the exact combination of these factors varies continuously in the real world, studying children’s perception of accented speech in naturalistic environments entails studying the contribution of each of these factors, as well as their interactions, during spoken language processing in early childhood. This work has taken a first step in this direction and emphasizes the importance of continuing to explore the consequences of other factors underlying children’s ability to contend with accents.

In sum, this study examined the effects of stimulus characteristics and task demands on toddlers’ ability to contend with unfamiliar accents. Manipulating both sentence context and prior speaker exposure, we found that children’s identification of accented words exceeds chance levels even under the most challenging listening conditions employed here. At least under the constrained conditions used at test, 28-month-olds are thus able to cope with accent variability, even in the absence of prior exposure to the unfamiliar speaker or accent. However, performance was enhanced when target words were presented in sentence carriers rather than in isolation. This suggests that, toddlers’ flexible language processing skills notwithstanding, task demands can modulate the ease with which accented words are recognized. This is important to keep in mind when attempting to unify the differences across studies in the proposed developmental timelines of learning to cope with accent deviation.

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Note

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