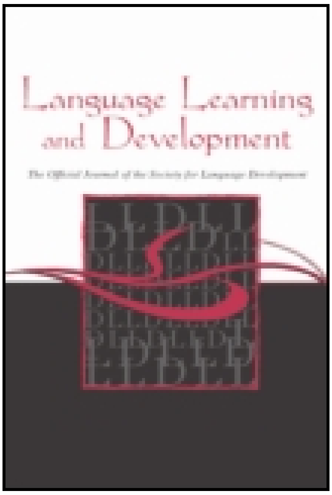

Language Learning and Development
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hlld20

The Developmental Trajectory of Toddlers' Comprehension of Unfamiliar Regional Accents

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Published online: 14 Mar 2014.

To cite this article: Marieke van Heugten, Dena R. Krieger & Elizabeth K. Johnson (2015) The Developmental Trajectory of Toddlers' Comprehension of Unfamiliar Regional Accents, Language Learning and Development, 11:1, 41-65, DOI: 10.1080/15475441.2013.879636

To link to this article: http://dx.doi.org/10.1080/15475441.2013.879636

Language Learning and Development, 11: 41–65, 2015

ISSN: 1547-5441 print / 1547-3341 online
DOI: 10.1080/15475441.2013.879636

Routledge
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Efficient language use involves the capacity to flexibly adjust to varied pronunciations of words. Although children can contend with some accent variability before their second birthday, it is currently unclear when and how this ability reaches its mature state. In a series of five experiments, we examine the developmental trajectory of toddlers' comprehension of unfamiliar regional accents. Experiments 1 and 2 reveal that Canadian-English-learning 25-month-olds outperform their 20-month-old peers on the recognition of Australian-accented words and that this effect is likely driven by 25-month-olds' larger vocabulary size. Experiments 3 to 5 subsequently show that 25-month-olds' recognition of familiar words holds regardless of prior exposure to the speaker or accent. Taken together, these findings suggest that children's ability to cope with accent variation improves substantially as their vocabulary expands in the second year of life and once it does, children recognize accented words on the fly, even without experience with the accent.

In today's modern society, interacting with people from a wide variety of linguistic backgrounds has become the rule rather than the exception. Many of these people will speak in unfamiliar accents and may hence pronounce words in a fashion that differs tremendously from the listener's native accent. Bostonians' pronunciation of *car keys*, for example, resembles Californians' pronunciation of the word *khakis.* Similarly, when Australians talk about a *shark* or a *heart*, this may sound more like the American way of saying *shock* and *hot*. Efficient speech perception thus entails that listeners recognize words in the face of substantial variation in their acoustic-phonetic realizations. Indeed, adults are effective language users and possess flexible signal-to-word mapping processes. This enables them to map phonetically distinct tokens of a word produced in an unfamiliar accent onto their corresponding lexical representation (e.g., Floccia, Goslin, Girard, & Konopczynski, 2006). And although adult listeners' word recognition is initially somewhat

Part of this work was reported in Marieke van Heugten's doctoral dissertation and has been presented at the 2013 Society for Research in Child Development Biennial Meeting, Seattle, Wash., and the 2013 Linguistic Society of America Variability Workshop, Ann Arbor, Michigan.

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slower for accented than for native speech, any such difference typically abates within less than a minute of exposure to an accented speaker (e.g., Clarke & Garrett, 2004; also see Bradlow & Bent, 2008). Here we ask how these adaptive signal-to-word mapping strategies develop over the course of first language acquisition.

The importance of understanding when and how children acquire flexible signal-to-word mapping abilities is reflected in the growing body of research focused on this issue (see Cristia et al., 2012, for a review). This work has revealed that in the absence of prior exposure to the accent, young children often struggle to recognize accented words. North-American 15-month-olds, for example, listen longer to highly familiar words such as *mommy* and *ball* than to low-frequency words that are likely not part of their vocabulary. This preference for familiar words, however, is only observed when stimuli are produced by a speaker of their own variant of English. When the unknown talker speaks an (unfamiliar) Jamaican variant of English, an accent distinct from their own North-American variant of English, children do not display this listening preference for familiar words (Best, Tyler, Gooding, Orlando, & Quann, 2009; also see Van Heugten & Johnson, 2014). Likewise, Australian 15-month-olds presented with two familiar objects on a TV screen reliably orient toward the labeled object when the label is produced in their own native Australian accent, but not when it is produced in an unfamiliar Jamaican accent (cf. Mulak, Best, Tyler, Kitamura, & Irwin, 2013). It is only with the increase in vocabulary size that children appear to start learning to spontaneously cope with accented speech in the absence of speaker exposure. For example, unlike the average 15-month-olds described above, 15- to 17-month-old English-learners with relatively large vocabularies, as well as their older 19-month-old counterparts, recognize words produced in an unfamiliar Jamaican accent (Best et al., 2009; Best, Tyler, Kitamura, & Bundgaard-Nielsen, 2010; Mulak et al., 2013).

The picture that emerges from these studies shows that there is a general trend toward gradual improvement in children's ability to cope with accented speakers. However, the precise time course of this developmental trajectory toward mature accent processing is less clear. Around 19-20 months of age, for example, when North-American English-learning toddlers understand Jamaican-accented words even in the absence of exposure to the speaker (Best et al., 2009; also see Mulak et al., 2013), British children raised in a rhotic accent environment continue to experience difficulty recognizing words in a nonrhotic accent (Floccia, Delle Luche, Durrant, Butler, & Goslin, 2012). That is, 20-month-olds growing up hearing words such as *car* and *bear* realized with a final /ɹ/ fail to recognize these words spoken by someone who does not produce this final /ɹ/. In fact, even toddlers in this study who hear at least one of their parents speak in an accent where /ɹ/s are *not* pronounced in word-final position fail to recognize such /ɹ/-less pronunciations of these words. Moreover, similar difficulties with unfamiliar accents are sometimes observed for older children. For example, 24-month-olds who have just learned a new word in their own native accent do not recognize this word produced in an unfamiliar foreign accent (Schmale, Hollich, & Seidl, 2011). And, when tested on a much more challenging task where children are asked to define a word, even 4-year-olds' responses are affected more by the accent than the responses of their 7-year-old peers (Nathan, Wells, & Donlan, 1998). Thus, despite the finding that children can deal with some accents under some conditions by 19 months of age (Best et al., 2009; Mulak et al., 2013), there are other situations where children struggle with accented speech until a much later age. Learning to contend with accents thus appears to be a gradual process that requires time to fully master.

Further evidence suggesting that there may not be an absolute threshold that distinguishes children who can from children who cannot cope with accent variation comes from studies examining the effects of brief accent exposure on children's accented word recognition. Such experience with a speaker has been shown to enhance adults' comprehension of speech in unfamiliar accents (Bradlow & Bent, 2008; Clarke & Garrett, 2004; Dahan, Drucker, & Scarborough, 2008; Maye, Aslin, & Tanenhaus, 2008; Skoruppa & Peperkamp, 2011; Trude & Brown-Schmidt, 2012). Recent work examining the effects of accent familiarity for language learners confirms that infants, too, benefit from brief speaker exposure. For example, although Canadian 15-month-olds fail to recognize words in Australian-accented English without exposure to the speaker or accent, infants this age do succeed at recognizing Australian-accented words after brief exposure to the speaker narrating a familiar story (Van Heugten & Johnson, 2014; also see Schmale, Cristia, & Seidl, 2012; White & Aslin, 2011 for benefits of accent exposure for older children). Thus, at least under some listening conditions, adaptable signal-to-word mapping abilities appear to be in place months before infants recognize accented words "on the fly," in the absence of prior exposure.

What is the nature of such adaptation to unfamiliar accents? On the one hand, studies testing children's ability to accommodate a particular vowel shift have revealed that children's recognition of words with modified vowels is improved after exposure to this shift, but that improvement is constrained to those shifts they have been trained on. For example, 19-month-olds presented with words such as *bottle* and *sock*, produced as *battle* and *sack*, later recognized *black* and *dag* as instances of *block* and *dog*. They did not, however, recognize *blick* and *dig* as referring to *block* and *dog* (White & Aslin, 2011; also see Maye et al., 2008, for similar results with adults), suggesting that adaptation is phonologically specific and does not cause toddlers to be more tolerant of other vowel mispronunciations. Other studies, on the other hand, have claimed that toddlers may, in fact, rely more on a general expansion strategy. That is, variability in bottom-up information can cause toddlers to be more accepting of accent deviation, even when this variability is accent-independent (e.g., exposure to multiple native-accented speakers) or when it is presented in a different modality (e.g., exposure to different people in the absence of speech; Schmale, Cristià, & Seidl, 2013). How children might adapt their reliance on each of these strategies is currently unclear, although it has been proposed that this general expansion strategy can be used as a fallback, in cases where children need more extensive experience with the accent to accommodate the discrepancies (Schmale et al., 2012).

In short, it is evident that toddlers experience greater difficulty processing accented speech than processing unaccented speech and that the ability to cope with and adapt to accent variation develops over time and with increasing vocabulary. It is, however, less clear exactly when this development is set into motion and what mechanisms drive accent adaptation. Some of the reported differences in children's ability to cope with accented speech might be due to differences between the populations tested, the unfamiliar accent's distance from the native accent, the extent to which the test words are known (cf. Schmale et al., 2011), whether the accent is native or foreign (cf. Goslin, Duffy, & Floccia, 2012), and more task-specific effects such as object pairing or label-object reinforcement (Floccia et al., 2012; Mulak et al., 2013; White & Aslin, 2011). This suggests that the specific (linguistic and nonlinguistic) context in which accented words are presented can greatly affect recognition at these early, arguably relatively fragile stages of language development. Thus, in order to draw generalizations from the specific studies and to better understand the nature of children's ability to contend with unfamiliar accents, it is important to begin to examine the factors underlying children's success or failure in coping with accent variability. In the current study, we therefore examine how toddlers learn to recognize words produced in an unfamiliar regional accent. Our goal is twofold. First, we examine changes in children's ability to recognize accented words that occur around their second birthday. Second, we explore the type of prior voice and accent exposure children require for an early understanding of accented speech.

EXPERIMENT 1

Experiment 1 tested Canadian-English-learning 20- and 25-month-olds' ability to recognize words produced in an unfamiliar Australian accent. Australian English is a particularly well-suited accent to use in this study, as it is unfamiliar to the majority of the Canadian children and differs drastically from Canadian English, both phonetically and prosodically (Wells, 1982). Perhaps most notably, Australian vowels tend to be more raised and fronted than Canadian English vowels. This causes vowels such as [ɪ] and [ɒ] to sound like [i] and [oː], respectively, in stressed positions. In addition, weak unstressed vowels are merged, causing unstressed [ɪ] and [ə] to sound alike.

To increase the likelihood that both 20- and 25-month-olds succeed in this task, toddlers were first presented with an exposure phase in which they listened to a recording of the *Very Hungry Caterpillar* story (Carle, 1969), produced in an Australian accent. Following this exposure phase, toddlers' recognition of Australian-accented test words was tested. On each test trial, two familiar objects appeared on a TV screen and children were presented with instructions recorded by the same Australian-accented speaker asking them to look at one of two depicted items. Children were presented with words that occurred in the story as well as with generalization words that had never been heard before in that speaker's accent. Recognition of the accented words in this paradigm is demonstrated by preferential fixation of the target once the word is named.

Given that children learn to recognize words in unfamiliar accents before their second birthday (Best et al., 2009; Mulak et al., 2013) and that brief accent exposure can be sufficient to help 24-month-olds who cannot spontaneously recognize newly learned words in unfamiliar accents (Schmale et al., 2012), we expected 25-month-olds to look more toward the target object than toward the distracter after object labeling. Since there is also evidence that children's accommodation of accented words generalizes to beyond the words they hear during exposure (see Schmale et al., 2012; Van Heugten & Johnson, 2014; White & Aslin, 2011) this potential adaptation process is predicted to be word-independent and children this age should hence recognize accented words regardless of whether they had heard the speaker produce them before. Preferential orientation toward the target object should thus be observed in both story word and generalization trials.

The outcome for the 20-month-olds is more difficult to predict. On the one hand, some studies have suggested that children this age cope well with between-accent deviation (Best et al., 2009; Mulak et al., 2013), especially after exposure to the accent (Van Heugten & Johnson, 2014; White & Aslin, 2011). This would make it plausible that Canadian 20-month-olds, much like their older counterparts, would recognize the Australian-accented generalization and story words in this experiment where word recognition is measured after an initial exposure phase. On the other hand, even daily exposure to a nonrhotic accent through at least one of children's caregivers may be insufficient for 20-month-olds to accommodate certain phonemes in that accent (Floccia et al., 2012). Another possibility would thus be that the ability for Canadian-English-learning children to recognize words in a much more distinct Australian accent only develops after this age and that our 20-month-olds would not be able to recognize words produced by an Australian speaker.

Method

Participants. A total of 32 normally developing monolingual English-learning toddlers from the Greater Toronto Area were tested. Half were between 19 and 21 months of age (henceforth: 20-month-olds; age range: 602-641 days; 8 boys) and the other half were between 24 and 26 months of age (henceforth: 25-month-olds; age range 737-785 days; 8 boys). All toddlers in this experiment and in the subsequent experiments presented here were free of any known hearing issues or recent ear infections and grew up in households where at least one parent spoke English with a North-American accent. In addition, none of the toddlers had had any substantial exposure to Australian-accented English, as established by a language questionnaire at the end of the lab visit. An additional six 20-month-olds and one additional 25-month-old were tested but excluded from the analyses due to extreme fussiness or failure to complete the study. All participating toddlers in this and subsequent experiments received a certificate and a small gift.

Stimuli. A total of 16 nouns (story words: *butterfly, cake, cheese, strawberry*; generalization words: *ball, boat, book, car, cat, cup, cow, dog, duck, fork, soup*, and *toast*, see Table 1 for a broad transcription) were selected to be used as target words in the test phase this study. For each noun, an image was selected to represent the word. These images were matched for approximate size and interest. A questionnaire administered to the parents at the end of their visit asking

TABLE 1
Target Words and Their Broad Phonetic Transcriptions in Canadian and Australian English

Target word	*Transcription (Canadian English)*	*Transcription (Australian English)*
ball	bɑːl	boːl
boat	boʊt	bəʉt
book	bʊk	bʊk
butterfly	bʌtɚflaɪ	bɐtəflɑe
cake	keɪk	kæɪk
car	kɑɚ	kɐː
cat	kæt	kæt
cheese	tʃiːz	tʃiːz
cow	kaʊ	kæɔ
cup	kʌp	kɐp
dog	dɑːg	dɔg
duck	dʌk	dɐk
fork	foɚk	foːk
soup	suːp	sʉːp
strawberry	strɑːbɛri	stɹoːbəɹiː
toast	toʊst	təʉst

The Australian transcriptions use the symbols described in Cox and Palethorpe (2007).

about their judgment of their toddlers' comprehension of the words and the recognition of each of the pictures in the study indicated that the words are generally known by children in this study (average reported word comprehension rate of 88.3% for the 20-month-olds and 96.4% for the 25-month-olds), and that the pictures clearly depicted the appropriate nouns (the average picture was reportedly recognized as depicting the target item by 82.8% of the 20-month-olds and 92.3% of the 25-month-olds).

Nouns were embedded in each of two carrier sentences; one imperative (*Look at the [noun]!*) and the other one a question (*Where's the [noun]?*). Nouns always occurred in sentence-final position. These sentences were recorded in a child-directed fashion by a female native bilingual speaker of Australian English and Cantonese. The speaker, living in Canada at the time of the recordings, was raised in Sydney, Australia, and self-identified as being more proficient in English than in Cantonese. Informal verification by another Australian English speaker confirmed that her accent sounded Australian and that she did not have a perceptible foreign accent. Her recordings of the target words lasted on average 646 ms. In addition, tokens of auditory attention attractors (*aww, hey, look, wow*) were recorded to be used to direct toddlers' attention to the screen prior to sentence onset. To increase toddlers' interest in the task, the speaker also recorded positive statements about the stimuli (e.g., *Fantastic, eh?* or *How cute!*).

The *Very Hungry Caterpillar* story presented to the toddlers prior to test was read by the same speaker. Since past work has successfully induced adaptation by means of picture labeling (White & Aslin, 2011), the video displayed the illustrations from the storybook (with the text erased) corresponding to the accompanying part of the story. The video lasted approximately 2 minutes and 21 seconds.

Design. During the test trials, the movie presented two pictures (a target and a distracter) side-by-side against a white background for a total of seven seconds. Picture pairs were created such that the pictures either both represented animate objects or both represented inanimate objects. Object labels started with the same onset consonant in half of the pairs and with different onset consonants in the other half of the pairs (see Table 2). To maintain the toddlers' interest in the video, both objects simultaneously increased and decreased in size in a gradual fashion. Approximately 2–2.5 s after the appearance of the two objects, toddlers were instructed to look at one of those two pictures. Target words occurred exactly 3 s after picture onset. The instruction

TABLE 2
Word Pairs Used in the Test Phase

Word type	*Pictures*	*Example auditory stimuli*
story words	cake - cheese	Look! Where's the cake/cheese? Can you see it?
story words	strawberry - butterfly	Hey! Look at the strawberry/butterfly! Can you find it?
generalization words	fork -book	Aww! Where's the fork/book? Fantastic, eh?
generalization words	ball - boat	Wow! Look at the ball/boat! Do you like it?
generalization words	cat - cow	Aww! Look at the cat/cow! How cute!
generalization words	toast - soup	Wow! Look at the toast/soup! What do you think?
generalization words	duck - dog	Look! Where's the duck/dog? Isn't it pretty?
generalization words	cup - car	Hey! Where's the cup/car? Amazing, eh?

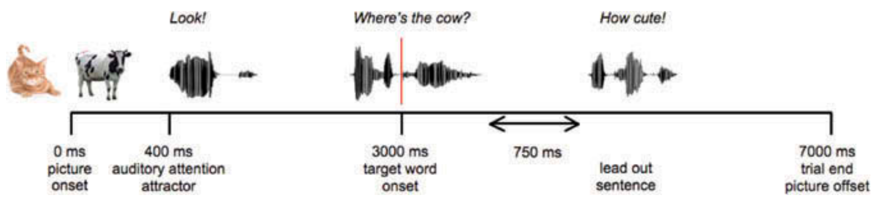

FIGURE 1 Visual representation of the test trials in Experiments 1–5. Analyses were conducted on the two-second time window starting 300 ms after target word onset. (Color figure available online.)

was preceded by an attention-getting statement and followed by a positive lead-out sentence, commenting about the target item (see Figure 1 for a trial outline).

In both age groups, toddlers were randomly assigned to one of four test orders. Each test order consisted of 16 test trials. In the four story word trials, the two pictures on the screen referred to words present in the *Very Hungry Caterpillar* story. In the 12 generalization trials, neither of the two depicted objects represented words previously mentioned by the speaker.

Each of the 16 nouns was presented as target once, such that each combination of pictures appeared twice during the study. The order of a picture being target or distracter as well as the position of the picture on the left or right of the screen was counterbalanced across orders. Within each order, targets occurred equally often on either side.

Procedure. Toddlers were individually tested using the Preferential Looking Paradigm. They were seated on their caregivers' lap approximately 1 m away from a Sony LDC TV screen in a double walled sound-attenuated IAC test booth. Once the toddler oriented toward this screen, the experimenter started the video. Sessions were videotaped by a camera below the screen for subsequent offline coding of gaze position. To avoid biases, parents were naïve to the experimental predictions and listened to masking music over closed headphones throughout the whole experiment. The experiment lasted approximately 5 minutes. After their toddler had watched the video, parents completed a questionnaire regarding the toddlers' comprehension of the target words and their recognition of the pictures used in the study. They also completed, either at the time of appointment or in the preceding or following few days, the vocabulary component of the MacArthur-Bates Communicative Development Inventory: Words and Sentences form designed for use with children between 16 and 30 months.

Off-line coding. Sessions were imported for off-line frame-by-frame coding using SuperCoder (http://hincapie.psych.purdue.edu/Splitscreen/home.html). For each 33-ms frame, the gaze position of the toddler was judged to be a look toward the left, right or neither picture. The coder was blind to both the audio and the video components of the trials. Four sessions of each age group were randomly selected to be recoded by a second coder. The agreement on individual fixation durations was consistently high between the two coders (mean correlation for the four sessions = .99 both for the 20-month-olds and for the 25-month-olds).

Data analysis. Following previous studies employing a similar procedure (e.g., Johnson, McQueen, & Huettig, 2011; Swingley, 2007; Van Heugten & Johnson, 2011; Zangl & Fernald, 2007), the proportion of fixations to the target picture was used as the dependent variable. This proportion was calculated by dividing the fixations to the target by the sum of the fixations to the target as well as the distracter. Thus, as only fixations toward one of the two pictures were taken into account (and looks away from the screen or shifts between pictures did not affect this ratio), a value of .5 suggests that the two pictures are fixated equally. Values greater than .5 are indicative of a looking preference toward the target picture.

To examine whether toddlers recognized the words in the study, the target fixation proportion was analyzed during a two-second time window, starting 300 ms after target word onset. Fixations occurring prior to that time window are likely initiated before target word onset and are not elicited as a result of hearing the target word (see Johnson & Huettig, 2011; Van Heugten & Johnson, 2011; Zangl & Fernald, 2007, for similar use of time windows).

Results

As can be seen in Figure 2, 25-month-olds spent a greater proportion of the time fixating the target (mean proportion of target fixations: .60; SEM: .020) than did the 20-month-olds (mean proportion of target fixations: .53; SEM: .016). In line with this observation, one-sample *t*-tests revealed

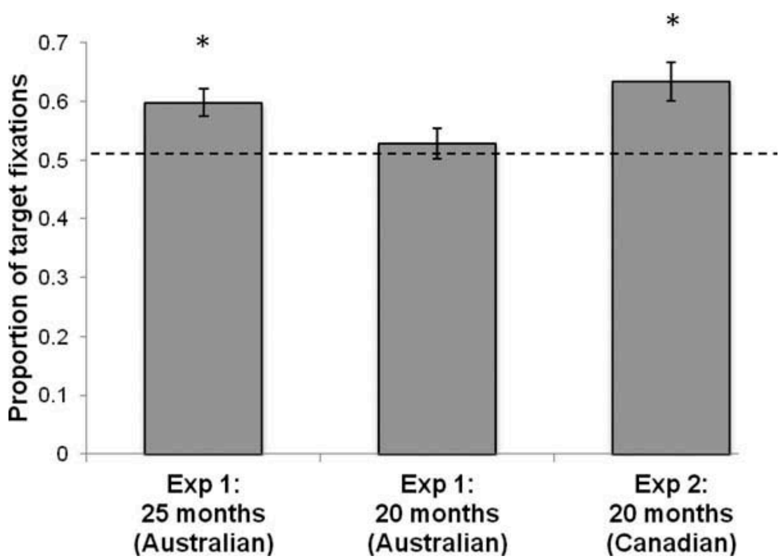

FIGURE 2 Proportion of fixations to target picture for the 25-month-olds (left) and 20-month-olds (middle) exposed to and tested on Australian English in Experiment 1, as well as for the 20-month-olds exposed to and tested on Canadian English in Experiment 2 (right, error bars display the SEM). Dashed line indicates chance level. Asterisks indicate above-chance performance.

that target fixation proportion exceeded chance level for the 25-month-olds ($t(15) = 4.871$; $p < .001$, $d = 1.22$) but not for the 20-month-olds ($t(15) = 1.799$; $p = .092$; all t-tests reported in this article are two-tailed). An independent samples t-test furthermore confirmed that the proportion of target fixations differed between the two age groups ($t(30) = 2.751$; $p = .010$; $d = 1.00$). Thus, during the two seconds after target word onset (corrected for eye movement latencies), the older group of children outperformed the younger group of children on the recognition of the target items.

One may wonder if this target word recognition may be driven solely by the recurrence of those words that toddlers had previously heard the speaker utter in the story. If this were the case, then 25-month-olds' proportion of target fixations following target onset should only exceed chance level in the story word trials. However, one-sample t-tests indicate that the fixation preference for target words was present in both the story word trials (mean target fixation proportion: .61 (SEM: .037); $t(15) = 3.061$; $p = .008$; $d = .77$) and the generalization trials (mean target fixation proportion: .59 (SEM: .022); $t(15) = 4.157$; $p = .001$; $d = 1.04$). A paired-samples t-test further indicated that there were no differences between the two trial types ($t(15) = -.515$; $p = .614$), suggesting that the increase in looks to the target picture was equivalent in both conditions. Similarly, 20-month-olds' difficulty in recognizing the target words was not dependent on the type of test trials. Neither the average proportion of fixations to target for story word items of .55 (SEM: .038) nor for the words that were not previously heard by the speaker of .52 (SEM: .015) exceeded chance level ($t(15) = 1.255$; $p = .229$ and $t(15) = 1.375$; $p = .189$, respectively) and the proportions of fixations to target did not differ across the trial types ($t(15) = .-709$; $p = .489$). Thus, 20-month-olds' inability to recognize the target words held for both the story word and the generalization trials.

Of course, the above finding that 25-month-olds outperform 20-month-olds on this task does not explain what may have driven the development between 20 and 25 months of age. While enhanced maturation of the 25-month-olds could, in theory, account for this developmental pattern, previous work has suggested that children's ability to recognize accented words may instead be due to advances in lexical development (Mulak et al., 2013; also see Van Heugten & Johnson, 2014, for a similar proposal). Indeed, parents in the current study estimated their children's productive vocabulary to be higher in the 25-month-old group (on average 314 words, range: 61–584 words, all 16 vocabulary reports completed) than in the 20-month-old group (on average 179 words, range: 27–362 words, 15 vocabulary reports completed). To examine the factors driving performance in this task more precisely, we conducted a multiple linear regression analysis comparing age in days and log-transformed vocabulary scores with the proportion of target fixations for the 31 children whose parents had completed the vocabulary form. Although both log-transformed vocabulary and age correlated with the proportion of target fixations ($r(29) = .651$; $p < .001$ and $r(29) = .407$; $p = .012$, respectively), only the log-transformed vocabulary scores added significantly to the model ($F(1,28) = 11.502$; $p < .001$), which accounted for 45.1% of the variance. Thus, in line with findings reported by Mulak and colleagues (2013), vocabulary score ($\beta = 3.816$; $p = .001$) appeared to be a better predictor than age ($\beta = .178$; $p = .253$) for the proportion of target fixations and age did not contribute predictive power to the model over and above the power the vocabulary score contributed. This suggests that the ability to recognize words in unfamiliar accents may develop as a function of expressive vocabulary score.

Discussion

In line with our predictions, the findings of Experiment 1 suggest that Canadian 25-month-olds readily recognize words produced in an Australian accent and that this holds regardless of whether they had previously heard the speaker utter the specific target item. By 25 months of age, toddlers can thus contend with accent-induced acoustic-phonetic deviations in the pronunciation of words. By contrast, 20-month-olds exhibited much more difficulty recognizing these target words, even the ones they had heard during exposure. Moreover, this development appears to be related to children's productive vocabulary size. This confirms, with a new population and a new regional accent, that although children have developed some ability to contend with unfamiliar accents before their second birthday (Best et al., 2009; Mulak et al., 2013; Van Heugten & Johnson, 2014; White & Aslin, 2011), this skill is not yet fully mature and may be subject to contextual factors. For example, the degree of accent deviation, the complexity of the utterance and task, as well as children's familiarity with the speaker and with the words could affect the recognition of the accented words at this younger age. Within the subsequent months, however, great developmental progress is made and the ability to contend with accented speakers becomes more robust.

An alternative explanation of our findings with the 20-month-olds, however, may be that their struggle to recognize words is due to our test items being too difficult. That is, children may not have had trouble recognizing the target words because they experienced difficulty coping with the unfamiliar accent, but rather because they did not know the meaning of the target heard during the test trials. While our questionnaire suggested that parents of the 20-month-olds on average judged 81.6% of the words and pictures to be understood and recognized by their children, it is possible that parental judgments in this study overestimated the words infants know. As a result, children may have had difficulty recognizing the words regardless of the accent spoken. Past work had ruled out such vocabulary confound by testing children on words produced both in their own accent and in the unfamiliar accent (Best et al., 2009; Floccia et al., 2012; Mulak et al., 2013; White & Aslin, 2011). To ensure that the selected words are generally known by 20-month-olds, Experiment 2 presents toddlers this age with the same words produced in their own Canadian accent.

EXPERIMENT 2

Experiment 1 shows that 20-month-old Canadian-English learners struggle to recognize words in Australian-accented English, even after some exposure to the speaker. To rule out the possibility that this observed difficulty in accented word recognition was found simply because toddlers did not comprehend the words, 20-month-olds in Experiment 2 were presented with the same materials as the toddlers in Experiment 1, but pronounced in their own Canadian English accent. If the words in Experiment 1 would be sufficiently accessible for the 20-month-old age group, then the presentation of these words in Canadian English should induce an increase in the proportion of looking time to target after target labeling.

Methods

Participants. Another 16 normally developing English-learning 19- to 21-month-old toddlers from the Greater Toronto Area were tested (age range: 595–636 days; 9 boys). An additional five toddlers were tested but excluded from the analyses due to extreme fussiness or failure to complete the study.

Stimuli. The stimuli of Experiment 2 closely followed those of Experiment 1. Unlike the stimuli in Experiment 1, however, all auditory stimuli for the current experiment were recorded by a female native Canadian-English speaker from the Greater Toronto Area. Toddlers thus heard both the story and the test phase in their own native accent (see Table 1 for a broad phonetic transcription of the test words). The *Very Hungry Caterpillar* story that was presented prior to test was included to ensure that toddlers had spent an equivalent amount of time in the test booth watching a movie prior to the onset of the test trials as those in Experiment 1. This controlled, as well as possible, for attention span differences between the experiments. Visual stimuli were identical to those in Experiment 1. Target words lasted on average 698 ms.

Design, procedure, and off-line coding. The design, procedure, and coding practice were identical to those in Experiment 1. Four videos were recoded by a second coder. As before, inter-coder reliability on the individual fixation durations was consistently high (mean correlation for the four sessions = .99).

Results

The 20-month-olds in Experiment 2 reliably looked toward the target picture following target word onset. A one-sample t-test showed that the proportion of looks to target of .63 (SEM: .027) exceeded chance ($t(1,15) = 4.982$; $p < .001$; $d = 1.25$; see Figure 2), indicative of their recognition of the target word in their own Canadian accent. An unequal variances independent-samples t-test between the 20-month-olds in the current experiment and those in Experiment 1 further revealed that the two groups of children differed in their behavior ($t(1,24.088) = 3.404$; $p = .002$; $d = 1.24$), in that only the latter group recognized the test items.

To ensure that target word recognition in this study was not solely due to the potential residual increase in activation of the items that had occurred in the story, one-sample t-tests were performed on the proportion of target fixations in both the story word trials and the generalization trials. This revealed that although children reliably looked toward the target picture in the generalization trials (mean target fixation proportion: .66 (SEM: .030); $t(15) = 5.297$; $p < .001$; $d = 1.32$), they failed to do so in the story word trials (mean target fixation proportion: .56 (SEM: .037); $t(15) = 1.587$; $p = .133$). A direct comparison between the two trial types conducted by means of a paired-samples t-test indicated that they did indeed give rise to different recognition patterns ($t(15) = 2.501$; $p = .024$; $d = .74$). Children thus experienced no difficulty recognizing words used on the generalization trials. Surprisingly, however, they failed to recognize the Canadian-accented story words they had heard before. These words may have been too advanced for 20-month-olds to be recognized in the current paradigm.

Discussion

When presented with a speaker of their own variant of English, Canadian 20-month-olds readily shift their gaze toward the appropriate target picture, indicating that the toddlers have no trouble recognizing the words in the test phase. As the target words in Experiment 2 are identical to those in Experiment 1, this suggests that 20-month-olds' failure to exhibit reliable evidence of word recognition in Experiment 1 cannot be due to their inability to recognize the particular words chosen in this study.

Interestingly, children fixated the target picture more reliably on generalization trials than on story word trials. In fact, despite toddlers' success on generalization trials, they did not recognize target items in the story word trials. One may wonder why children's performance on the generalization trials exceeded that of the story word trials. After all, the story words were the ones that had been heard during exposure, and this preexposure may be thought to facilitate access. However, the advantage for generalization words over story words could potentially be due to the fact that the words that occurred in the story occur less frequently in children's everyday language input than the previously unheard words. Indeed, a frequency count of each of the target words in the child-directed speech portion of the Brent corpus (Brent & Siskind, 2001), as composed by Lisa Pearl (Pearl, Goldwater, & Steyvers, 2010; containing more than 144,000 utterances), available in the CHILDES database (MacWhinney, 1991), indicates that the generalization words occur almost three times more often in 8- to 15-month-old infants' speech input than the story words (average generalization word count: 300; average story word count: 105). It thus stands to reason that the story words used in this study may be acquired later than the generalization words. In line with this explanation, parents judged their toddlers to understand and recognize 85.9% of the words in the generalization trials, but only an average of 68.8% of the words in the story word trials. Failure to accommodate Australian-accented pronunciations in Experiment 1 may thus have been due to children's inability to access sufficient words during the presentation of the story (cf. Van Heugten & Johnson, 2014). Albeit speculative, it is thus possible that had toddlers been familiar to the story or had easier, more accessible, words been used, 20-month-olds in Experiment 1 might have adapted to the speaker's accent, much like older children use lexical information to retune their speech sound categories (see McQueen, Tyler, & Cutler, 2012). If this were the case, vocabulary development may thus help drive children's ability to create long-term between-accent mappings that can be used to tune into the accent-specific pronunciation of words, thereby improving subsequent comprehension of the accented speaker.

Since the exact same target words are used in Experiments 1 and 2, the finding that 20-month-olds reliably recognize the Canadian-accented words in the generalization trials of the current experiment, but not the Australian-accented words in Experiment 1 supports the notion that there is a substantial improvement in children's ability to deal with accents around the age of two. What is currently unclear, however, is what this improvement entails. Children in Experiment 1 were tested on Australian English after a few minutes of exposure to the accented speaker prior to test. It is thus possible that this exposure phase, likely containing a sufficient number of words known by 25-month-olds, may have helped them accommodate the accented pronunciations of words. Alternatively, children's performance in Experiment 1 may reflect their ability to recognize words "on the fly" and would have been observed even in the absence of any exposure. To examine whether exposure to the accent was a necessary condition for the recognition of the Australian-accented words, Experiment 3 presents 25-month-olds with the same speaker narrating the *Very Hungry Caterpillar* story in Cantonese, a language with which children in this experiment are not familiar.

EXPERIMENT 3

Experiment 3 tested whether Canadian-English-learning 25-month-olds' ability to recognize words in Australian English rests on prior exposure to the accent. If toddlers' experience with Australian-accented English was crucial to perform well in this task, then replacing the Australian-accented exposure phase with an exposure phase containing irrelevant speech should prevent recognition of the accented words at test. To examine this possibility, the same Australian English test phase as in Experiment 1 was preceded by exposure to the Cantonese translation of the *Very Hungry Caterpillar*. Thus, only the exposure phase differed between Experiments 1 and 3. If 25-month-olds' performance in Experiment 1 was driven by adaptation to the Australian accent, then listening to Cantonese during the exposure phase should lead to children's failure to recognize the familiar words spoken in Australian English at test. By contrast, if children's recognition of Australian-accented words in the test phase did not improve as a function of experience with the accent characteristics, but was the result of spontaneous between-accent mapping abilities, then children should continue to recognize the accented words, even in the absence of prior exposure to the Australian accent.

Methods

Participants. A total of 16 normally developing English-learning 24- to 26-month-old toddlers from the Greater Toronto Area were tested (age range: 740–782 days; 11 boys). None of the toddlers had had substantial exposure to either Australian-accented English or Cantonese, as established by a language questionnaire at the end of the lab visit. An additional three toddlers were tested but excluded from the analyses due to extreme fussiness or failure to complete the study.

Stimuli. The test items of Experiment 3, spoken in Australian-accented English, were identical to those of Experiment 1. This test phase was preceded by the narration of the *Very Hungry Caterpillar* in Cantonese by the same female bilingual speaker of Australian English and Cantonese, who had also recorded the test items. Visual stimuli used during the exposure phase were identical to those in Experiments 1 and 2.

Design, procedure, and off-line coding. The design, procedure, and coding practice were identical to those in Experiment 1 and 2. Four videos were recoded by a second coder. As before, inter-coder reliability on the individual fixation durations was consistently high (mean correlation for the four sessions = .99).

Results

The mid-left panel of Figure 3 displays children's proportion of fixations to the target picture in the current experiment. As before, children's ability to recognize the target words was tested using a one-sample *t*-test on the average proportion of fixations to target of .62 (SEM: .021) compared to .5 chance level. This revealed that children successfully recognized Australian-accented

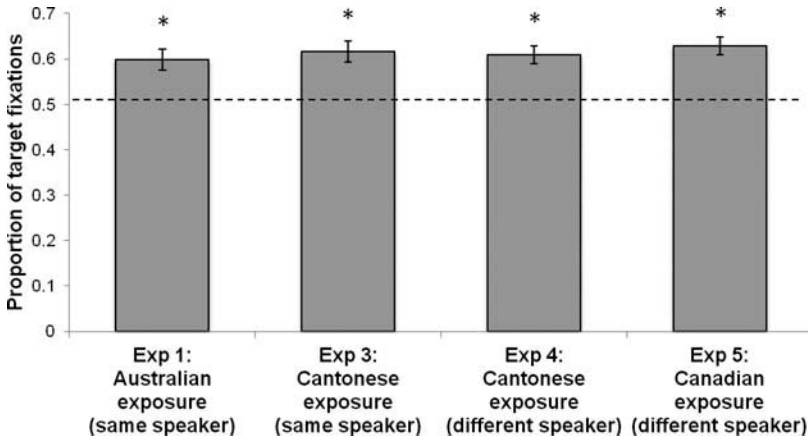

FIGURE 3 Proportion of fixations to target picture for the 25-month-olds tested on Australian English. Prior to test, children were exposed to the same speaker speaking Australian English (left) in Experiment 1, the same speaker speaking Cantonese (mid-left) in Experiment 3, a different speaker speaking Cantonese (mid-right) in Experiment 4, and a different speaker speaking Canadian English (right) in Experiment 5 (error bars display the SEM). Dashed line indicates chance level. Asterisks indicate above-chance performance.

words ($t(15) = 5.522$; $p < .001$; $d = 1.38$). Moreover, an independent-samples t-test suggested that the recognition level did not differ from 25-month-olds in Experiment 1 ($t(30) = -.642$; $p = .526$).

Note that because the *Very Hungry Caterpillar* story in the exposure phase was narrated in Cantonese, a language that children in this study are unfamiliar with, both the story words and the generalization words were heard for the first time at test. Logically speaking, the exposure phase should thus not exclusively facilitate the recognition of the story words. The results with 25-month-olds in Experiment 1 further indicated that children this age no longer experience difficulty recognizing the items from the story word trials. For this reason, no differences are expected to be obtained between story word and generalization trials. One-sample t-tests indicate that children did indeed reliably look towards the target picture in both the story word trials (mean target fixation proportion: .64 (SEM: .031); $t(15) = 4.450$; $p < .001$; $d = 1.11$) and in the generalization trials (mean target fixation proportion: .61 (SEM: .022); $t(15) = 4.933$; $p < .001$; $d = 1.23$). A paired-samples t-test further suggested that they did so equally in both conditions ($t(15) = -.929$; $p = .368$).

Discussion

The current experiment, where the test phase in Australian English was preceded by exposure to distinctly different (and unfamiliar) Cantonese, shows that Canadian 25-month-olds readily recognize familiar words produced in an unfamiliar accent, even in the absence of prior exposure to the characteristics of the accent. Moreover, recognition scores are similar to those of Experiment 1, where children had been exposed to the speaker's accent. This suggests not only that toddlers' ability to contend with unfamiliar accents is independent of prior exposure to the speaker's accented pronunciation of words, but also that prior exposure to the Australian-accented pronunciations does not further enhance word recognition. This could be seen as surprising given that speaker exposure continues to be beneficial in adulthood, allowing adult listeners to *better* deal with accented speech (Bradlow & Bent, 2008; Clarke & Garrett, 2004; Dahan et al., 2008; Maye et al., 2008; Trude & Brown-Schmidt, 2012). Note, however, that task demands in a preferential looking study with only two depicted objects on the screen are relatively low, especially compared to adult work. It is thus possible that benefits of accent exposure might only be apparent under more challenging listening conditions.

If 25-month-olds in this study do not require prior experience with the accent, does this imply that toddlers' speech perception abilities are sufficiently robust to recognize accented speech even in the absence of any prior exposure to the speaker? Given the results so far, this does not necessarily have to be the case. Even though children in Experiment 3 had not heard the speaker speak English before, they had heard the speaker speak Cantonese. While adult listeners only benefit from speaker familiarity for word recognition when prior experience to the speaker is in the same language (Levi, Winters, & Pisoni, 2011; though see Reinisch, Weber, & Mitterer, 2013), suggesting that they rely on linguistically relevant characteristics of the speaker's pronunciation of words, it is possible that children, whose linguistic development is not yet mature, rely more heavily on language-independent cues. In line with this idea, young infants without full knowledge about the phoneme inventory of their native language sometimes benefit from speaker familiarity (Barker & Newman, 2004), even when experience with the speaker's voice is extremely brief (Van Heugten & Johnson, 2012). If slightly older children would similarly benefit from language-independent speaker cues, it is possible that toddlers in Experiments 1 and 3 may have used the speaker's vocal cues to tune into the (accent-independent) speaker characteristics (e.g., average pitch, pitch modulation). Thus, in order to test whether speaker exposure is playing a role in children's success in this task, the Cantonese exposure phase would need to be produced by a different speaker.

A second way in which the exposure phase may have played a role stems from children's inability to understand Cantonese. That is, children's failure to comprehend any of the speech in the exposure phase might have caused them to relax their criteria for word access. Such loosening of their expectations may have enabled them to recognize the Australian-accented words at test, despite the acoustic-phonetic divergence from their typical language input (see Schmale et al., 2012 for a similar argument). If this were the case, an exposure phase containing speech children have access to on a daily basis, such as speech produced by a speaker of their own accent, should prevent word recognition in unfamiliar accents. Experiments 4 and 5 examine whether either of these two possibilities may have induced children's comprehension of accented speech.

EXPERIMENT 4

Experiments 1 and 3 have shown that children recognize Australian-accented words in the absence of prior exposure to Australian English. This could mean that there is no relationship between the exposure phase and children's performance at test. However, given that the

Cantonese exposure phase in Experiment 3 was narrated by the same bilingual speaker who also produced the test items, it is also possible that exposure to the speaker's voice may have facilitated word recognition. To examine whether this is the case, the Australian-accented test trials in Experiment 4 followed the presentation of the *Very Hungry Caterpillar* story narrated in Cantonese by a different Cantonese speaker. By replacing the female bilingual speaker with a male Cantonese speaker, we ensured that children did not have any prior experience with the speaker and that they could hence not have tuned into the speaker's voice. Were this exposure to the speaker's voice crucial to children's ability to recognize accented words, they should no longer recognize the Australian-accented test items. However, if children's ability to contend with accented speech is independent of prior exposure to the speaker's voice, then children should continue to recognize the test words in the current experiment.

Methods

Participants. 16 normally developing English-learning 24- to 26-month-old toddlers from the Greater Toronto Area were tested (age range: 737–793 days; 9 boys). As in Experiment 3, the language questionnaire at the end of the lab visit established that none of the toddlers had had substantial exposure to either Cantonese or Australian-accented English. An additional five toddlers were tested but excluded from the analyses due to extreme fussiness or failure to complete the study.

Stimuli. The Australian-accented test items of Experiment 4 are identical to those of Experiment 1 and 3. However, the exposure story was narrated in Cantonese by a male native speaker of Cantonese, born and raised in China.

Design, procedure, and off-line coding. The design, procedure, and coding practice were identical to those in Experiments 1, 2, and 3. Four videos were recoded by a second coder. Intercoder reliability on the individual fixation durations was again consistently high (mean correlation for the four sessions = .99).

Results

As can be seen in the mid-right panel of Figure 3, the average proportion of target fixations was .61 (SEM: .018). A one sample t-test revealed that this is significantly higher than the .5 chance mark ($t(15) = 5.968$; $p < .001$; $d = 1.49$), suggesting that 25-month-olds reliably recognized the test items, even in the absence of prior exposure to the speaker. Recognition did furthermore not differ from the 25-month-olds tested in Experiment 1 ($t(30) = -.421$; $p = .677$). Much like before, both children's recognition of the words in the story word trials (mean target fixation proportion: .60 (SEM: .029); $t(15) = 3.390$; $p = .004$; $d = .85$) and in the generalization trials (mean target fixation proportion: .61 (SEM: .022); $t(15) = 5.180$; $p < .001$; $d = 1.29$) followed this pattern and no differences were obtained between the two types of trials ($t(15) = 367$; $p = .719$).

Discussion

The results of Experiment 4, together with those of Experiment 3, show that by 25 months of age, Canadian-English-learners recognize words in Australian-accented English and that they do so even without ever having heard the speaker or the accent before. This indicates that the potential accent-related information available from the test sentence contexts alone may be sufficient to allow 25-month-old children to comprehend words in unfamiliar accents.

Note, however, that although Experiment 4 neither provided children with information regarding the unfamiliar accent, nor with the vocal characteristics of the speaker, it did present children with a language they do not typically hear in their daily linguistic environment. Such exposure to (from the toddlers' perspective) atypical speech may have caused them to expand their phoneme categories, thereby allowing for greater deviation from the standard pronunciation of words (see Schmale et al., 2012, 2013). If this were the case, then the exposure period *was* crucial to the children's performance, albeit not through the formation of between-accent mappings. This possibility is addressed in Experiment 5, where Canadian-English learners are presented with the same test phase used in Experiments 1, 3, and 4. This time, however, the test phase was preceded by exposure to a Canadian English speaker, an accent children in this study are used to hearing on a daily basis.

EXPERIMENT 5

The combination of Experiments 1, 3, and 4 has shown that 25-month-olds recognize Australian-accented words in the absence of prior exposure to the speaker or the accent. In all of these experiments, however, children were presented with an unfamiliar accent or language in the exposure phase before proceeding to the test phase. To examine whether exposure to an unfamiliar form of speech may have caused these children to expand their phonological categories, allowing them to access the target words in the face of acoustic-phonetic deviation, the Australian-accented test trials in Experiment 5 followed the presentation of the *Very Hungry Caterpillar* read by a speaker in their own Canadian accent. By 25 months of age, children have had extensive experience with their language. Exposure to a speaker of their native accent should thus not lead to adjustments in their criteria for word recognition. This inclusion of an exposure phase does, however, ensure that toddlers in this experiment experienced the same pre-test movie as those in the previous experiments, thus making it unlikely for the results to be due to elevated attention in the test phase.

If 25-month-old Canadian-English-learners can recognize words produced in an Australian accent after little exposure and if exposure to the unfamiliar accent (Experiment 1) or language (Experiments 3 and 4) was not crucial to toddlers' success at this task holds, then children in this experiment should recognize words to the same levels as those in the previous experiments, even after listening to Canadian English. If, by contrast, exposure to a novel form of speech prior to test was crucial to children's success and children only succeeded at the task because they had loosened their phonemic boundaries, then children should fail to recognize Australian-accented words after listening to Canadian English.

Methods

Participants. 16 normally developing English-learning 24- to 26-month-old toddlers from the Greater Toronto Area were tested (age range: 757–789 days; 6 boys). The language questionnaire at the end of the visit revealed that none of the toddlers had had substantial exposure to Australian-accented English. An additional six toddlers were tested but excluded from the analyses due to parental interference (1) or extreme fussiness or failure to complete the study (5).

Stimuli. The Australian English test items in Experiment 5 are identical to those in Experiments 1, 3 and 4, while the preceding Canadian English narration of the *Very Hungry Caterpillar* was identical to that of Experiment 2.

Design, procedure, and off-line coding. The design, procedure, and coding practice were identical to those used before. Four videos were recoded by a second coder. Inter-coder reliability on the individual fixation durations was consistently high (mean correlation for the four sessions = .99).

Results

As displayed in the right panel of Figure 3, the proportion of looks toward the target picture was .63 (SEM: .021). A one-sample t-test revealed that this reliably exceeded chance level ($t(15) = 5.990$; $p < .001$; $d = 1.50$). Moreover, a one-way ANOVA on the proportion of fixations to target including all 25-month-olds tested in this study (Australian English vs. same female Cantonese vs. different male Cantonese vs. Canadian English) showed that target word recognition did not differ as a function of the preceding exposure phase ($F(3,60) = .380$; $p = .768$).

To ensure that children in this experiment recognized both the previously heard (but in Canadian English) items and the previously unheard items, one-sample t-tests were conducted on the proportion of target fixations in each of the two trial types separately. Children recognized both the story word trials (average proportion of target fixations: .65 (SEM: .029); $t(15) = 5.351$; $p < .001$; $d = 1.34$) and the generalization trials (average proportion of target fixations: .62 (SEM: .025); $t(15) = 4.787$; $p < .001$; $d = 1.20$). A paired-samples t-test revealed no differences between the two trial types ($t(15) = 1.041$; $p = .314$).

Discussion

Experiment 5 shows that Canadian 25-month-olds exposed to a Canadian speaker subsequently recognize words produced in an Australian accent, and that they do so to the same extent as children exposed to the same Australian speaker. Thus, exposure to an unfamiliar form of speech cannot be the sole explanation for children's success in this task. This lends support to the notion that children this age can efficiently cope with unfamiliar accents "on the fly" without requiring any prior experience with the speaker, the accent, or unfamiliar speech. This finding also rules out the possibility that general expansion may have been the mechanism that allowed children in Experiments 1, 3, and 4 to cope with unfamiliar accents and highlights the stability of

25-month-olds' ability to recognize accented words. Moreover, given the finding that 20-month-olds experienced substantial difficulty recognizing the accented words in this task, this suggests that toddlers' ability to contend with accent deviation makes drastic progress between 20 and 25 months of age, presumably driven by the increase in vocabulary size in the months prior to children's second birthday.

GENERAL DISCUSSION

Understanding speakers from various language backgrounds is crucial for efficient oral communication. In a series of five word comprehension experiments, we examined if and under what conditions young language learners can recognize familiar words produced in an unfamiliar regional accent. Our findings suggest that Canadian-English-learning 25-month-olds consistently map Australian-accented words onto their stored representations in their lexicon, and that they do so equally well with words they had heard as with words they had not heard the speaker produce before. By contrast, 20-month-olds tested in the current study experience more difficulty deducing this between-accent mapping, even when provided with exposure to the Australian-accented speaker prior to test. Thus, even though by 20 months of age, children have developed some capacity to contend with accent-induced discrepancies in the pronunciation of words (Best et al., 2009; Mulak et al., 2013; Van Heugten & Johnson, 2014; White & Aslin, 2011), the finding that children this age appear to struggle in at least some situations aligns with work suggesting that this skill has yet to mature (Floccia et al., 2012). The transition from children's initial inability to reliably recognize Australian-accented words in this task to the ability to readily recognize such accented words a few months later underlines the dramatic developmental changes in children's speech processing abilities that develop concurrently with increases in their vocabulary size around their second birthday.

Interestingly, this improvement in contending with unfamiliar regional accents is so substantial that by 25 months of age toddlers recognize accented words even in the absence of prior speaker experience. Specifically, the older age group recognized words equally well regardless of whether they had heard a story read by the same accented speaker, the same speaker speaking a completely different language, a different speaker speaking a completely different language, or by a speaker of their own native accent. This suggests that 25-month-olds' signal-to-word mappings are sufficiently developed to allow them to spontaneously deal with accent-related variability. Thus, although the ability to contend with accents may continue to be fine-tuned during the course of development, the basic machinery to compensate for accent-induced difficulties is well-advanced by this age.

Of course, the finding that prior exposure to the speaker or to the accent does not improve word comprehension in this study does not imply that familiarity with a speaker or accent never aids speech perception at or after this age. In fact, several studies have suggested that toddlers' recognition of accented words is substantially improved following exposure to the relevant accent (Schmale et al., 2012; Van Heugten & Johnson, 2014; White & Aslin, 2011) and even adults can benefit from accent experience (Bradlow & Bent, 2008; Clarke & Garrett, 2004; Floccia et al., 2006; Nygaard & Pisoni, 1998; Nygaard, Sommers, & Pisoni, 1994; Trude & Brown-Schmidt, 2012; though see Floccia, Butler, Goslin, & Ellis, 2009; Trude, Tremblay, & Brown-Schmidt, 2013, for findings suggesting that this is not always the case). Had our task been more demanding (e.g., more than two pictures on the screen, using pictures of unfamiliar objects as distracters, imposing less ideal listening conditions possibly by introducing background noise), and hence better reflected everyday listening situations, accent familiarity would likely have conferred processing advantages. Future work could examine this possible interaction between the advantage of accent familiarity and task demands in greater detail.

Previous work testing language learners on their ability to adapt to unfamiliar accents has typically presented toddlers with exposure to the same test speaker (Schmale et al., 2012; Van Heugten & Johnson, 2014). This raises the possibility that toddlers may have accommodated the vocal characteristics of a speaker, rather than the accent. For this reason, we examined whether exposure to the vocal characteristics of the speaker alone may induce speaker accommodation in young language learners. While access to such language-independent vocal cues does not appear to help adults accommodate speakers in their native accent (Levi et al., 2011), it is possible that it might help listeners accommodate speakers in an unfamiliar accent. It is also possible that toddlers, whose linguistic system is not yet mature and whose top-down processes may be less reliable, rely more on vocal cues than do adults. In line with this reasoning, preverbal infants, who are still in the process of learning the phonemic inventory of their language, have been suggested to benefit from even very limited experience with the speaker's voice information for word form encoding (Van Heugten & Johnson, 2012). However, under the relatively easy task demands employed in the current study, exposure to the speaker's vocal characteristics, much like exposure to the accent, did not assist children's accented word recognition. Whether experience with the speaker's vocal characteristics may affect children's subsequent ability to cope with the speaker's unfamiliar accent differently under more challenging conditions could be addressed in the future.

The current study also ruled out the possibility that 25-month-olds performed well in our task, simply because they had just heard a form of speech they had never experienced before. Previous work had suggested that such exposure to unfamiliar speech can sometimes alter the processing of accented speech, in that it may "loosen" or "broaden" children's phonemic categories (Schmale et al., 2013). Although it is certainly possible that the different exposure phases altered children's processing strategies, the finding that children recognize Australian-accented words to the same extent regardless of whether the test phase followed exposure in children's own Canadian English accent (an accent that will not induce general expansion) or after exposure to speech in an unfamiliar language or accent shows that prior speaker or accent exposure cannot be the determining factor explaining why the older children succeeded in the current task. This speaks to the readily adaptive nature of 25-month-olds' signal-to-word mapping skills, even in the face of unfamiliar accents.

Toddlers' ability to deal with accent deviation by 25 months of age stands in sharp contrast to 20-month-olds failure to exhibit reliable recognition of accented words in this study. This raises the question of what may have hindered the 20-month-olds in their comprehension of accented words. Clearly, as reported in previous work, 20-month-olds can contend with accent variability in some situations (Best et al., 2009; Mulak et al., 2013), suggesting that their word representations are sufficiently abstract to recognize words despite the variability in acoustic-phonetic realization. At the same time, children this age continue experiencing difficulty contending with regional accents in other situations, even when there are only few phonetic discrepancies between the native and the unfamiliar accent (Floccia et al., 2012). It is thus possible that although 20-month-olds have started to develop the ability to recognize accented pronunciations of familiar words, this ability is still fragile. For this reason, the observation that children do recognize accented words at this age may depend on processing demands incurred by the listening conditions. One obvious difference between the current study and that of Mulak and colleagues (2013), for example, concerns the selected accents. While their study used Jamaican-accented English as the unfamiliar accent for Australian toddlers, this study tested Canadian toddlers on Australian-accented English. Although it is hard to quantify accent differences, it is possible that the perceived distance between Canadian and Australian English is larger than the perceived distance between Australian and Jamaican English. In the absence of exposure to relatively easy words produced in the unfamiliar accent, children may struggle longer with perceptually more distant accents than with perceptually less distant accents. Such increases in the recognition of words whose acoustic-phonetic realizations are closer to the typically perceived variant of the word seem plausible, especially given work on the recognition of mispronounced words suggesting that the extent to which children recognize words with single-segment mispronunciations depends on the phonological feature distance between the target and the mispronounced segment (Creel, 2012; Mani & Plunkett, 2007; White & Morgan, 2008). Although accents and mispronunciations clearly differ in terms of systematicity and overall degree of acoustic-phonetic divergence, it is possible that there is a common component in the basic mechanism allowing children to contend with these two types of variation in the input overlap. Such machinery underlining graded sensitivity to acoustic-phonetic distance would also align with recent work suggesting that children experience less difficulty recognizing accented pronunciations of words that do not cross native phonemic boundaries than (more deviant) pronunciations that do cross phonemic boundaries (Best, Kitamura, Pal, & Dwyer, 2012).

In addition to perceptual differences between accents, other experimental features of the Mulak et al. (2013) study may have further improved performance in their task relative to the current study. For example, their animation of the labeled object in combination with the reward sentences commenting on the animated picture (e.g., *That's the one! There it is!*) after the child had been asked to find the object could have induced anticipation of this animation and may consequently have led toddlers to fixate the labeled object longer. In addition, it may have provided children with a more unambiguous label-object mapping compared with studies without reinforcement (where such mapping might have to be deduced from a comparison of the accented pronunciation of the target to either of the two pictures on the screen), potentially allowing them to better adapt to the accent during the course of the experiment. Thus, clear mappings during test may trigger accommodation patterns similar to those observed after speaker exposure involving explicit label-object mappings (White & Aslin, 2011). Such reinforcement may also explain why the Australian 19-month-olds (Mulak et al., 2013) outperformed the British 20-month-olds (Floccia et al., 2012). Factors such as the use of multiple speakers (Ryalls & Pisoni, 1997), the use of single words without a carrier phrase (Fernald & Hurtado, 2006), and the use of word pairs starting with the same onset consonants may have additionally impeded performance in the British compared with the Australian children. Other differences across tasks such as the semantic relatedness between target and distracter (some of our targets and distracters contained referents of words belonging to the same semantic category), whether words are long known or newly learned, and whether or not the distracter displays a familiar item may also affect the ease of word recognition. The exact linguistic and nonlinguistic context may thus play an important role in children's performance in this task. Moreover, given that children's ability to recognize accented words is best predicted by their vocabulary size (both here and in Mulak et al., 2013), potential differences in rates of vocabulary development across populations may also explain differences between studies. Better insight into these conditions for children's success at contending with accent variation would allow us to begin develop an understanding of the mechanisms underlying early accent accommodation. It is thus important that these contributing factors be further explored.

A few minutes of exposure to the speaker was not sufficient for the 20-month-olds in our study to overcome the difficulties induced by the unfamiliar accent. Thus, even in cases where children's early speech perception skills are fragile, experience with the speaker's voice and accent does not always alleviate the processing demands. Given that children can accommodate artificially produced accents involving just a single phoneme shift (White & Aslin, 2011), it may not just be the spontaneous recognition skills but also the accent adaptation skills that have yet to fully mature at this age. It seems plausible that with more extreme variability, toddlers may need exposure to a wider variety of words before the complete signal-to-word mappings are in place. The finding that words that had occurred in the storybook were only retrieved with difficulty, even in children's own native accent, and even though these constituted some of the easiest words from the story (*butterfly, cake, cheese, and strawberry* compared to much more advanced key words such as *caterpillar, sausage*, and *cocoon*), further suggests that the 20-month-olds in Experiment 1 may have been unable to access the majority of the Australian-accented words in the exposure phase. If accent accommodation depends on lexical access (see McQueen et al., 2012; Van Heugten & Johnson, 2014; White & Aslin, 2011, for such proposals), this may explain why these younger children could not accommodate the speaker. This would also align with previous findings showing that Canadian 15-month-olds tested on the same Australian speaker were able to accommodate the speaker, but only after they had been familiarized with the storybook, likely enhancing children's knowledge of the words in the story (Van Heugten & Johnson, 2014). It is thus possible that in order for accent exposure to be useful at the early stages of accent accommodation, toddlers would need to be extremely familiar with the words presented to them in the accent.

The picture emerging from the growing collection of studies on children's early perception of accented speech indicates that infants' initial inability to spontaneously contend with accent variability just after their first birthday (Best et al., 2009; Mulak et al., 2013; Van Heugten & Johnson, 2014) slowly transitions into a robust ability to cope with accent variation over time and with increasing vocabulary development. Within the second year of life, children learn to contend with and adapt to accented speech under some circumstances (Best et al., 2009; Mulak et al., 2013; Van Heugten & Johnson, 2014; White & Aslin, 2011), with this transition being set off earlier for children with higher rates of vocabulary development than for those with lower rates of vocabulary development. Although at least some form of phonological constancy is generally in place by the end of the second year, the substantial variation among studies testing these children, where slight modifications to the stimuli and test procedure can lead to seemingly contrastive outcomes (Best et al., 2009; Floccia et al., 2012; Mulak et al., 2013; Van Heugten & Johnson, 2014; White & Aslin, 2011) implies that the developmental process is still ongoing. In fact, it is not until close to their second birthday that children's ability to reliably recognize accented pronunciations of familiar words in the absence of prior exposure to the accent improves dramatically. And even then, children sometimes still experience difficulty recognizing words across accents when task demands are high (Schmale et al., 2011; also see Nathan et al., 1998). Over time, and with the emergence of additional processing resources, these differences between children and adults will ultimately disappear.

Taken together, the current set of experiments have shown that by 25 months of age, toddlers are remarkably proficient at dealing with accent-related variation in the realization of words, regardless of whether they have heard the accented speaker beforehand. This accommodation of speaker accents "on the fly" has its roots in the few months preceding their second birthday, when children's ability to cope with accents develops from being fragile to being more robust, and is likely mediated by their expanding vocabulary size. Learning to contend with unfamiliar accents is thus a gradual process that continues to develop within the second year of life.

ACKNOWLEDGMENTS

We thank Victoria Ng, Melissa Paquette-Smith, and David Chen for producing our speech materials and Michael Tyler for his help with the Australian transcriptions.

FUNDING

This work was supported by grants from the Natural Sciences and Engineering Research Council of Canada and the Canada Foundation for Innovation awarded to EKJ, as well as an Ontario Graduate Scholarship to MvH.

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