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Navigating Accent Variation: A Developmental Perspective

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Abstract

Adult processing of other-accented speech is fast, dependent on lexical access, and readily generalizable to new words. But what does children's processing of other-accented speech look like? Although many acquisition researchers have emphasized how other-accented speech presents a formidable challenge to young children, we argue that the field has perhaps underestimated children's early accent processing abilities. In support of this view, we present evidence that 2-year-olds' accent processing abilities appear to be in many respects adult-like, and discuss the growing literature on children's ability to cope with multi-accent input in the natural world. We outline different theoretical outlooks on the transition children make from infancy to later childhood, and discuss how the growing sophistication of infants' accent processing abilities feeds into their social perception of the world (and perhaps vice versa). We

also argue that efficient processing and meaningful interpretation of accent variation are fundamental to human cognition, and that early proficiency with accent variation (along with all of the implied representational and learning capacities) is difficult to explain without assuming the early emergence of abstract speech representations.

1. INTRODUCTION

Despite the lay notion that some speakers have accents and others do not, we all speak in an accent—and our accent can reveal our geographic or cultural origins, or tag us as an in-group or out-group member in any particular setting (Fuertes et al. 2012). Indeed, accent identification and accent adaptation are such an integral part of human interactions that it is hard to conceive of a world without accents, or accent adaptation. If we were to imagine a hypothetical person who does not make any social inferences based on an interlocutor's accent, or who is unable to adapt to the pronunciation of words produced in different accents, we would imagine someone who struggles to function in day-to-day interactions. However, in the adult world, this is not something we typically find. Rather, adults readily draw social inferences based on how others talk, and display great flexibility in adapting to different pronunciations and accents—abilities that we would argue are core design features of the human mind.

But there is a plot twist to this story, and this plot twist (and the conundrum it presents to language researchers) is the focus of our review. Although our hypothetical speaker is not typically found in the adult world, some have argued that young children may in some sense be that struggling language user, initially lacking sufficient tools to make sense of speech produced in an unfamiliar accent, and unaware of many of the social implications encoded in the way different interlocutors speak. But if we accept that the efficient processing of other-accented speech is a slow-emerging ability in children, then this presents a bit of a paradox for developmental researchers. How can children—who struggle with other-accented speech—otherwise show such great facility in acquiring language (e.g., Johnson 2016) and use the linguistic knowledge they have to navigate their social environment (e.g., Kinzler 2021)?

There is currently no consensus regarding the answer to this question. Indeed, reasonable answers range from the possibility that we have overestimated children's struggles with other-accented speech to the possibility that the skills and knowledge used when adapting to accents

are not so much a prerequisite for language acquisition but rather a by-product of the process. In this article, we review the development of children's ability to adapt to accent-related variation in the realization of spoken words, emphasizing crucial gaps in our knowledge. We outline different theoretical approaches to explaining developmental changes in children's perception of other-accented speech, and weigh the evidence for each viewpoint. Where relevant, we also discuss the practical implications of how children cope with different accents, and support our arguments by drawing on literatures outside of linguistics—including social and developmental psychology, early childhood literacy, and the speech sciences. In doing so, we point out how answering questions about accent processing in young children requires us to look beyond the linguistic input a child receives and consider the broader context of human communication. Most importantly, we challenge language acquisition researchers to see the efficient processing of accented speech for what it is—an integral component of human cognition that enables linguistic interactions.

2. A CHRONOLOGICAL VIEW OF DEVELOPMENT

In the past 50 years, we have learned a great deal about the remarkable efficiency with which the typical infant masters their native language or languages (for an overview, see Johnson & White 2020, Swingley 2009, Werker & Curtin 2005). Crucially, however, most of this research has presented infants with stimuli spoken in the regionally dominant variety of their native language. As a result, currently dominant models of infant speech processing do not adequately address how languages spoken by other-accented talkers is processed. Here, we review children's developing ability to handle accent variation from birth to adolescence, and discuss these findings in relation to well-established milestones in early language development (**Figure 1**). The general picture that emerges from this chronological review is a consensus that perceptual and social processing of other-accented speech develop in parallel, but there is some debate in the field regarding when and how children begin to demonstrate an adult-like ability to make sense of other-accented speech and how this ability may be related to the early development of social accent-based inferences.

2.1. Early Beginnings: 0 to 12 Months

Speech development proceeds at a remarkable pace during the first 12 months of life. One of the

first linguistic competencies demonstrated by infants is their preference to listen to their mother's language over another language (e.g., Moon et al. 1993). This ability is presumably driven by exposure in the womb and has been touted as evidence for the precocious nature of infants' language abilities. But follow-up studies have revealed that newborns distinguish between their mother's language and an unfamiliar language only if the two are rhythmically dissimilar (e.g., Mehler et al. 1988). Indeed, infants' ability to tell apart their own native language(s) from rhythmically similar other languages does not emerge until around 4 to 5 months of age (e.g., Bosch & Sebastián-Gallés 1997, Nazzi et al. 2000). Thus, given that most (but not all) varieties of any language tend to belong to the same rhythmic class, it is not surprising that infants cannot typically tell apart different varieties of their native language until 5 months [e.g., English-learning American 5-month-olds distinguish British and American English (Nazzi et al. 2000), though there is evidence that this sensitivity may sometimes emerge slightly earlier (Kitamura et al. 2013)]. But even at 5 months, infants' ability to distinguish accents is still limited. For instance, 5-month-old infants learning a South-West variant of British English can tell apart their home accent from an unfamiliar Welsh accent, but they fail to discriminate Scottish and Welsh English, two unfamiliar variants of their native language (Butler et al. 2011; for similar findings with older children, see Wagner et al. 2014). And although 5-month-olds readily distinguish stress-timed English from syllable-timed Spanish, they fail to tell apart Spanish from Spanish-accented English (presumably because Spanish-accented English is rhythmically more similar to Spanish than English; Paquette-Smith & Johnson 2015). One could conclude from these studies that in the first few months of life, infants tend to treat different varieties of the native language as equivalent, and that infants' sensitivity to differences does not typically develop until after they have accumulated a few months of relevant language experience.

Over time, infants' language processing abilities become more sophisticated. In the latter half of the first year, we begin seeing much increasingly specific attunement to the native language. Infants no longer show a universal sensitivity to all sound contrasts used in the world's languages (Best et al. 1988, Kuhl et al. 2006, Werker & Tees 1984), and they move beyond simply identifying or preferring familiar languages and language varieties. For instance, by 6 to 7.5 months of age, children begin segmenting words from speech (Bortfeld et al. 2005, Johnson et al. 2014, Jusczyk et al. 1999) and begin to demonstrate some comprehension of highly frequent words (Bergelson & Swingley 2012, Tincoff & Jusczyk 1999). By 7.5 to 9 months,

infants begin using knowledge of their native language sound structure, including prosody and phonotactics, to find words in fluent speech (e.g., Jusczyk et al. 1999, Mattys & Jusczyk 2001, Polka & Sundara 2012). The highly frequent words infants first discover fuel further lexical growth by facilitating the segmentation of additional word forms from speech (e.g., Bortfeld et al. 2005, Mersad & Nazzi 2012, Shi et al. 2006). Some researchers have estimated that, by 12 months of age, infants' receptive lexicons contain as many as 70 words (Frank et al. 2017).

Throughout this early infancy period, as children are rapidly tuning in to the sound structure of their native language, they seem to handle talker variability fairly well. This holds both for talker variation introduced in the lab (Bergelson & Swingley 2018, Johnson et al. 2014, Kuhl 1979, van Heugten & Johnson 2012; though see Houston & Jusczyk 2000) and for real-world talker variability infants hear in their daily lives. Indeed, the number of speakers in an infant's environment has no measurable impact on their early speech development (Bergmann & Cristia 2018). But in line with claims that talker and accent adaptation are distinct processes (Kriengwatana et al. 2016), accent variation seems to present infants with a much bigger challenge initially. For example, although young infants recognize words familiarized in an unfamiliar accent when they are once again presented in that same unfamiliar accent at test (Nazzi et al. 2014), 9- to 10-month-old infants familiarized with a word form in one accent fail to recognize it in a second accent (Schmale & Seidl 2009, Schmale et al. 2010). This finding has been interpreted as evidence that children's early lexical representations are overspecified and not equipped to handle accent variation, supporting influential models of infant speech perception that argue for an episodic account of early word recognition (Jusczyk 1993, Werker & Curtin 2005).

As infants' speech perception abilities rapidly develop and they become more sensitive to the fine acoustic–phonetic details identifying their own language variety, so too does their understanding that language can act as a social marker (e.g., Kinzler 2021). By 6 months of age, infants (in at least some communities) associate foreign languages with other-race individuals (Uttley et al. 2013; see the sidebar titled Integrating Extralinguistic Contextual Cues into Speech Processing). Around the same time, they tend to direct their attention to linguistic in-group members, for example, preferring to listen to a tune introduced by a speaker of their native language than an unfamiliar language (Soley & Sebastián-Gallés 2015). By 11 to 12 months, infants preferentially try foods introduced by speakers of their native language as opposed to a

foreign language (Shutts et al. 2009) and also preferentially imitate speakers of their own language (Buttelmann et al. 2013, de Klerk et al. 2019). Thus, there is ample evidence that the language spoken by an interlocutor informs infants' attentional preferences—but do children also make social inferences based on the accent spoken by an interlocutor?

INTEGRATING EXTRALINGUISTIC CONTEXTUAL CUES INTO SPEECH PROCESSING

In this review, our discussions of children's accent processing focus almost entirely on information conveyed in the speech signal. In everyday life, however, communication does not happen in a vacuum. Adult accent processing, for example, is affected by visual information, including the perceived race of accented interlocutors (Babel & Russell 2015, Rubin 1992). There is growing evidence that young children's language processing is similarly sensitive to extralinguistic contextual cues, such as a talker's race (Singh et al. 2020, Uttley et al. 2013, Weatherhead & White 2018). Considering these factors in our models of language processing may provide a fuller understanding of how children navigate their linguistic environment.

To date, not much work has been conducted on how infants use accent information to make social inferences. Notably, however, one study demonstrates that 6-month-old infants look longer to people whom they have previously heard speaking their native language with a familiar accent than to people they have heard speaking in an unfamiliar accent (Kinzler et al. 2007). Although such attentional biases do not necessarily imply social preference (Haith 1998; see the sidebar titled The Development of Language-Based Social Preferences for related discussion), they may indicate that infants have identified accent as a cue to group membership, an initial stage in the development of accent-based social categorization (Bigler & Liben 2007, Imuta & Spence 2020). Thus, in the latter 6 months of the first year of life, although infants struggle to cope with accent variability in speech perception, they may have already begun using accent information to guide their interactions. That said, they are still a long way off from adults, who rely heavily on subtle accent information to draw social inferences about others in their environment (Kozlowski 2015, Labov 1966, Purnell et al. 1999).

THE DEVELOPMENT OF LANGUAGE-BASED SOCIAL PREFERENCES

A growing body of literature examines the development of language-based social preferences. Key findings include infants' looking preference for same- over other-accented talkers, and older children's preference for friendships with same- over other-accented peers (Kinzler 2021).

Language-based biases appear to grow stronger with age (St. Pierre & Johnson 2020), outflank any preference for same-race peers (Kinzler et al. 2009), and are present even in children routinely exposed to accent variation (Cohen & Haun 2013, Paquette-Smith et al. 2019). But many questions remain. Are these preferences purely social in nature, or are they also cognitive and/or linguistic? For example, does liking drive infants' looking preferences, or is this behavior rooted in an expectation for useful information from same-accented interlocutors? Or do infants prefer what is perceived as more familiar? Likewise, do older children prefer same-accented peers for social reasons, or is their preference partially due to anticipated ease of communication? And what are the origins of these behaviors? Is there a critical period for their malleability (for a related discussion in the face processing literature, see Anzures et al. 2013)? All of these questions, and many more, remain to be fully addressed by the burgeoning literature on developmental social cognition.

2.2. Dramatic Changes in Accent Accommodation: 12 to 24 Months

In the second year of life, as children transition from infancy to toddlerhood, their language abilities dramatically improve. They develop sensitivity to fine-grained mispronunciations in familiar words (e.g., Mahr et al. 2015, Paquette-Smith et al. 2016, White & Morgan 2008), broaden their repertoire of word learning strategies to facilitate their fast mapping (e.g., Graf Estes et al. 2007, Paquette-Smith & Johnson 2016, Spiegel & Halberda 2011), begin using grammatical knowledge to constrain the processing of spoken language (e.g., Cauvet et al. 2014, van Heugten & Christophe 2015, van Heugten & Shi 2009), show sensitivity to semantic relatedness between items in their lexicon (e.g., Arias-Trejo & Plunkett 2009, Johnson et al. 2011, Mani et al. 2013, Willits et al. 2013), and experience an explosion in their receptive vocabulary (e.g., Bloom 1973). Children's production abilities also take off during this period, with children in the USA typically producing 90 words by the time they reach 18 months of age and 300 words by the time they reach 24 months of age (Frank et al. 2017). During this period, we also see substantial growth in children's ability to use social information to make inference about intended meaning and to make judgments about the reliability of different types of information (Howard et al. 2015, Stenberg 2009).

Perhaps unsurprisingly, these dramatic developmental changes in language processing are accompanied by a striking improvement in children's ability to handle accent variation. In the first 6 months of the second year of life, these improvements are still slow, but progression is more rapid in the second 6 months. At 12 to 13 months, cross-accent recognition of newly segmented word forms is first observed (i.e., word forms learned in a familiar variety of the native language can be recognized when spoken in a different variety; Schmale & Seidl 2009, Schmale et

al. 2010). This is a great advance from the word form recognition abilities we see in younger infants. However, spontaneous recognition of familiar word forms produced in unfamiliar accents emerges much later and is not reliably observed until approximately 19 months of age. That is, although children at 12.5 and 15 months of age listen longer to known word forms (e.g., *ball*, *diaper*) than to low-frequency or nonsense word forms (*deuce*, *koddy*) in their own variety of English, we do not see comparable performance when the same word forms are produced in an unfamiliar accent until approximately 19 months of age (Best et al. 2009, van Heugten & Johnson 2014, van Heugten et al. 2018). Eye-tracking studies, where infants are presented with two images side by side on a screen and an auditory label directs them to look at one of the two images, reveal a similar pattern of results (Mulak et al. 2013, van der Feest & Johnson 2016, van Heugten et al. 2015). Without any previous exposure to an accent, infants typically fail to recognize familiar words spoken in unfamiliar accents, even with a visual prompt for named targets clearly presented. But as their vocabulary size and linguistic skills increase around their second birthday, toddlers exhibit what on the surface appears to be a quantum leap in their ability to process unfamiliar accents—rapidly comprehending isolated words spoken in unfamiliar accents, even in the absence of prior exposure to the accent (Mulak & Best 2013, van Heugten & Johnson 2014, van Heugten et al. 2015). Some have argued that this dramatic shift in children's accent processing abilities is linked to a qualitative shift in children's phonological abilities (see Section 3.1, below).

But is it really true that infants under the age of 19 months have no ability to contend with other-accented speech? The implications would be profound. How could young children acquire language so quickly and efficiently if their word recognition abilities ground to a halt every time they encountered a novel accent? If this were the case, shouldn't we expect to see dramatic differences in the language processing abilities of children growing up in linguistically diverse environments (where other-accented speech would be frequently encountered) compared with linguistically homogeneous environments (where other-accented speech would be less frequently encountered)? Upon closer inspection, it becomes clear that all of the studies discussed above examine children's ability to contend with accent variation in a relatively unnatural lab task, where unfamiliar, disembodied voices produce words in isolation or short sentences with little communicative context. This does not fully represent everyday listening situations for children, who in their daily lives may know (and may have previously interacted with) the other-accented

interlocutor. Maybe children—like adults—would perform better with other-accented speech if given a chance to adapt to it (e.g., Bradlow & Bent 2008, Clarke & Garrett 2004, Maye et al. 2008, Trude & Brown-Schmidt 2012).

To address this question, an accent adaptation paradigm has been used where infants are given a brief (typically well-controlled and highly engaging) exposure to an unfamiliar accent in the lab. By comparing word recognition performance in a specific accent with and without exposure to that same accent, researchers can examine what children can learn from engaging with or listening to other-accented talkers. This approach to understanding children's ability to handle accent variation is in many ways more ecologically valid than the approaches outlined above, and has revealed a great deal about how infants process other-accented speech (see discussion in Section 3, below). Results show that by 19 to 24 months, just a few minutes of exposure can dramatically improve infants' ability to recognize words in that accent (van der Feest & Johnson 2016, van Heugten & Johnson 2014, White & Aslin 2011), and this adaptation occurs even for words that had never been heard in that accent before. Indeed, one study has demonstrated adaptation to a novel accent in children as young as 15 months of age (van Heugten & Johnson 2014; see also Paquette-Smith et al. 2021a). Such findings call into question claims that successful recognition of other-accented words does not emerge until the emergence of phonological constancy at 19 months of age (e.g., Best et al. 2009, Mulak et al. 2013).

Regardless of when infants begin to demonstrate the ability to cope with accent variation, the efficiency and generalizability of adaptation in 15- to 24-month old-children continue to be dependent on various factors, such as whether the exposure involves live interaction (Paquette-Smith et al. 2021a), how many accents were present during exposure (Potter & Saffran 2017), how different the unfamiliar accent is from the infant's own accent (Cooper et al. forthcoming, Newman et al. 2018), whether social information is available (Singh et al. 2020, Weatherhead & White 2018), the size of a child's vocabulary (Mulak & Best 2013, van Heugten & Johnson 2014), and what the task demands are (van Heugten & Johnson 2016, van Heugten et al. 2015). This speaks to a complex interaction between all sources of information available to the child during early accent accommodation.

2.3. Beyond 24 Months: Continued Development

Although children are fairly adept at recognizing familiar words spoken in unfamiliar accents by

their second birthday, substantial differences in accent processing have been argued to exist between children and adults for an extensive period of time (see the sidebar titled How Accent Perception Relates to Accent Production). Research with school-aged children, for instance, has revealed that their comprehension of speech in unfamiliar accents lags behind that of adults (Bent 2014; Bent & Atagi 2015, 2017; Bent & Holt 2018; Creel et al. 2016; Nathan et al. 1998; Newton & Ridgway 2016). In one study, 5- to 6-year-olds and adults were presented with a sentence repetition task, which is arguably more cognitively demanding than the tasks typically used with infants and toddlers. Crucially, the sentences participants were asked to repeat were presented in both the participant's native North American accent and an unfamiliar Japanese accent. Children performed worse than adults, with this difference driven primarily by the unfamiliar accent condition. That is, although both children and adults repeated fewer correct words when listening to the other-accented than to the own-accented speaker, the other-accented speaker affected children's performance more than that of adults (Bent & Atagi 2015). In fact, a recent study showed that the developmental trajectory of learning to cope with unfamiliar accents may continue through adolescence (Bent 2018). Thus, although the fundamental capacity to contend with accent variation is present early in life, accents may nonetheless make language processing more effortful or less efficient for a protracted period of time.

HOW ACCENT PERCEPTION RELATES TO ACCENT PRODUCTION

The developmental speech perception literature tends to emphasize how difficult children find it to process unfamiliar accents (e.g., Bent 2014, 2018). But a much more positive outlook predominates in the speech production literature. Indeed, children are typically characterized as adopting new accents far more rapidly and successfully than adults (Chambers 1992, Smith et al. 2007, Tagliamonte & Molfenter 2007). To date, very little work has examined the intersection of accent perception and accent production in children (though see Paquette-Smith et al. 2021b for related work). Given claims that speech perception and production abilities are intimately related, even in infancy (e.g., Best et al. 2016, Bruderer et al. 2015), the lack of cross talk between these literatures is surprising. Examining how the perception and production of accents relate could help researchers gain a new perspective on how children process other-accented speech—and acquire language more generally.

Throughout the school years, as children's processing of other-accented speech appears to gradually improve, they also exhibit a growing recognition of their own language variety. Metalinguistic tasks demonstrate that children as young as 5 years of age are able to distinguish

their own accent from a perceptually distinct foreign accent (Floccia et al. 2009, Girard et al. 2008, Paquette-Smith et al. 2019, Wagner et al. 2014), but the ability to tell apart less distinct accents is more challenging, with gradual improvement observed throughout childhood and into adolescence (Jones et al. 2017, McCullough et al. 2019).

As children become better at distinguishing their own language variety from others, their tendency to make social inferences based on accent information also matures. For example, 3- to 6-year-olds use accent to infer a speaker's geographical origins (Kinzler & DeJesus 2013; Weatherhead et al. 2016, 2018, 2019). That is, they believe that two speakers who share the same accent live in the same place (Weatherhead et al. 2016) and that speakers with more pronounced accent differences live in more distant locations (Weatherhead et al. 2019). Interestingly, these effects are driven only by a speaker's accent, not their grammatical skill (Hwang & Markson 2018, St. Pierre et al. 2021). Children also link cultural items (Wagner et al. 2014) and cultural norms (Weatherhead et al. 2016) with accents. Between 3 and 8 years of age, children increasingly rely on speaker accent to decide who to trust and learn from (Kinzler et al. 2011; S. Ronfard, T. St. Pierre, K.S. White & E.K. Johnson, manuscript under review). During this same time period, children develop a preference for same-accented peers (Creel 2018, Paquette-Smith et al. 2019, St. Pierre & Johnson 2020) and rate foreign-accented adults as being worse teachers than same-accented adults (Paquette-Smith et al. forthcoming). These tendencies grow stronger between 4 and 11 years of age (Liberman et al. 2018, Spence & Imuta 2020, St. Pierre & Johnson 2020). Children's sensitivity to other people's attitudes toward accents also develops during this period, and in the process they come to understand that their own variety may be stigmatized. This awareness can have an impact on children's literacy development and educational achievement (for a review in US and UK contexts, see Patton et al. 2010, Snell & Andrews 2017).

A fruitful avenue for future research would be to move toward a more integrative approach of the development of accent processing as a whole. By encouraging developmental psychologists and language acquisition researchers to bridge their areas of expertise, a collaborative effort can be established to map out how general language development and improvements in the processing of other-accented speech are related to children's growing tendency to draw social inferences based on the accent spoken by interlocutors. For example, one aspect that requires further examination involves the direction of the relationship between

language attention and social information. Does children's attention to language and accents cause them to extract social information, or does social information drive the attention to language? Or is there a synergy between the two, where each factor feeds into the other (see Bortfeld et al. 2013 for a related discussion)? At this point, we have so few data to directly address this question that it is hard to conceptualize with any confidence how these factors relate (**Figure 2**). One way to begin to approach these issues might be to longitudinally track individual differences in children's proficiency of language and accent processing as well as their development of generating language-based social inferences.

3. TAKING A CLOSER LOOK AT CHILDREN'S PERCEPTION OF ACCENTED SPEECH

As discussed above, children's ability to handle other-accented speech is in place early in life. Precisely when and how children's other accent processing abilities become adult-like, however, are debatable. In our view, before 2 years of age, toddlers' perceptual adaptation to accented speech is already fundamentally similar in quality to that of adults, in that it is fast (Clarke & Garrett 2004), generalizable across words (Bradlow & Bent 2008, Maye et al. 2008, McQueen et al. 2006), and dependent on lexical access (Norris et al. 2003). It is also dependent on the number of accents present (Baese-Bark et al. 2013, Bradlow & Bent 2008), the acoustic–phonetic similarity to the native accent (Cooper et al. forthcoming, Escudero et al. 2014, Witteman et al. 2013), and access to social information (Niedzielski 1999, Yi et al. 2013). But how do children accomplish this? In this section we take a twofold approach to addressing these questions. First, we review and compare three accounts for explaining the dramatic shift observed in children's accent processing abilities in the second year of life (Section 3.1). Second, we examine how infants and toddlers use prior exposure to an accented speaker to adapt to different accents (Section 3.2).

3.1. Making the Quantum Leap from Infancy to Toddlerhood

At approximately 19 months of age, infants appear to make a dramatic and sudden improvement in their ability to cope with accent-related variation. That is, lab studies show that infants of this age suddenly start to spontaneously recognize familiar words in unfamiliar accents (Best et al. 2009; Mulak et al. 2013; van Heugten & Johnson 2014; van Heugten et al. 2015, 2018). But is

what we observe as researchers truly a quantum leap in accent processing abilities, or is it just the result of tiny, incremental changes in infants' abilities that eventually result in what appears to be a quantum leap? If the former, what drives the quantum leap? And if the latter, what types of incremental changes could be happening prior to 19 months of age that could build up into what appears to be such a dramatic change?

How researchers answer this question depends in part on how they view adult speech perception and in part on which theory of phonological development they find most plausible. Some researchers have argued that word representations are episodic in nature across the lifespan (e.g., Goldinger 1996, Houston & Jusczyk 2000). In a nutshell, the exemplar-based account posits that the mental lexicon consists of traces of previously experienced surface forms of words. These traces include indexical details such as the speaker's voice and accent. Only if the incoming word is acoustically similar to one or more stored episodic traces will the word be recognized. According to this view, cross-accent word recognition is initially a challenge for infants because their trace-based memories do not capture the acoustic variation of a different accent. But over time, as listeners experience greater variation in the pronunciation of words, their ability to cope with other-accented speakers improves (see Rost & McMurray 2009 for such evidence with infants in the domain of speaker variability). That is, when more exemplars are stored, less prototypical pronunciations are more likely to activate a trace associated with the intended word. This view thus stipulates that the improvement in the ability to cope with accents between infancy and toddlerhood can be attributed to relatively small gradual changes over time. Support for this account comes from the protracted period of development in children's ability to handle accent variation. At the same time, however, the storage of episodic tokens implies that any benefit of experience with an accent would be limited to the words heard in that accent before, and would not generalize to words that had not been heard previously—a finding that does not align with children's early adaptation abilities (van Heugten & Johnson 2014, White & Aslin 2011).

In contrast, other researchers have argued that abstract phoneme representations are necessary to explain accent adaptation in both childhood and adulthood (e.g., Cutler 2008, McQueen et al. 2012, van Heugten & Johnson 2014). Abstractionist accounts for the sudden shift we see in toddlers' behavior around 18 to 19 months come in two closely related, but somewhat different, flavors. We refer to these as the phonological reorganization account and the

continuous abstract account. According to the phonological reorganization account, the changes we see in toddlers' ability to spontaneously recognize other-accented words at around 18 to 19 months are attributable to a sudden shift in children's representational capabilities. Different variants may or may not assume abstract representations before 18 to 19 months, but when abstract representations are assumed, they are rudimentary (at best) and are qualitatively different from those that emerge later (**Table 1**). Proponents of this view tend to emphasize that this shift in representations coincides with the naming explosion (e.g., Mulak & Best 2013). The change in children's accent processing abilities could be instigated by children's greater ability to detect the invariant phonological structure of words (i.e., the development of phonological constancy; Best et al. 2009) or because initially holistic representations of lexical items transform into more abstract segmental representations (Metsala & Walley 1998). Although the dramatic changes in toddlers' behavior at approximately 18 to 19 months align with this view, findings that adaptation following brief exposure is observed in children under 18 months of age (cf. Cooper et al. forthcoming, van Heugten & Johnson 2014) would be difficult to explain under these accounts.

Not all researchers who emphasize the importance of abstract phoneme representations for accent processing agree that children necessarily undergo a dramatic change in their representational capabilities at 18 to 19 months (e.g., van Heugten & Johnson 2014). Findings of early accent adaptation are more readily supported by the continuous abstract account, which assumes a stronger continuity between young infants' early (pre)lexical representations and toddlers' more mature lexical representations and makes a clear assumption about abstract phonological representations existing early in infancy. For this reason, we argue that children's word representations are continuously abstract in nature, with changes in children's performance on accent adaptation tasks being driven by quantitative rather than qualitative differences that emerge over time. We thus consider abstraction to be a fundamental component of human speech processing, and necessary to explain infants' early success at building a proto-lexicon and handling talker variability. Toddlers' improved handling of other-accented speech can instead be attributed to factors such as increased attunement to the native language phonology and greater experience mapping the speech signal to underlying representations (cf. van Heugten & Johnson 2014). That is, the striking changes observed between infancy and toddlerhood are not observed as a result of a stage-like shift in representational capacities. Rather, children's abilities to handle

accent variation improve gradually over time, and the appearance of a stage-like developmental pattern is attributed largely to the limited sensitivity of our testing procedures. Adoption studies further support this view by providing independent evidence for the early emergence of abstract speech representations in infants (Choi et al. 2017).

In summary, three explanations have been proposed to explain developmental improvements in children's accent processing abilities. A side-by-side comparison of these accounts suggests that the nature of and continuity (or lack thereof) in the representations used by infants and toddlers to recognize other-accented words are major factors distinguishing different accounts for early accent processing (**Table 1**). In this regard, debates over how toddlers improve in their ability to process accented speech echo classic debates on the stage-like versus continuous development of cognitive abilities (e.g., Courage & Howe 2002). We suspect that, just as in the literature on cognitive development, ever-growing improvements to the sensitivity of infant testing methodologies as well as increased attention to the ecological validity of our experimental work may lead to greater support for the gradual and early emergence of abstract speech representations in children—an assumption of the continuous abstract account. But asking why we see developmental shifts in children's accent processing behavior does not explain the mechanism by which toddlers and young children adapt to new accents once those abilities emerge. In Section 3.2, we turn to this topic.

3.2. Taking a Closer Look at How Accent Exposure Induces Accent Adaptation

As mentioned above, toddlers are able to adapt to a speaker's accent after as little as two minutes of exposure (Paquette-Smith et al. 2021a, van Heugten & Johnson 2014, White & Aslin 2011). But how is this accomplished? Two distinct types of explanations have been proposed (**Table 2**). One class of explanations, often referred to as the specific mapping hypothesis, proposes that any other-accented input can cause toddlers to change their perception by generating precise between-accent mappings, perhaps in a lexically guided fashion (van Heugten & Johnson 2014, van Heugten et al. 2018, White & Aslin 2011). Through updating of the specific signal-to-phoneme mappings in line with the observed evidence, specific, directional shifts are created. For example, if a child hears a speaker produce the words *kiss* and *bib* with a long, raised vowel, [kiːs] and [biːb], instead of [kɪs] and [bɪb], they will deduce that this speaker pronounces the sound [ɪ] as [iː]. They will then adjust their expectations and will not be surprised when words they have never

heard the speaker produce follow this same pattern (e.g., *fish* produced as [fiːʃ]). As the child's expectations adjust, their processing of the other-accented speech should show rapid and notable improvement. This view generally assumes an abstract prelexical level of processing, so that a listener's lexical representations themselves are unaffected by short-term exposure to a different-accented talker. Instead, the mapping between the prelexical and lexical levels is adjusted so that the accented surface forms can be mapped onto the underlying representations. Note that since this strategy makes use of the prelexical phoneme level, it is really only viable with abstractionist accounts of language processing.

An alternative strategy of accent adaptation involves the general expansion hypothesis, which suggests that exposure to accented speech could lead children to rely less on the specific details of the word representations. For example, if a child hears the same speaker as before produce [kiːs] and [biːb] instead of [kɪs] and [bɪb], they will loosen their criteria for lexical access in such a way that they will not only readily perceive [iː] as an acceptable pronunciation of [ɪ] but will also accept [eː] or perhaps even [ɛ] as an instance of [ɪ], despite the lack of evidence that the other-accented talker produces [ɪ] in this fashion. This general expansion of acceptable pronunciations could be instigated by expanding the mapping between the speaker's pronunciation of the words and the underlying lexical representations and/or simply by lowering the activation threshold for word recognition. This would result in children being able to recognize words in unfamiliar accents, although one unfortunate by-product would be that minimally different word pairs would become more confusing. This increased lexical competition, in turn, would likely slow word recognition. While this approach can be realized as broadening on the prelexical phoneme, it can also be established at the level of lexical representations themselves. For this reason, the general expansion account is congruent with both abstractionist and exemplar-based models of language processing.

There is substantial evidence for both the specific mapping and general expansion hypotheses. On the one hand, evidence for the specific mapping hypothesis comes from an accent adaptation study with 19-month-olds. After brief exposure to an artificial accent, toddlers demonstrate accent-specific adaptation to novel productions of familiar words (White & Aslin 2011). Furthermore, by 24 months, after two minutes of exposure to an unfamiliar variety of the native language that maintains a phonological contrast not present in the child's own variety, children begin demonstrating sensitivity to a voicing contrast they initially ignored (van der

Feest & Johnson 2016; see also van Heugten et al. 2018 for additional evidence of children's detection of mispronunciations in unfamiliar accents). This sensitivity requires access to a prelexical level, which exemplar-based models do not have. On the other hand, there is also good evidence for general expansion. For example, after brief exposure to some type of variability, whether in the form of speech or completely outside the speech realm, children appear to recognize words spoken in an accent never heard before (Schmale et al. 2015). Similarly, other work shows that prior exposure to multiple unfamiliar accents helps children cope with a fourth accent not previously heard (Potter & Saffran 2017) and that routine exposure to more than one accent variant can slow down word recognition (Buckler et al. 2017). These findings suggest that the presence of variability or unexpected events (either in the speech signal or elsewhere) can cause infants to loosen their expectations regarding the exact pronunciations of words, and that this can happen without generating a specific mapping between the child's own accent and the talker's accent.

In short, the developmental literature contains evidence for both the specific mapping and general expansion explanations for accent adaptation. In most publications to date, these two theories have been presented as two categorically distinct explanations for early accent adaptation (cf. Schmale et al. 2012, 2015; van Heugten et al. 2018; van Heugten & Johnson 2014; White & Aslin 2011). But neither of these accounts on its own can explain the available data in a full satisfactory manner. Could a hybrid explanation—combining some elements of the specific mapping account with some elements of the general expansion account—provide a better explanation for how children adapt to other-accented talkers? The adult accent processing literature, where hybrid explanations have become common, provides a good rationale for such a proposal (e.g., Cooper & Bradlow 2018, Goldinger 1996, Kleinschmidt & Jaeger 2015, Pierrehumbert 2016). A flexible, dual-systems account, such as the hybrid models popular in the adult literature, could work particularly well for young children, who lack the speech processing efficiency and vocabulary that adults have. We refer to this particularly attractive possibility as the hybrid flexibility hypothesis. One can imagine that children could employ a general expansion approach when initially confronted with an unfamiliar accent (or when a newly confronted accent is particularly distinct from the child's own accent), and then replace it with the specific mapping approach after having been able to fine-tune their expectations. Note that because the hybrid flexibility hypothesis posits that specific mapping emerges after sufficient

consistent exposure to particular between-accent differences, children's lexical representations necessarily need to contain abstract phonological detail for this account to work.

The flexible hybrid approach makes specific predictions about what factors should elicit a general expansion versus specific mapping approach to accents, and ongoing work in our laboratories is further testing these predictions. For example, in support of the category broadening hypothesis for distant accents, we have recently found that toddlers preexposed to a distant novel accent before a word recognition test subsequently recognized words more slowly in their own accent than children who did not experience this preexposure. This suggests that the children experiencing the distant accent preexposure broadened their criteria for what counts as acceptable pronunciation for familiar words, resulting in slower word recognition even in their own accent variety (e.g., Cooper et al. forthcoming). We are also currently exploring whether routine exposure to multiple accents in everyday life enables toddlers and preschoolers, like older school-aged children (Levy et al. 2019) and adults (Laturnus 2018), to better adapt to speech produced in unfamiliar accents.

4. LOOKING FORWARD: ACCENT PROCESSING IN LINGUISTICALLY DIVERSE SETTINGS

Laboratory studies clearly demonstrate that in the absence of prior exposure to an accent, infants initially struggle to handle accent variation, and although toddlers' accent processing abilities may be qualitatively similar to adults' accent processing abilities, children continue to process other-accented speech less efficiently than adults well into late childhood [and perhaps even adolescence (Bent 2014; Bent & Atagi 2015, 2017; Bent & Holt 2018; Creel et al. 2016; Nathan et al. 1998; Newton & Ridgway 2016)]. But how does this play out in the real world? Do children who are exposed to more than one accent in their day-to-day life show a different language development trajectory than those who are primarily exposed to just a single accent? If so, what are the potential benefits of multi-accent exposure? What are the potential drawbacks? And how can children's proficiency with multi-accent input (or lack thereof) inform our models of speech and language development?

Exposure to multiple accents in early childhood is not rare, and is in fact the norm in many parts of the world, such as in large multicultural cities (e.g., Hong Kong, Toronto, and Los Angeles) and even more rural locations where pockets of linguistic diversity overlap or are

tightly packed together. Imagine a child growing up in Canada with one Australian parent and one American parent. On the basis of input at home, this child would need to learn that the similar-sounding forms of the word *ball* pronounced with an Australian accent and the word *bowl* pronounced with an American accent refer to different entities, whereas the more dissimilar pronunciations of the word *ball* in the two accents refer to the same referent. And what would this same child do when they go to daycare and hear their peers speaking in a Canadian English accent, and their teacher speaking with a French accent?

It is surprising that, despite the prevalence of multi-accent exposure in early childhood and an increasing awareness of the consequences of multilingual development among infant language researchers and speech therapists (e.g., Byers-Heinlein 2018, McLeod et al. 2017), very little work to date has examined how multi-accent exposure affects early language acquisition (Johnson 2018). Although numerous studies have documented how accent variation affects speech production in children over the age of 3 years (Kaiser 2021), much less research has examined how accent variation in the input to an infant or toddler affects early acquisition. Given suggestions that infants struggle to handle accent variation, these studies seem imperative to understand how language initially emerges in the face of accent variation. Examining the development of accent processing abilities in these children is crucial not only for testing the ecological validity of the laboratory studies reviewed above but also for understanding the factors that shape language learning trajectories in the real world, and possibly even for developing fair access to education (e.g., Morgan et al. 2015) and speech language assessments (e.g., Goldstein & Iglesias 2001, Morgan et al. 2016).

The few studies to date that have examined how multi-accent exposure affects toddlers' speech and language development can be divided roughly into two categories: those that have identified potential benefits of multi-accent exposure and those that have identified potential drawbacks. The first two experimental studies to examine how multi-accent exposure influences early language development fall into the latter category. In these studies with British 20-month-olds, word recognition in mono- versus multi-accent toddlers was examined using a Looking-While-Listening paradigm. Mono-accent children were exposed to the locally dominant rhotic variety of British English both at home and in their day-to-day life, whereas multi-accent children had at least one parent who was a speaker of a nonrhotic variety. The results of the first study were surprising: The mono- and multi-accent toddlers recognized familiar r-containing

words only when they were produced in the socially dominant rhotic variety (Floccia et al. 2012). This led the authors to conclude that the multi-accent children were selectively acquiring the dominant variety spoken in the community and, as a result, failed to recognize words in a nonrhotic accent. Note that this would suggest that multi-accent children might not always be able to understand language input provided by their own parents, which is somewhat alarming. In the second study working with the same population, British children were tested using a similar paradigm on correctly versus incorrectly pronounced versions of familiar words spoken in the locally dominant community accent. Unlike mono-accent children, who were found to recognize only the correctly pronounced versions of the familiar words, multi-accent children recognized target words with both the correctly and the incorrectly pronounced versions of the labels (Durrant et al. 2015). As a result, the variable nature of multi-accent children's language input has been claimed to cause them to generate poorly specified lexical representations. These poorly specified representations would presumably slow word recognition by increasing lexical competition between similar-sounding word candidates. Thus, overall, these two studies with British toddlers could be taken to suggest that multi-accent exposure may have a negative impact on the development of word recognition abilities in that children may be unable to fully benefit from linguistic input from their own parents who speak a nonstandard variety, while at the same time developing less well-specified representations of words produced in the socially dominant variety of their native language.

Other, more recent studies examining the effect of multi-accent exposure on toddler word recognition have presented a more positive outlook for multi-accent children. For example, in a mispronunciation detection study using both the dominant local accent and the nondominant accent spoken by parents of multi-accent children, Dutch-learning 24-month-olds routinely exposed to two varieties of their native language in their day-to-day life appeared to outperform their age-matched peers who were exposed to only one variety of their language (van der Feest & Johnson 2016). While multi-accent toddlers readily adjusted their speech processing expectations to suit the accent of the talker at hand, their mono-accent peers required more time and exposure to the accent used in the study to accomplish this same task. A follow-up study working with this same population examined the speed of word recognition and demonstrated that the multi-accent Dutch learners recognized words in both the dominant community accent and the less dominant accent just as efficiently as (if not more efficiently than) the mono-accent toddlers (S.V.H. van

der Feest, M.S. Rose, E.K. Johnson, manuscript in preparation). Likewise, a recent study examining word learning abilities in mono- and multi-accent Norwegian toddlers reported that multi-accent children revealed better word learning than their mono-accent counterparts when labels for the new words were provided in multiple accents (Kartushina et al. 2021). This suggests that multi-accent toddlers have a word learning advantage over mono-accent toddlers when speech input contains accent variability (i.e., the word learning abilities of the multi-accent infants appear well adapted to the environment they often find themselves in). Clearly, these findings with Dutch- and Norwegian-learning toddlers paint a much more positive picture of multi-accent exposure than the studies with the British toddlers described in the previous paragraph. Then again, other studies with Canadian toddlers exposed to nonnative varieties of the native language as well as the socially dominant variety have suggested that multi-accent exposure may slow recognition during early development (Buckler et al. 2017).

Although studies examining the effects of multi-accent exposure on toddler speech processing are rare, studies examining these effects in infants are even rarer. This is unfortunate, since laboratory studies on accent processing suggest that infancy is the period of development when multi-accent exposure would be most likely to affect speech and language development. In the one study to date that has directly examined this issue mono- and multi-accent 12.5-month-olds were tested on their ability to recognize word forms produced in the locally dominant variety of Canadian English (van Heugten & Johnson 2017). Whereas mono-accent 12.5-month-olds readily recognized word forms in this accent, their multi-accent peers did not. Indeed, the multi-accent infants showed no evidence of recognizing familiar words in the locally dominant variety of their language until they reached 18 months of age, roughly the same age at which mono-accent infants appear to readily recognize other-accented words. Thus, the only study examining the impact of multi-accent language input in infancy suggests that routine exposure to accent variability has dramatic consequences for early word recognition. Interestingly, however, children's reported vocabulary growth did not differ between the two groups (also see Fung et al. 2019 for similar findings), suggesting that it is not word learning that is affected but rather the in-lab mapping of the surface form onto the underlying representation. Future work could establish whether the observed discrepancies between the two groups of infants are due to differences in the flexibility of lexical access, whether reduced exposure to the locally dominant accent in combination with the many-to-one mapping may result in a more prolonged trajectory of

detecting the invariant structure of speech, or whether uncertainty of the accent in which the (unfamiliar) speaker talked may have complicated word recognition.

In summary, multi-accent exposure is common in childhood, but researchers are only beginning to investigate how exposure to accent variation might affect early speech and language development. Although the handful of studies that have been published on this topic come to different conclusions regarding the benefits and drawbacks of multi-accent exposure, there is one thing all of these studies unanimously agree on: Multi-accent exposure strongly influences how infants process the speech signal. But beyond the simple conclusion that multi-accent exposure affects speech development, many questions remain unresolved. For example, we argue that it is not yet clear how performance differences in the lab translate into speech processing efficiency in the real world and suspect that, when it comes to speech processing by multi-accent infants, what sometimes appears to be a deficiency in laboratory test conditions may in fact be an adaptive benefit in real-world situations. For example, multi-accent children may simply not assume that everyone will necessarily speak in the dominant community accent, and may enter the lab with different baseline assumptions than their mono-accent peers about how speakers sound. In a Bayesian framework of speech processing (e.g., Kleinschmidt & Jaeger 2015), this could perhaps be conceptualized as having weaker priors due to less exposure to the socially dominant variety of the native language, which in turn would give infants increased flexibility for recognizing words in a linguistically diverse environment (see Kartushina et al. 2021 for such findings with older children).

Although there is a lot we do not know about how multi-accent exposure affects language development in young infants and toddlers, or how being tested in a different variety in the lab than children hear at home may affect performance in studies, it is imperative that these issues be further examined, for at least two reasons. First, on a theoretical level, most influential models of early speech and language development (Jusczyk 1993, Werker & Curtin 2005) predate the current data on early accent processing. Clearly, future models should incorporate children's abilities to process language in multi-accent environments. And second, on a more practical level, data on children's development in multi-accent settings could inform debates regarding the best way to instruct multi-accent children and ensure that children's accent background does not interfere with the delivery of appropriate speech and language services. In the future, it will also be useful to consider how social factors may play a role in multi-accent children's language

behavior and development. Initial work in this area suggests that multi-accent children evaluate age-matched peers (Paquette-Smith et al. 2019) and adults (Paquette-Smith et al. forthcoming; S. Ronfard, T. St. Pierre, K.S. White & E.K. Johnson, manuscript under review) more positively when they speak the dominant community accent, but replications and extensions will be needed to draw firm conclusions.

5. WRAPPING THINGS UP

We began this review by emphasizing how important the ability to handle accent variation is to ensuring successful communication. We then discussed how children's ability to cope with accent variation improves between infancy and toddlerhood, and argued that early emerging abstract speech representations are necessary to explain the accent processing successes we see in toddlers. We also proposed a flexible, dual-systems approach to account for children's early accent adaptation. In the future, we recommend that the field focus more on potentially important links between children's perceptual sensitivity to accent variation, their ability to comprehend other-accented talkers, and the relationship between these two factors and the social inferences children draw about members of their community. Examining these questions is important for adequately understanding the development of human interaction, which is inherently social in nature.

We implore researchers to pay closer attention to how accent variation and sociolinguistic information may be affecting our findings in the lab, and to take a more holistic approach to understanding early language acquisition. Developmental psychologists need to understand children's accent processing abilities to be able to properly interpret social cognition studies, and language acquisition researchers need to pay attention to cognitive development studies to properly interpret children's verbal communication. By failing to fully consider the impact of these factors in developmental studies—treating children's ability to handle accent variation as a peripheral topic that can be studied separately from language acquisition as a whole, and largely ignoring language variety differences in the input children receive—we have risked developing models of child speech and language development that are at best unrepresentative of the acquisition challenges experienced by many children in the world, and at worst a distortion of the overall acquisition process itself.

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Table 1 Feature breakdown of the three accounts that explain the shift the ability to cope with accents between infancy and toddlerhood

	Requires abstract phonological representations in infancy?	**Assumes continuity in lexical representations?**	**Requires abstract phonological representations in toddlerhood?**
Exemplar-based account	No	Yes	No
Phonological reorganization account	Possibly, but only rudimentary	No	Yes
Continuous abstract account	Yes	Yes	Yes

Table 2 Feature breakdown of the three types of explanations for toddlers' exposure-based adaptation to unfamiliar accents

	Adaptation accent specific?	**Abstract phoneme representations required?**	**Can be influenced by nonlinguistic factors?**
Specific mapping	Yes	Yes	Not specified
General expansion	No	Not necessarily	Yes
Hybrid flexibility	Sometimes	Yes	Yes

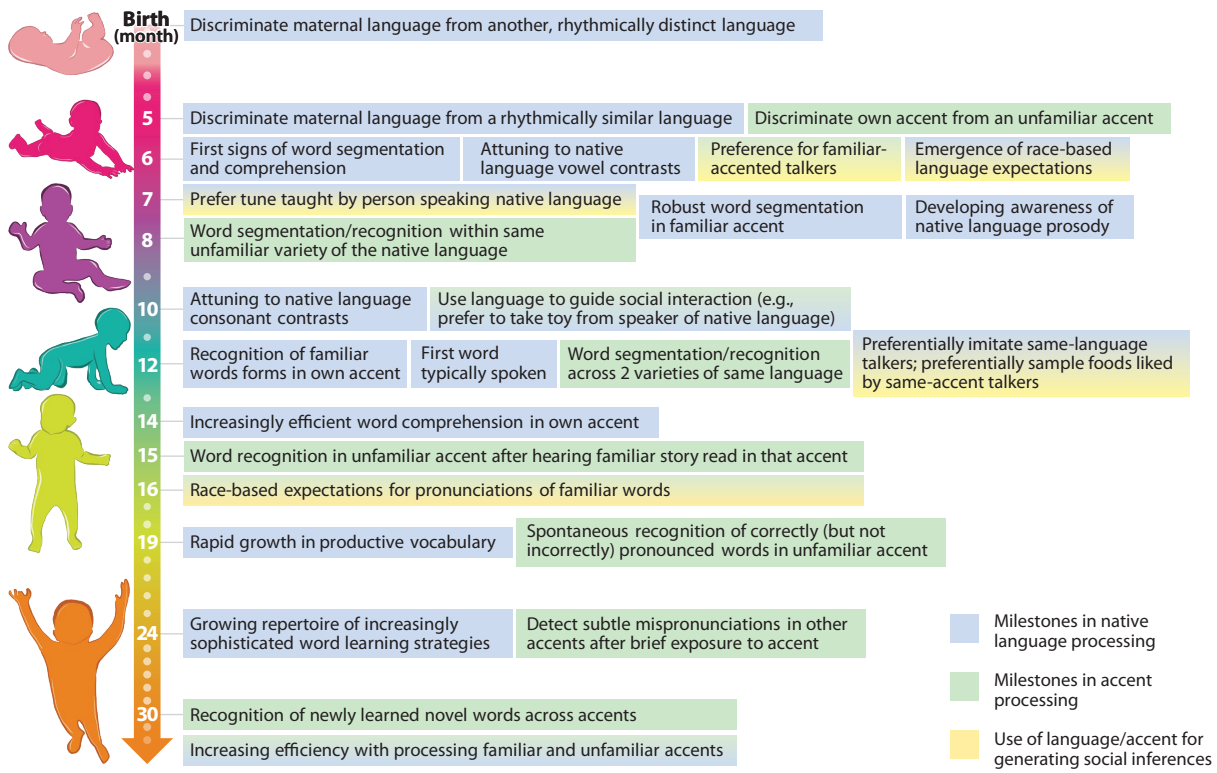

Figure 1

Outline of children's development of native language skills (blue), their ability to cope with accents (green), and their ability to generate social inferences about speakers based on their language or accent (yellow). Note that prior to 16 months of age, we know very little about how accent information affects infants' social perception of the world.

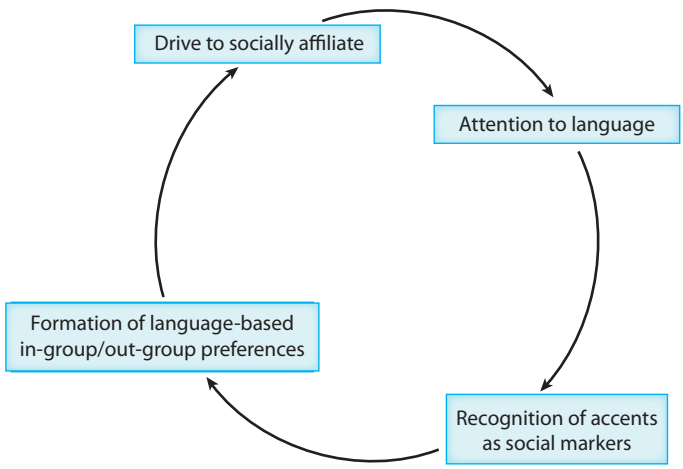

Figure 2
This circle represents one hypothetical (and admittedly overly simplified) conceptualization of how perceptual, cognitive, and sociolinguistic competency with accented speech might emerge. But where is the entry point for children? Do children begin with attention to language and derive social information? Or does the drive to extract social information cause their attention to language? It is also possible that multiple, perhaps bidirectional, pathways are simultaneously contributing to the pattern of development outlined in Figure 1 and that the direction and strength of the arrows may change at different points in development. At present, we have very few experimental data with infants and toddlers that could help us distinguish between these alternatives.