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Review

Exploring the Implications of Input Variability for Unfamiliar Accented Speech Perception: A Focused Review and New Hypotheses

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Abstract: Children with and without communication disorders have difficulty understanding words and sentences produced by talkers with unfamiliar characteristics, such as unfamiliar accents. To date, few studies have investigated how this difficulty manifests in linguistically diverse children. Studies of monolingual children have found that lexical and phonological skills predict accurate perception. For linguistically diverse children, there are differences in the structure of their linguistic input relative to their monolingual peers. These differences in their linguistic input influence their lexical and phonological development, suggesting that they may also differ in how they perceive unfamiliar accented speech. In this paper we present different hypotheses for how input variability might affect unfamiliar accented speech perception. Then, we conduct a focused review of the literature on how input variability affects early linguistic development for bilingual and bidialectal children. We link this information to the literature on how children with and without language disorders understand unfamiliar accented speech to identify important areas for future inquiry. Determining how input variability interacts with linguistic skills to predict unfamiliar speech perception is a crucial area for future inquiry. Effective clinical recommendations and educational accommodations require understanding of the linguistic skills and experience that support accurate variable speech perception for diverse populations.

Keywords: linguistic diversity; perceptual flexibility; speech perception

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1. Introduction

When an individual hears a word produced in an unfamiliar accent, they must map the unfamiliar production onto an existing lexical item, or word form. According to the Ease of Language Understanding model (Rönnberg et al. 2008; Rönnberg et al. 2013), mapping unfamiliar productions taxes working memory and creates a processing cost that negatively affects speech recognition accuracy and processing speed (Creel 2012; Munro and Derwing 1995a, 1995b). This processing cost is modulated by the linguistic skills of a listener, such as the phonological (Bent and Atagi 2017; Brosseau-Lapré and Kim 2020) and lexical (Bent 2014; Mulak et al. 2013) skills developed throughout the preschool and school years. Therefore, adults can accommodate unfamiliar accents with relative ease (Bradlow and Bent 2008; Clarke and Garrett 2004), but children, who are still developing these skills, have more difficulty understanding unfamiliar accented speech (Bent 2014, 2018; Bent and Atagi 2015; Best et al. 1988; Creel 2012; Creel et al. 2016; van Heugten et al. 2015).

This account of how individuals understand unfamiliar accented speech is simplified, but, importantly, the model only reflects how monolingual children and adults understand unfamiliar accented speech. The story may be more complicated for a large segment of the population that speaks more than one language or dialect. For children in this group, the development of linguistic skills may be less associated with age and more associated with

the relative linguistic input (henceforth "input") in each language compared to monolingual peers (e.g., Hoff et al. 2012; Unsworth 2016). Understanding how differences in input among linguistically diverse populations affect language development is key to clarifying and expanding the account of how individuals develop the ability to understand unfamiliar accented speech.

Input strongly influences language development (Huttenlocher et al. 1991; Pearson 2007) and is commonly described in terms of quantity (e.g., length of exposure, percentage of daily exposure) and quality (e.g., contexts of use) of experience (Unsworth et al. 2019). The input to linguistically diverse children is different from that of monolingual children in several important ways. For one, bilingual and bidialectal children's input is divided among multiple language systems. Therefore, the child will learn two languages at rates reflecting the daily experience in each language (Hoff et al. 2012; Unsworth 2016). Another difference is that for bilingual and bidialectal children there are commonly higher amounts of variability in the input compared to monolingual peers. For instance, bilingual children will need to learn more speech sounds than a monolingual child (e.g., Werker and Tees 1984). These differences in input properties and language experience lead to greater variability in the development of phonological and lexical skills for bilingual children compared to monolingual ones (Chondrogianni and Marinis 2011; Oller et al. 2007; Unsworth et al. 2019). This implies that differences in input properties are likely to impact the perception of unfamiliar accented speech, a task that is associated with both lexical and phonological skills.

Input Variability

Input variability is an inherent part of listening to speech. Across speakers there is considerable variability because no two speakers produce a sound in precisely the same way. Within the productions of an individual speaker, variability occurs as a function of a variety of factors, such as the coarticulatory context (Ambridge and Lieven 2011). However, this variability in the input is likely to be greater in (1) multi-dialectal households, (2) native-foreign accented households, and (3) bilingual households.

One type of variability is subphonemic variability. Subphonemic variability occurs when a listener hears the same phoneme produced using different articulatory gestures. Such variability may be more prevalent within multi-dialectal, native-foreign, and bilingual households than in monolingual ones. For example, imagine two native English speakers from different geographic regions of the United States saying the word "caught". One speaker may pronounce the word [kɔt] while the other may produce [kɑt] due to dialectal differences. A child living in this household and learning the phoneme inventory of her language will need to recognize that the two distinct gestures [ɔ] and [ɑ] represent one phoneme. In a bilingual household, the picture may become more complex with additional sources of variability making accurate segregation of phonemes more complicated. For example, imagine a child growing up in a Spanish-English bilingual household where one parent is a native speaker of English, and one is a native speaker of Spanish. The caregiver whose second language (L2) is English and whose native language (L1) is Spanish may produce the English word "ship" as [ʃip], while the other parent, a native speaker of English, may produce the word as [ʃɪp]. For a child learning language in this context, both [i] and [ɪ] will be productions of /ɪ/ across talkers in English. However, /i/ and /ɪ/ are also distinct phonemes for the native English-speaking parent. The young child must extract these distinctions from the input to understand each caregiver's speech and produce speech sounds with stability (e.g., Abu El Adas et al. 2020).

In bilingual households, variability in the input can also occur at the phonemic level. Phonemic variability occurs when an infant is exposed to more than one phonological system. Bilingual infants must extract information from the input to categorize the sounds of each language into two inventories (Werker and Byers-Heinlein 2008). For example, infants exposed to French and English must segregate productions of /d/ that vary by place of articulation: the French dental production and the English alveolar production.

Although these sounds are similar, bilingual infants differentiate between the contrasts by the end of the first year (e.g., Sundara et al. 2008).

2. Theoretical Frameworks and Hypotheses

There are multiple frameworks that predict which individual factors support unfamiliar accented speech perception. Below we contrast two hypotheses that predict differential influences of receptive vocabulary size and input variability on phonological refinement and speech processing.

Experimental research documents the positive correlation between receptive vocabulary size and unfamiliar accented speech perception accuracy (e.g., Bent 2014; Mulak et al. 2013). For children, these findings suggest that individual differences in lexical and, perhaps, phonological development could yield differences in recognizing unfamiliar accented words. In this section we review the lexical restructuring hypothesis ([LR]; Metsala and Walley 1998), which makes useful predictions for how differences in lexical-phonological development could yield differences in spoken word recognition between bilingual, bidialectal, and monolingual children.

The LR is a developmental framework that describes the trajectory of spoken word recognition (Metsala and Walley 1998). It posits that lexical and phonological skills are interrelated, and that vocabulary size drives the refinement of phonological representations as children develop. The hypothesis predicts that in early word learning children acquire words as whole units. Then, as the child is exposed to more words, they create more detailed phonological representations to allow for differentiation of similar sounding words (Metsala and Walley 1998; Walley 1993). This hypothesis is, in part, supported by experiments that document the association between receptive vocabulary size and nonword repetition in English-speaking monolingual children (e.g., Metsala 1999).

In addition to making predictions about the relationship between vocabulary size and phonological refinement, the LR makes predictions for how children understand unfamiliar accented speech. Refined phonological representations support the efficient mapping of unfamiliar productions to representations by allowing listeners to identify differences in sound productions and map them to existing representations. A listener with a less refined phonological representation may be less likely to recognize the novel production and to inaccurately categorize it. In this way, refined representations should reduce the processing cost associated with encountering a talker with unfamiliar characteristics, such as an unfamiliar accent.

Although the LR was developed to explain the monolingual developmental trajectory of word recognition, researchers have tested its predictions in bilingual populations as well (Dickinson et al. 2003; Scarpino et al. 2011). For example, Scarpino et al. (2011) found that for Spanish-English preschool-age bilingual children the largest predictor of English phonological awareness skills was English vocabulary size. They did not find a significant association between Spanish vocabulary size and English phonological awareness. The authors interpreted these results to be similar to those of Metsala (1999), and, therefore, that they support the predictions of the LR in a bilingual sample (Scarpino et al. 2011).

The LR is also useful for making predictions about bilingual developmental speech perception. This framework suggests that the variable input of bilingual and bidialectal children may contribute to less-refined representations at the lexical level. Thus, bilingual and bidialectal children may have a higher processing cost associated with listening to unfamiliar accented speech than their monolingual peers. Further, the LR highlights the difficulties that may be encountered by monolingual and bilingual children with disorders who commonly exhibit deficits in lexical and phonological skills.

The LR is supported by experimental research investigating how vocabulary size is associated with the accurate perception of speech in adverse conditions, such when encountering variable speech (Bent 2014; Brosseau-Lapré and Kim 2020; Creel 2012; Mulak et al. 2013). The next paragraph will review studies that have evaluated the association between lexical and phonological skills to assess how the results relate to the predictions of the LR.

Receptive vocabulary measures have been commonly used in studies evaluating how children perceive unfamiliar accented speech (e.g., Bent 2014; Brosseau-Lapré and Kim 2020; Mulak et al. 2013). Research in this vein generally supports the predictions of the LR. That is, children with larger receptive vocabularies more accurately understand words and sentences presented in unfamiliar accents. Some researchers interpret receptive vocabulary size as a proxy for the phonological detail in representations (e.g., Brosseau-Lapré and Kim 2020). If receptive vocabulary size does serve as a proxy for phonological refinement, then the experimental literature largely supports the predictions of the LR. However, alternative hypotheses regarding the relationship between lexical refinement and phonological skills challenge this notion.

One alternative account of phonological development is offered by Clopper (2014). In this hypothesis children with more variable input could be more accurate in understanding unfamiliar accented speech but slower in reaction time as a result of the structure of their phonological input (Clopper 2014). In this hypothesis, the structure of input creates more flexible phonological representations that encompass a wider range of gestures per speech sound compared to listeners with less variable input. If true, these flexible phonological representations should support the accurate perception of unfamiliar accented speech. However, evaluating more flexible representations could come with a processing cost. This hypothesis emphasizes one way in which input variability could refine phonological representations in linguistically diverse children.

A hypothesis related to this view may posit that experience with input variability helps listeners identify the core features of a speech sound and ignore irrelevant gestural differences, like those that may accompany unfamiliar accented productions. Evidence for this hypothesis comes from studies that test how children and adults learn to discriminate foreign speech sounds (sounds from another language's inventory) or foreign accented speech sounds (from the listener's inventory) better when perceptual training uses multiple talkers as compared to one (e.g., Bradlow et al. 1997; Logan et al. 1991; Iverson et al. 2012). Therefore, it is possible that in development when children are exposed to increased input variability associated with linguistic diversity, they may have representations that emphasize core features of speech sounds while accepting or ignoring other speech gestures. If true, then input variability could offer an alternate route to understanding unfamiliar accented speech separate from the influence of vocabulary size. For instance, it is possible that listening experience and language ability differentially contribute to speech perception accuracy when encountering a variable source. Listening experience could cultivate listener expectations and listening strategies for encountering unfamiliar variable sources, while language ability could enhance the use of top-down strategies when encountering those sources. Thus, vocabulary and input variability could have differential contributions to unfamiliar accented speech perception. The respective roles of vocabulary and input variability in supporting phonological refinement and speech processing have yet to be determined.

While there are different frameworks that predict various routes to phonological refinement in development, there is a paucity of frameworks that consider both lexical knowledge and input variability as factors that influence speech processing. Therefore, experiments tend to evaluate either the influence of linguistic knowledge, like vocabulary, or the influence of variable input on unfamiliar accented speech perception, but do not often assess their combined contributions. Below, we will summarize the literature on how input variability affects the trajectory of phonological and lexical development in linguistically diverse populations. Then, we will review the literature on how linguistically diverse children understand and adapt to unfamiliar accented speech. Lastly, we will discuss the crucial need to investigate how linguistic knowledge and input variability influence unfamiliar accented speech processing for linguistically diverse children with and without language disorders.

2.1. Influence of Input Variability on Speech Perception

Phonological development broadly refers to how children refine their perception and production of speech sounds over time (Kelley and Lambert 2011). In this section of the paper, we will discuss how input variability influences speech perception for bilingual and bidialectal children.

There are different theoretical accounts that describe how bilingual infants learn to discriminate between the sounds of two languages over time. One such framework is the Processing Rich Information from Multidimensional Interactive Representations framework ([PRIMIR]; Curtin et al. 2011; Werker and Curtin 2005). Within the PRIMIR framework speech processing depends upon the demands of the communication context and the existing perceptual biases of the individual. Infants are born with perceptual biases that predispose them to prefer listening to human speech over music (e.g., Vouloumanos et al. 2010), and, eventually, the sounds of their native language to other human speech (Best et al. 1988; Burns et al. 2007). These perceptual biases are refined over time and are influenced by the languages the child is hearing in their environment. Higher amounts of variability in the input, by definition, are associated with greater variation in distributional cues (e.g., articulatory and acoustic cues) for the child to tune into. Therefore, while monolingual and bilingual children develop phonological skills similarly, the demands of their listening contexts are likely to differ. In this section we review how bilingual and bidialectal infants and young children process higher amounts of variability in the input, and the effect this has on the tuning of perceptual biases and developmental speech perception.

Higher levels of input variability and divided input exposure for linguistically diverse infants suggests that bilingual and bidialectal infants might develop phonological skills differently than monolingual children. Despite differences in input, throughout the first year monodialectal, bidialectal, and bilingual children meet early phonological milestones at approximately the same time. For example, at around ten months of age both monolingual and bilingual infants' ability to discriminate foreign contrasts decreases (Werker and Tees 1984; Kuhl et al. 2006; Liu and Kager 2018), and their preference for native sounds increases (Best et al. 1988; Burns et al. 2007).

Although early milestones are met at comparable times, these groups are not identical. For example, bilingual and bidialectal infants may have more flexible phonetic categories compared to monolingual infants that lead them to have a higher tolerance of variation in word forms (Bosch and Ramon-Casas 2011; Durrant et al. 2015; Ramon-Casas et al. 2009). Ramon-Casas et al. (2009) examined this difference by manipulating the vowels in words to evaluate how alterations affected word recognition for bilingual toddlers who spoke Spanish and Catalan, and monolingual toddlers who spoke Spanish. Spanish and Catalan are phonetically similar languages. One key difference is that Catalan has two mid-front vowels and Spanish has one. In the study, children were shown pairs of pictures while their eye movements were tracked. The pictures were labeled with one of two types of vowel alterations: a within-language change (i.e., another Spanish vowel), or a crosslinguistic change (i.e., a Catalan vowel). Monolinguals' word recognition was unaffected by a foreign vowel being produced in a target label. However, monolinguals were slower to recognize words that contained a within-language vowel change. Bilingual children were not sensitive to within-language vowel change and were equally fast at identifying target words regardless of the type of vowel change. A similar experiment found that bidialectal infants are also less affected by mispronunciations in familiar words compared to monodialectal infants (Durrant et al. 2015). Such findings could suggest that bilingual and bidialectal children have more flexible representations than their monolingual peers. If true, these children would be robust to variability at the word level and may be more efficient in processing variable input.

Investigations of how bilingual children develop phonemes are important to test hypotheses about the effect of variability in the input. Some have argued that the trajectory phonetic category development depends upon the variability in how sounds are produced in the input to the child. Therefore, it is possible that young children with variable input,

like the bilingual children in Ramon-Casas et al. (2009), would be less sensitive to specific types of sound alterations in familiar words (Bosch and Ramon-Casas 2011; Sundara et al. 2006). For example, in the input to French-English bilingual children, the production of [d] for /ð/ in English is common meaning that they may hear inconsistent gestures for /ð/ in English. Sundara et al. (2006) found that 4-year-old French-English bilinguals did not discriminate the /d–ð/ contrast as accurately as monolingual peers. The authors directly interpreted their finding to indicate that the lack of discrimination of the contrast might be attributed to variability in the input to the infants. If true, then the insensitivity to alterations between certain phonemes (e.g., Bosch and Ramon-Casas 2011; Durrant et al. 2015; Ramon-Casas et al. 2009) would be rooted in experience-based perceptual biases that help the infant accurately process the variation in speech input in the home environment.

The patterns observed in bilingual children may also be apparent in bidialectal ones. In another study, Floccia et al. (2012) investigated how the amount of exposure to a dialect affected phonetic category formation for infants. Twenty-month-old infants who were either raised in homes with two caregivers that spoke with the common accent of the community (mono-accentual) or in one where a caregiver spoke with an accent that differed from the community (bi-accentual) were evaluated on word identification in the predominant accent of the community and the less common accent. The infants would be shown a target picture and a distractor. Then, a research assistant would say, "Look! A ____," and name a target word. The accuracy of word identification in each accented condition was calculated using the looks to the target. Both mono-accentual and bi-accentual infants identified the familiar words produced with the community accent more accurately than the ones produced in the alternative accent, even if one caregiver spoke with the alternative accent. Such a finding implies that bi-accentual infants acquire phonological representations that reflect the more common accent of their community. If true, then bi-accentual infants are likely to acquire separate representations per accent, like bilingual infants do per language (Floccia et al. 2012).

In a follow up study, Van der Feest et al. (2022) investigated how bidialectal Dutch-learning 24-month-olds recognized words in both dialects they were regularly exposed to. The study evaluated how efficiently bidialectal and monodialectal Dutch-learning 24-months-olds identified familiar words produced with two different dialects using eye-tracking procedures. Word stimuli could either be presented in a standard dialect or a dialectal variant, and the onset timing could either be matched or mismatched. The results suggested that bidialectal toddlers recognized words more efficiently than monodialectal peers in the matched conditions, and that both groups performed similarly in the mismatched conditions. There were no reaction time differences by dialect condition. The authors interpret these findings to indicate that bidialectal toddlers recognize word forms in both dialects they are regularly exposed to with ease (Van der Feest et al. 2022).

It appears, then, that bilingual and bidialectal children develop phonetic boundaries differently than monolingual peers, and this may be due to the variability in their input. These differences in category formation may allow linguistically diverse listeners to be more flexible when it comes to processing speech sounds at the word level. However, some researchers have hypothesized that the flexibility exhibited by linguistically diverse children could negatively affect word learning during the first years of life. Specifically, bilingual and bidialectal infants may have unstable or under-specified phonological representations that could lead to the infants mistakenly accepting two distinct productions as one lexical item (e.g., Bosch and Ramon-Casas 2011; Durrant et al. 2015). In the next section, we will evaluate such hypotheses by examining how input variability influences early word learning and lexical skills.

2.2. Influence of Input Variability on Lexical Development

Lexical development is the process of learning words and their associated meanings. In order to do this a child must encounter a word and then create an entry in their lexicon containing the phonological representation and the meaning. Vocabulary acquisition is

different for monolingual and bilingual children. For bilingual children, vocabulary is a distributed language skill that requires them to learn two different labels per concept (e.g., Oller et al. 2007). The acquisition of the label *dog* in English will not facilitate the learning of *perro* in Spanish, or vice versa. Similarly, in the example discussed above for biaccentual children, Floccia et al. (2012) found that the acquisition of the rhotic form for "bird" did not facilitate the learning of the dialect-specific, non-rhotic form for "bird". Distributed language skills that cannot transfer between languages may develop at a slower rate in each language when compared to monolingual norms, even though a bilingual child's total vocabulary size across both languages commonly approximates or exceeds monolingual norms (e.g., De Houwer et al. 2014).

Monolingual and bilingual infants meet early lexical milestones at approximately the same time. At six months of age, bilingual and monolingual infants begin to recognize common words in their input (Tincoff and Jusczyk 1999, 2012) and, on average, both groups say their first words at around twelve months (Fenson et al. 1994; Patterson and Pearson 2004). However, by the second year of life monolingual and bilingual lexical trajectories diverge. Bilingual children have smaller vocabularies compared to monolingual peers during the second year of life (Core et al. 2013). The rate of language development for vocabulary growth and other distributed skills will depend upon the amount and quality of input in each language. That is, if a child receives more daily input in one language, then they will learn new words at a faster rate in that language compared to the other (Chondrogianni and Marinis 2011; Hoff et al. 2012; Unsworth 2016).

During the school years, input continues to influence vocabulary growth. Thordardottir and Rioux (2019) compared first and third grade monolingual students to age-matched simultaneous and sequential bilinguals and found that both groups of bilingual students had smaller conceptual vocabularies compared to monolingual peers. The input-related factor that accounted for the most variation in vocabulary size was the amount of daily exposure to each language, not the initial age of acquisition (Thordardottir and Rioux 2019). This implies that vocabulary size and growth cannot be properly assessed by only focusing on order or age of acquisition for school-age bilingual children. Daily input remains an important factor to consider in the context of academic or language evaluations.

3. Understanding Unfamiliar Accented Speech

Above, we described two competing hypotheses about what drives phonological refinement in development. These hypotheses yield divergent predictions about how bilingual and bidialectal young children process a new accent. One interpretation of the phonological trajectory of bilingual and bidialectal development suggests that bilingual and bidialectal children could have more flexible speech sound categories compared to monolingual and mono-dialectal peers. For instance, Clopper (2014) interpreted observed category flexibility to be adaptive because it allows for infants and children developing language in more variable environments to efficiently process a wider range of speech sound productions. If linguistically diverse children demonstrate increased flexibility in phonological representations, then bilingual and bidialectal children would be more accurate than their monolingual peers at processing unfamiliar accented speech. Their flexible representations could facilitate efficient matching of new sound productions onto existing representations.

On the other hand, the LR states that vocabulary development is crucial for phonological refinement which, in turn, supports processing of unfamiliar accented speech. Given the differences between bilingual and monolingual vocabulary development, it is likely that some bilingual children would have less lexical information in each language to aid in the processing of accented speech in early childhood when compared to monolingual peers. Within the LR, this would predict less-refined phonological representations causing the bilingual child more difficulty interpreting unfamiliar accented speech as compared to monolingual age-matched peers. These competing hypotheses have not yet been evaluated

in experimental literature. This section will review the existing studies to discuss what is known and identify crucial gaps that future inquiry must fill.

Encountering a talker with an unfamiliar accent is challenging for young listeners who are still developing cognitive and linguistic skills. However, the amount of difficulty the new accent poses is modulated by characteristics of the listener. Levy et al. (2019) hypothesized that the input variability of bidialectal and bilingual children would increase the flexibility of their phonological representations and aid them in understanding unfamiliar accented speech. To investigate how bilingual, bidialectal, and monolingual children understand unfamiliar accented speech they recruited school-age children and asked them to repeat anomalous sentences that either had an unfamiliar foreign or an unfamiliar dialectal accent. They found that greater experience with dialectal accents supported the accurate understanding of an unfamiliar dialectal accent. However, greater experience with foreign accents did not support the perception of unfamiliar foreign accents. The authors concluded that experience with foreign accents could be accent specific, and that experience with one foreign accent may not generalize to support the perception of other foreign accents. This interpretation seems to imply that within language subphonemic variability creates more flexible phonological representations for words and assists in the processing of other dialectal or within-language accented speech. However, experience with foreign accents is more specific, since the phonological and prosodic characteristics between languages may be quite different. One limitation of this study is that the participant groups were not language-matched (e.g., by vocabulary size), so language ability could be a confound in these analyses, since the monolingual children had higher vocabulary scores and reported more experience with regional dialects than the bilingual children.

McDonald et al. (2018) investigated how experience facilitated the comprehension of foreign-accented speech for monolingual English-speaking children and two groups of bilingual Spanish-English speaking (sequential and simultaneous) children between the ages of five and seven. Simultaneous bilinguals were exposed to Spanish prior to 36 months, whereas sequential bilinguals were exposed to Spanish after that point. McDonald et al. (2018) tested how native-accented English versus Spanish-accented English speech influenced the semantic judgments of two different types of sentences: meaningful and nonsensical. All three participant groups understood the meaningful sentences across accent conditions. The monolingual and sequential bilinguals were less accurate at understanding Spanish-accented nonsensical sentences compared to the simultaneous bilinguals. The findings suggested that specific experience with an accent might facilitate speech processing when the sentence-level context is vague or semantically nonsensical. However, experience may not be necessary to support processing when the sentence-level context is meaningful (McDonald et al. 2018). The authors interpreted the findings to indicate that, since all the groups of children understood the Spanish-accented speech when the sentence included adequate semantic and sentence-level context, in real life communicative contexts, they should be able to adequately understand unfamiliar accented speech. This interpretation highlights how vocabulary knowledge facilitates unfamiliar accented speech perception when sentences are meaningful for a reason beyond phonological refinement. Vocabulary knowledge is useful for recognizing unfamiliar accented productions because lexical constraints in the incoming speech facilitate understanding of the accent, a process referred to as lexical guidance (see Felker et al. 2021). When children listen to incoming speech, they can use cues from the utterance's meaning to constrain the lexical item options for unfamiliar productions. For instance, if an unfamiliar talker is telling a story about a dog and the child is unsure about the distribution of /b/ and /d/ for this unfamiliar talker, the context can help the child infer that the talker said "bog" instead of "dog." Lexical guidance helps listeners identify patterns in unfamiliar accented speech and perceptually adjust to those patterns by providing constraints during the initial exposure period. In McDonald et al. (2018), monolingual, simultaneous bilingual, and sequential bilingual children understood meaningful sentences similarly, but the simultaneous bilinguals showed an advantage in understanding nonsensical sentences. This could be because all children

were able to use lexical constraints to understand meaningful Spanish-accented sentences, whereas direct experience could have facilitated comprehension for nonsensical Spanish-accented sentences. This study demonstrates how investigations that vary the content of sentences help identify which factors refine phonological representations without the confound of lexical guidance (Levy et al. 2019; McDonald et al. 2018).

The review of the literature on how bilingual and bidialectal children perceive unfamiliar accented speech provided preliminary evidence that, in certain contexts, increased variability in the input yielded improved perception of accented (variable) speech. Levy et al. (2019) found that children with greater experience with dialectal accented speech understood unfamiliar dialectal accented speech more accurately than children without such listening experience. McDonald et al. (2018) found that children with experience with a specific accent were more accurate at rating anomalous sentences relative to peers who were less familiar with the accent. Although the findings are preliminary due to the small number of studies, the results suggest that there are communicative contexts wherein the listener would be at an advantage if they had more variable listening experience. This is especially true in contexts where the semantic meaning of utterances is limited or nonsensical and listeners cannot use lexical constraints to guide speech perception.

3.1. Perceptual Learning

Perceptual learning refers to a listener's ability to accommodate unfamiliar accented speech and generalize their learning to another talker (Bent and Baese-Berk 2021). Below we will provide an overview of the literature on perceptual learning in monolingual children. Then, we will discuss implications for how variability in proficiency could influence perceptual learning for bilingual children.

While cross-talker and within-talker variability associated with unfamiliar accented speech may present some challenges to young listeners, there can also be systematicity that aids the listener's understanding. Foreign accents can be systematic across talkers because the patterns of production are, in part, constrained by the differences between the L1 and the L2 (Bent and Baese-Berk 2021). For example, in Spanish, the vowel /ɪ/ is not in the inventory. Therefore, when an L1 Spanish-L2 English speaker produces a word containing the vowel /ɪ/ they often produce [i], because that gesture corresponds to a vowel that exists in the Spanish inventory (e.g., Flege et al. 1997), instead. This systematicity is helpful because it allows listeners to either form representations for the accent or to expand their existing representations to incorporate the production. In the context of variable speech perception, perceptual learning describes the process of forming new representations or expanding existing ones.

Perceptual learning has been exhibited by monolingual infants and young children after brief periods of exposure to an unfamiliar accent (Schmale et al. 2010, 2012; Schmale and Seidl 2009; van Heugten and Johnson 2014; van Heugten et al. 2015). Schmale and Seidl (2009) evaluated how voice and accent variability influenced word recognition for 9- and 13-month monolingual English learning infants. In a series of experiments, infants were first familiarized to words spoken in one voice and then tested for perception of the same words in a different voice. Infants in both age groups recognized words spoken by a monolingual English talker after having been familiarized to a different monolingual English talker. However, when the infants were familiarized to a Spanish-accented talker, only the 13-month-old infants were able to recognize words spoken by a different Spanish-accented talker. Nine-month-olds were only able to recognize Spanish-accented words in the test phase when they were spoken by the same talker as in the familiarization phase. Such results suggest that monolingual infants and children easily adapt to unfamiliar accented speech after a period of exposure (e.g., Schmale and Seidl 2009; Schmale et al. 2012; van Heugten et al. 2015), even though their adaptation may not extend to new talkers. However, the finding that all children within an age group efficiently adapt to unfamiliar accented speech has not been consistent in the literature (Levi 2015; White and Aslin 2011).

For young children, both language knowledge, estimated across domains such as sentence production and comprehension, may predict perceptual learning. Levi et al. (2019) evaluated the individual-level factors that predicted perceptual learning in 6- and 12-year-old children. The experiment comprised a pretest, training, and posttest phase in which speech from four talkers, one with a familiar speech pattern (i.e., native-accented English) and three with unfamiliar properties (i.e., German-accented English), were presented. The children's language knowledge was assessed in both expressive and receptive domains. The study showed that language ability mediated age effects in perceptual adaptation. Such a finding could help account for the differences in experimental studies evaluating how children adapt to unfamiliar accented speech by suggesting that the language abilities of the sample will influence their response to perceptual training.

Linguistically diverse populations can vary in their language knowledge across languages. The studies reviewed above, while focusing on monolingual learners, suggest that the variability in language knowledge for diverse populations may modulate perceptual learning significantly. Thus, evaluation of how linguistically diverse children generalize their learning from one talker to others and how this ability relates to the language knowledge of the child should be a central goal of research in this domain.

3.2. Communication Disorders

This section will discuss the need for future inquiry to determine how linguistically diverse children with communication disorders process variable speech. Such questions are important because children with disorders commonly have cognitive deficits, in areas like attention (e.g., Park et al. 2019; Spaulding et al. 2008) and linguistic deficits in lexical-semantic (e.g., McGregor et al. 2013; Sheng and McGregor 2010) and phonological skills (e.g., De Groot et al. 2015; Raitano et al. 2004; Waring et al. 2018). Understanding how such deficits affect speech processing when the input has unfamiliar characteristics could yield important clinical recommendations for assessment and intervention.

There are a limited number of studies that have examined how children with communication disorders process accented speech, with most studies recruiting monolingual populations. In general, children with communication disorders, such as speech sound disorders (SSDs), autism spectrum disorder (ASD), and language disorders exhibit difficulty processing accented speech (Brosseau-Lapré and Kim 2020; Frizelle et al. 2018; Knowland et al. 2019; Nathan and Wells 2001). Children with speech sound disorders (SSDs) commonly demonstrate phonological deficits relative to age-matched peers. Brosseau-Lapré and Kim (2020) hypothesized that children with SSDs would have difficulty accurately understanding unfamiliar accented speech and that certain words would be more difficult to identify than others. They predicted, in line with the LR, that words with many phonological competitors (what the authors refer to as "lexically-hard" words) would be more difficult to identify than words with few phonological competitors (what the authors refer to as "lexically-easy" words) because they require more refined phonological representations for identification. In the study, four- and five-year olds with and without SSDs identified lexically-hard and lexically-easy words presented in native and foreign (Korean) accents. The children with SSDs identified foreign accented words less accurately than their peers. Both groups of children exhibited increased difficulty in identifying lexically-hard words compared to lexically-easy ones, supporting the hypotheses of the LR. However, this finding was not significant after accounting for receptive vocabulary scores. Children with communication disorders like SSDs are likely to have less refined phonological representations than age-matched peers, making them likely to exhibit greater difficulty processing unfamiliar accented speech compared to peers (Brosseau-Lapré and Kim 2020; Nathan and Wells 2001).

To date there has been one experimental study investigating how children with developmental language disorder (referred to in the study as language impairment) perceive unfamiliar dialectal accented speech. Children with language disorders may have smaller vocabulary sizes relative to peers (e.g., McGregor et al. 2013). Within the context of the LR,

such lexical deficits should negatively affect the processing of unfamiliar accented speech. Frizelle et al. (2018) recruited 43 preschool-age children with language disorders and younger peers who were matched on a measure of sentence comprehension. All children completed sentence comprehension tasks presented in three accents: local Irish accent, neutral Irish accent, and a Northern Irish accent. The local accent and neutral accent were expected to be familiar to participants, while the Northern Irish accent was expected to be an unfamiliar dialect. Both groups performed similarly and were less accurate at recognizing words produced in the Northern Irish accent compared to the familiar accent conditions. Although children with DLD had language deficits relative to age-matched peers, when compared to younger children with comparable receptive language abilities, they understood the unfamiliar accent at a commensurate rate. The results of the study imply that receptive language skills are an important factor for predicting how children with and without language disorders understand unfamiliar accented speech (Frizelle et al. 2018). These findings align with prior work involving children with neurotypical language skills, which demonstrated that receptive vocabulary predicted unfamiliar accented speech perception.

While the studies reviewed in the present paper have focused on how unfamiliar accented speech affects perception accuracy, there are other important areas of inquiry to evaluate how children with communication disorders process variable speech. For example, an important area of concern relates to assessment of children for speech and language disorders. As noted above, McDonald et al. (2018) suggested that children can use sentence-level context to facilitate the accurate perception of unfamiliar accented speech. However, the structure of standardized assessments purposely removes semantic context that could support the processing of accented speech. From a practical perspective, investigations as to how monolingual and bilingual children with and without disorders process accented speech could affect clinical evaluation and intervention practices. For example, Gibson (2019) investigated how foreign accented administration of a vocabulary test affected bilingual children's scores. The vocabulary task included a carrier phrase and a target word, such as, "Show me the bus." Then, the child scanned a set of four pictures to select the stimulus that matched the targeted word. The results indicated that children performed significantly worse in the foreign accented condition, which was English-accented Spanish. Although this study was preliminary, it is important to note that vocabulary tests are quite structured and offer a closed set of options. The visual context was not enough to promote a commensurate selection of items in the unfamiliar accented condition compared to the familiar (native) accented condition. It is important to evaluate how the accent of administration might affect the validity of the results of other standardized instruments that are administered verbally in clinical practice.

Above we have summarized the existing literature on how monolingual children with communication disorders perceive unfamiliar accented speech. Future empirical work should investigate how bilingual children with and without language disorders perceive unfamiliar accented speech. Two paramount reasons being that it could improve identification accuracy and identify new ways to support variable speech perception. Accurate understanding of neurotypical bilingual development helps clinicians and researchers identify characteristics of neurodevelopmental disorders and create appropriate criteria for diagnosis and intervention (Kohnert 2010).

4. Discussion

This focused review summarized the literature on how bilingual and bidialectal children perceive and adapt to unfamiliar accented speech, but there are few conclusions to draw from the existing body of work. The literature provides limited evidence that lexical and phonological skills are associated with accurate variable speech perception for bilingual children (Levy et al. 2019; McDonald et al. 2018), like their monolingual peers (Bent and Atagi 2017; Levi et al. 2019; Mulak et al. 2013; van Heugten et al. 2015). Preliminary evidence also suggests that experience with within-language variability can facilitate the processing of unfamiliar dialectal accents, but that experience with foreign accented speech

may not generalize to aid in the perception of unfamiliar foreign accented speech for children (Levy et al. 2019). Further inquiry is necessary to determine what linguistic and experiential factors support the accurate perception of unfamiliar accented speech for linguistically diverse children. The next sections will review general recommendations for future empirical work, and present clinical implications derived from the focused review.

4.1. General Recommendations for Future Inquiry

In the present paper, we broadly discussed various hypotheses for how input variability associated with linguistic diversity could influence unfamiliar accented speech perception. However, our discussion is largely speculative given the dearth of research in this area. A primary goal for this paper is to spur research in this domain to determine the patterns of unfamiliar accented speech perception for linguistically diverse populations. In the following paragraphs, we outline what we view as essential next steps for investigating this question.

Above, we discussed that a central tenet of the LR is that vocabulary size drives phonological refinement. Such a hypothesis is supported by the monolingual literature, which documents a strong relationship between receptive vocabulary size and variable speech perception accuracy. However, vocabulary size in monolingual populations may be a proxy for more than just lexical knowledge, such as the quantity of input, or listening experience in a language. The evaluation of how linguistically diverse children recognize and adapt to talkers with variable characteristics would allow us to clarify the role of vocabulary in phonological refinement and speech perception, since it would allow for input quantity and quality to be separated from vocabulary size.

One such example that allows for the dissociation of vocabulary size and the quantity of input is the comparison of bilingual children who vary in language dominance. Language dominance refers to the relative language use, preference for use and language competency within one child (Birdsong 2014; Gathercole and Thomas 2009). Incorporating both dominance and vocabulary size into models of variable speech perception could help elucidate the respective roles of these variables in speech perception. Although untested in the literature examining how bilingual children perceive unfamiliar accented speech, language dominance has been found to account for significant variation in masked-speech recognition for bilingual adults (e.g., Shi 2014, 2015). Future studies could determine if such an association extends to explain individual differences in accurate unfamiliar accented speech perception for bilingual children.

Another way to dissociate input from vocabulary size is to investigate how qualitative differences between the input for different languages may impact unfamiliar accented speech perception. Bilingual and bidialectal children are exposed to more variable input compared to monolingual peers. Such listening experience could create more flexible phonological representations and increased phonetic plasticity relative to those with more homogenous input. If true, then input variability could account for individual differences in unfamiliar accented speech perception. Testing such hypotheses requires the evaluation of how bilingual and vocabulary-matched monolingual peers understand unfamiliar accented speech. Evaluating which factors are associated with the accurate understanding of unfamiliar accented speech for bilingual and monolingual children could help elucidate the role of input variability.

Another important consideration is that there is no standard for assessing input variability. The relative amount of input variability will depend upon factors like the number of interlocutors the child has in each dialect, language, or accent, as well as the cumulative exposure to each. These differences in the amount of input variability could also impact the child's perceptual development (e.g., Floccia et al. 2012 and see also Place and Hoff 2011).

4.2. Clinical Implications

Research suggesting that the administration of language assessments in unfamiliar accented speech to bilingual children invalidates the results of the test justifies the need for more work examining bilingual children's ability to perceive unfamiliar accented speech (Gibson 2019). For example, difficulty understanding unfamiliar accented speech during standardized testing could be partially attributable to intentionally vague sentence-level context which have been shown to highlight differences in language groups (e.g., McDonald et al. 2018). Correctly interpreting language test data is critically important for speech-language pathologists since making incorrect assumptions about bilingual cognitive and linguistic development could yield inaccurate diagnoses. Therefore, it is important for communication disorders research to describe the development of bilingual and bidialectal children to reflect and better serve this growing portion of the U.S. population.

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