Bilingualism: Language and Cognition

cambridge.org/bil

Variability and stability in early language acquisition: Comparing monolingual and bilingual infants' speech perception and word recognition

Review Article

Cite this article: Höhle B, Bijeljac-Babic R, Nazzi T (2020). Variability and stability in early language acquisition: Comparing monolingual and bilingual infants' speech perception and word recognition. *Bilingualism: Language and Cognition* **23**, 56–71. https://doi.org/10.1017/S1366728919000348

Received: 27 May 2019
Revised: 4 June 2019
Accepted: 5 June 2019
First published online: 4 July 2019

Keywords:
language acquisition; bilingual infants; bilingual phonological development; bilingual lexical development; simultaneous bilingualism

Address for correspondence: Barbara Höhle, E-mail: hoehle@uni-potsdam.de

Barbara Höhle[1], Ranka Bijeljac-Babic[2] and Thierry Nazzi[3]

[1]Universität Potsdam, Potsdam, Germany; [2]Université Paris Descartes – CNRS, Paris, France and Université Poitiers, Poitiers, France and [3]Université Paris Descartes – CNRS, Paris, France

Abstract

Many human infants grow up learning more than one language simultaneously but only recently has research started to study early language acquisition in this population more systematically. The paper gives an overview on findings on early language acquisition in bilingual infants during the first two years of life and compares these findings to current knowledge on early language acquisition in monolingual infants. Given the state of the research, the overview focuses on research on phonological and early lexical development in the first two years of life. We will show that the developmental trajectory of early language acquisition in these areas is very similar in mono- and bilingual infants suggesting that these early steps into language are guided by mechanisms that are rather robust against the differences in the conditions of language exposure that mono- and bilingual infants typically experience.

1. Introduction

For a long time, monolingual language acquisition has been in the focus of research and only recently has simultaneous bilingual early language acquisition attracted more scientific attention. In this paper we will focus on bilingual language acquisition in infants, and we will restrict our focus on acquisitions in the first two years of life. This age focus is justified by the fact that research on monolingual acquisition has established that this developmental period covers important, rapid acquisition in the phonological, lexical, syntactic and semantic domains (e.g., for recent reviews, Dye, Kedar & Lust, 2019; Werker, 2018). Research on monolinguals has also started to establish that these early acquisitions are related to later language outcomes (Höhle, Pauen, Hesse & Weissenborn, 2014; Junge, Kooijman, Hagoort & Cutler, 2012; Kooijman, Junge, Johnson, Hagoort & Cutler, 2013; Newman, Ratner, Jusczyk, Jusczyk & Dow, 2006; Singh, Reznick & Xuehua, 2012; Tsao, Liu & Kuhl, 2004; Von Holzen, Nishibayashi & Nazzi, 2018). Given this age constraint, we consider the target population as being simultaneous bilinguals without any need to discuss borders between simultaneous and successive bilingualism in children or between acquiring two L1s and acquiring one L1 and one L2. Following previous proposals, we start with the assumption that acquiring two languages during the first two years of life means acquiring two L1s simultaneously (for a recent discussion see Grosjean & Byers-Heinlein, 2018). Given that adult bilinguals are "not two monolinguals in one person" (Grosjean, 1989), our review will aim to shed light on the similarities and differences between mono- and bilingual infants on early language acquisition steps related to speech perception and their word learning and word recognition skills.

The picture we will be able to draw will remain very sketchy for several reasons. First, research on bilingual language acquisition in infants is still very fragmentary and quantitatively far behind research on monolingual early acquisition. Second, the available papers are highly variable concerning the languages involved and the linguistic domains that the reported research is targeting. Third, many factors that might affect bilingual acquisition have received little attention, as will be discussed in the conclusion. For example, language dominance/proficiency, which has been found to affect language processing in bilingual adults (e.g., Dupoux, Peperkamp & Sebastián-Gallés, 2010; Sebastián-Gallés, Echeverria & Bosch, 2005) has received little attention in infancy research, as it is hard to estimate in infants. As infants' proficiency in one or the other language cannot be assessed directly, the typical measure used is language dominance, defined as percentage of exposure to each language. This information is usually obtained via questionnaires about language use at home and at day nurseries filled out by the parents and thus can only constitute a more-or-less gross estimate of infants' linguistic environment. The past 20 years of research nevertheless provide us with an outline of early bilingual language acquisition, which allows us to start venturing some comparisons with monolingual acquisition.

This is important since comparing bilingual and monolingual infants' language acquisition is a source of information that can provide new insights in one of the oldest debates in language acquisition research: what are the contributions of inborn universal mechanisms and of experience-driven mechanisms to language acquisition? Assuming that monolingual and bilingual infants share the inborn universal mechanisms but that their language experience is rather different will allow for a better understanding of the relevance of these two types of forces that drive development and their interactions. The basic difference between the two types of language acquisition can be summarized as follows: bilingual learners have to establish two language systems at the same time – i.e., two systems of phonological, lexical, syntactic and semantic categories, two grammatical, semantic and pragmatic systems and two lexical inventories. There is now a large consensus that infants usually comply successfully with this complex learning task. However, compared to their monolingual peers, the task of bilingual infants is not only different concerning the establishment of mental representations but also concerning the experiential conditions that are relevant for language acquisition.

In terms of input, a first difference relates to the amount of exposure to each language. Given that the exposure is distributed across the languages, the exposure to each of the languages (or at least to one of the languages) may be considerably lower than in an infant growing up in a monolingual setting. A second major difference lays in the fact that input will include a higher degree of variability: for instance, if the parents communicate in a language that is non-native for one of them and is thus spoken with a foreign accent. Third, the bilinguals' languages differ in many aspects (for example, on the presence or not of lexical stress, see Bijeljac-Babic, Serres, Höhle & Nazzi, 2012). Hence, learning these different sets of properties from input in which the two languages coexist will be a challenge that will, among other things, require bilingual infants to be able to separate and process distinctly the input from their two languages. Indeed, monolingual infants are extremely efficient in learning distributional properties of their linguistic input: for instance, the frequency of occurrence of specific sound exemplars has been linked to the establishment of phonological categories (Kuhl, 1993; Maye, Werker & Gerken, 2002; Yoshida, Pons, Maye & Werker, 2010) and transitional probabilities across syllables support speech segmentation (Saffran, Aslin & Newport, 1996). Mixing up different languages as input for these input-driven learning mechanisms would probably make their results inefficient for acquiring more than one language simultaneously.

We will organize the chapter as follows: in a first section we will report on studies that compared the initial perceptual abilities that children bring to the task of language acquisition. A second section will report on studies on how speech perception in bilingual infants attunes to the sound systems of the ambient language (s). A third section will focus on word segmentation as a prerequisite to lexical development. The fourth section will summarize the research on early bilingual lexical development, focusing on its general trajectory as well as on the establishment of phonological and semantic representations. Finally, we will discuss the state of knowledge that the reviewed research provides, concerning various factors that need to be considered in trying to understand the commonalities and differences between mono- and multilingual early language acquisition.

2. Initial speech perception abilities

2.1. Language discrimination

One specific challenge for infants growing up with regular multilingual exposure consists in discriminating the languages. Being able to separate the languages from very early on seems crucial given that the child has to establish different linguistic systems for the languages.

Early research on monolingual infants has demonstrated that newborns are able to discriminate between different languages but only if the languages belong to different rhythmic classes; i.e., French newborns could discriminate English from Japanese, Spanish and Italian but not from Dutch (Nazzi, Bertoncini & Mehler, 1998; Ramus, Hauser, Miller, Morris & Mehler, 2000). This pattern reflects the typological distinction between stress-timed (e.g., English, German, Dutch), syllable-timed (e.g., French, Italian, Spanish) and mora-timed languages (e.g., Japanese, Korean). The acoustic bases of perceiving languages as being rhythmically distinct is not really clear but the relative proportion of vocalic and consonantal parts and their variability are considered to be relevant (Low, Grabe & Nolan, 2000; Ramus, Nespor & Mehler, 1999). At the age of 4 months, monolingual infants begin to discriminate between languages of the same rhythmical class from their native language (Bosch & Sebastián-Gallés, 1997, 2001; Chong, Vicenik & Sundara, 2018; Molnar, Gervain & Carreiras, 2013; Nazzi, Jusczyk & Johnson, 2000) suggesting that they have acquired some inventory of cues that help them separate their native language from other languages. At the same age, besides recognizing specific acoustic cues of their native language, monolingual infants can also discriminate a silent face producing the native language from a face producing another language (Weikum, Vouloumanos, Navarra, Soto-Faraco & Sebastián-Gallés, 2007).

Research on language discrimination in bilingual infants has focused on rhythmic classes as well. The only study on bilingual exposure's effects on newborns tested infants from bilingual English–Tagalog mothers who regularly used both languages during pregnancy (Byers-Heinlein, Burns & Werker, 2010). Tagalog shares properties with typical syllable-timed languages and is thus rhythmically different from English. In a first experiment, infants' preference for English versus Tagalog sentences was tested using the high-amplitude sucking procedure. While infants with monolingual English-speaking mothers showed higher sucking rates when presented with English compared to Tagalog sentences, no such preference was found for the infants with bilingual mothers. A second experiment tested discrimination with a habituation paradigm in which infants were first exposed to either English or Tagalog sentences until their sucking rates decreased below a predefined criterion and then tested with sentences from the other language. Both groups of infants showed an increase in their sucking after the language change, demonstrating that infants from mono- and bilingual mothers were able to discriminate between the languages, suggesting that the ability to discriminate between these rhythmically different languages was not compromised by the in-utero exposure to both languages that the infants with bilingual mothers had received.

At the age of 4 months, Spanish- or Catalan-learning monolinguals and bilingual infants learning simultaneously both Spanish and Catalan were tested with Spanish, Catalan, Italian (three rhythmically similar languages) and English (rhythmically different) stimuli (Bosch & Sebastián-Gallés, 1997). In this study, infants were presented with speech stimuli from one of two

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

loudspeakers mounted at the left and right side of a central monitor, and the authors measured how long it took the infants to initiate a look toward the loudspeaker. Both monolingual groups discriminated between the languages presented, as evidenced by orienting faster to the stimuli in their respective native language as compared to those in a non-native language, irrespective of whether the non-native language came from the rhythmically different class (English) or from the same rhythmic class (Spanish/Catalan). The bilingual infants – who were additionally tested with Italian – also discriminated, establishing that they can also discriminate a rhythmically similar language from their native language(s). However, they showed a reversed pattern, orienting faster to the non-native languages (English or Italian) compared to either Spanish or Catalan. This slower response of the 4-month-old bilinguals to their native language – in contrast to the pattern found for monolinguals – could indicate that this recognition is more demanding or requires other processes than in monolinguals, possibly because the bilingual system has to recognize which of their native languages is being presented.

As the experimental procedure used in the previous study was not suited to show that the bilingual infants could discriminate between their two languages, a further study used a different method, a version of the so-called headturn preference procedure (Bosch & Sebastián-Gallés, 2001). In this procedure, infants are presented with a visual stimulus (either on a monitor, or as a blinking lamp) in the same location as a loudspeaker playing the speech stimuli. The dependent measure is the duration for which infants look at the visual display while the speech sound is presented (listening time). In this study, monolingual Spanish or Catalan 4-month-olds were first presented with stimuli only from their native language for a fixed amount of time (familiarization) and then tested with Spanish and Catalan stimuli. The results revealed longer listening times to the respective non-native language over the native language, indicating successful discrimination. The same procedure was then applied to bilingual Spanish–Catalan 4-month-olds with familiarization to only one of their languages (the mother's language). Like their monolingual peers, the bilingual infants showed longer listening times to the non-familiarized language, indicating that they successfully discriminated between their two languages.

Bilingual infants' discrimination between their native languages and two other non-native languages was also investigated using EEG (Narca Garcia, Guerrero-Mosquera, Colomer & Sebastián-Gallés, 2018). Four-month-old monolingual Spanish or Catalan and bilingual Catalan–Spanish infants were presented with Catalan, Spanish, Italian and German sentences. For the monolingual groups, ERP analysis revealed a faster neural response (P200) to the native language compared to German but not compared to Italian. However, no differences in the ERP responses to the four languages were found for the bilingual group. In contrast, time-frequency-analysis revealed effects only for the bilingual group in the low-frequency theta-band oscillations of the EEG: enhanced activation was observed when the bilingual infants were exposed to their native languages compared to both German and Italian. These results establish that bilinguals discriminate their native language(s) from rhythmically dissimilar but also from rhythmically similar languages. However, in line with the behavioral results from Bosch and Sebastián-Gallés (1997), this study also shows differences in the electrophysiological responses between mono- and bilingual infants indicating that the processes underlying language discrimination may not be identical in bi- and monolinguals.

Discrimination of another language pair, Spanish and Basque (which is considered rhythmically less similar to Spanish than Catalan; Nespor, Shukla & Mehler, 2011), was compared in monolingual and bilingual Spanish/Basque 4-month-olds (Molnar et al., 2013). Using a visual fixation paradigm in which infants' looking behavior at a visual display during speech presentation is measured, the infants were first habituated with stimuli from one language, and then tested with stimuli from both languages. The monolingual Basque and the bilingual infants discriminated between the two languages independent of the language that was presented during habituation. However, the monolingual Spanish infants had an asymmetrical result pattern, only showing a discrimination response when habituated with Basque stimuli (which the authors interpret as resulting from Spanish infants' strong preference for the Spanish stimuli). Most importantly, these results provide further evidence that bilingual infants around 4 months do not show any disadvantages in discriminating their languages compared to infants for whom one of the languages is non-native.

Like monolingual infants, bilingual infants can also use face information to separate their language from other languages. Monolingual English infants observing a silent face speaking English responded with an increase in looking duration when a switch in language occurred (i.e., from English to French) at 6 months but not at 8 months, while bilingual English–French infants responded to the switch at both ages (Weikum et al., 2007). Even bilingual Spanish–Catalan 8-month-olds could detect the switch from a silent face speaking English to a silent face speaking French while monolingual Spanish or Catalan infants could not (Sebastián-Gallés, Albareda-Castellot, Weikum & Werker, 2012). These results suggest that the ability to use visual cues for language discrimination is extended in development in bilingual infants, which may be a consequence of their exposure to the constant challenge to keep their languages apart. This assumption is corroborated by findings showing that, as compared to monolinguals, bilingual infants look more to the mouth than to the eyes when looking at talking faces and that this advantage for looking at the mouth is more pronounced in bilingual 15-month-olds and 4-to-6-year-olds learning two rhythmically similar languages (Birulés, Bosch, Brieke, Pons & Lewkowicz, 2018; Pons, Bosch & Lewkowicz, 2015).

So far, the developmental trajectory of language discrimination looks very similar in mono- and bilingual infants. There is evidence that newborns from bilingual mothers can discriminate between their mothers' native languages when they are rhythmically different, which mirrors the capacities of monolinguals who also can discriminate between rhythmically similar languages at birth. Most importantly, this finding indicates that being exposed to two rhythmically different languages prenatally does not interfere with this ability. Second, the available research shows that bilinguals have achieved the ability to discriminate their native language from rhythmically similar languages at the same age as monolinguals. This suggests that by the age of 4 months bilingual infants have detected some properties that separate their two languages and that they can assign these properties specifically to one of their languages.

2.2. Sound perception / perceptual attunement

Infants are born with excellent acoustic skills allowing them to discriminate between all kinds of speech sound contrasts independently of whether these sounds occur in the ambient language(s) or not. During the first year of life, speech perception attunes to the phonetic properties of the language being learnt: while the ability to discriminate between sounds that are contrastive in that language is maintained or even enhanced, the ability to discriminate between many sounds that are not contrastive in the language being learnt decreases (for a recent overview see Werker, 2018). The phonetic/phonological systems of languages are not only different with respect to their sound inventory but also in their categorization of acoustic signals: sounds that are assigned to different phonological categories in one language may merge into one in another language. Further, the boundaries between two phonological categories may be placed at different values of a relevant phonetic dimension in different languages. Given the assumption that infants make use of frequency distributions of specific sound exemplars in their input for the formation of language-specific categories (Kuhl, 1993; Maye et al., 2002; Yoshida et al., 2010), the question of how this challenge is mastered by bilingual children arises. Does the simultaneous exposure to two phonological systems affect perceptual attunement in bilingual infants?

Consonants

By the end of the first year of life, monolingual infants' perception of consonantal contrasts has started attuning to those that are phonemically relevant in the respective native language. This process has been shown for a number of phonetic features like place of articulation (e.g., Werker & Tees, 1984), manner of articulation (e.g., Tsao, Liu & Kuhl, 2006) and voicing (e.g., Burns, Yoshida, Hill & Werker, 2007). Yet, consonantal discrimination does not change for all non-native contrasts – in particular, when these contrasts involve phonemes that fall outside the phonetic space of the native language (Best, McRoberts & Sithole, 1988).

The first study on consonant discrimination in bilingual infants tested English–French bilingual infants and English monolingual infants (Burns et al., 2007). English and French both use voicing as a contrastive cue, but the voice-onset-time (VOT) boundary between a voiced and an unvoiced labial is different for these two languages. In the study, three syllables varying in VOT were used: one with short VOT (perceived by adult listeners of both languages as voiced /ba/), one with medial VOT (perceived differently cross-linguistically, as /pa/ by adult French speakers and /ba/ by adult English speakers), and one with long VOT (perceived as aspirated /p^{h}a/ in both languages). Using a visual fixation paradigm, infants were habituated to the syllable with medial VOT value and then exposed to the other two syllables during a test phase. The results for the mono- and bilingual 6-to-8-month-olds were the same: dishabituation was only observed for the aspirated sound with long VOT. Monolingual English 10-to-12-month-olds and 14-to-20-month-olds showed the same pattern as the younger infants but their bilingual peers showed dishabituation for both contrasts. According to these findings, bilingual vs. monolingual exposure did not yet modulate the perception of the tested sounds at 6-to-8 months, corroborating other results that perceptual attunement for consonants occurs in the second half of the first year of life. Correspondingly, by the end of the first year, differences between the mono- and bilingual children emerged. The monolingual English infants mapped the sound with medial VOT to the voiced category. In contrast, the bilingual infants discriminated between three sounds on the voicing dimension: like the English monolingual infants, they discriminated the sound with medial versus long VOT and – as would be expected from French monolingual infants of that age – they also discriminated the sounds with medial versus short VOT.

A second study tested French and English monolingual and French–English bilingual infants' discrimination of two exemplars of a syllable with the initial coronal /d/ produced either by a Canadian English or a Canadian French speaker (Sundara, Polka & Molnar, 2008). English and French /d/s differ slightly in their place of articulation, with French showing a more dental production and English a more alveolar one. Research with adults had shown that English monolingual and English–French bilingual adults outperform monolingual French adults in their discrimination of these differences in place of articulation (Sundara & Polka, 2008). Six-to-8- and 10-to-12-month-olds were habituated with stimuli from either the French or the English speaker and then tested with stimuli from different speakers of both languages. Independent of their language background, the 6-to-8-month-olds discriminated between the French and English exemplars. For the older infants, language background effects were found: while the English monolinguals and the bilingual infants still discriminated between the sounds, no discrimination response was found for the French monolinguals. Again, these results show very similar developmental trajectories between monolingual and bilingual infants suggesting that the ability to discriminate one sound contrast from another is maintained if one of the languages supports it.

Another series of studies tested English monolingual and Spanish–English bilingual infants' neural underpinnings of discrimination of VOT differences that reflected native or non-native sound contrasts using ERP or MEG measures (Ferjan Ramirez, Ramirez, Clarke, Taulu & Kuhl, 2017; Garcia-Sierra, Rivera-Gaxiola, Percaccia, Conboy, Romo, Klarman, Ortiz & Kuhl, 2011; Rivera-Gaxiola, Silva-Pereyra & Kuhl, 2005). In these studies, three stimulus types from a voicing continuum for the /d/ - /t/ contrast were used: one was pre-voiced with a negative VOT which is characteristic of the Spanish voiced /d/, another one had a long positive VOT characteristic of the English voiceless /ta/ and another one had a short positive VOT which is categorized as voiceless /ta/ in Spanish and as voiced /da/ in English. The studies used a double-oddball paradigm in which the sound with the short positive VOT served as the standard and the neurophysiological mismatch response (MMR) to the change from the standard to the two types of deviants was measured. For the Spanish–English bilinguals, there was no MMR found for the English nor Spanish deviants at 6-to-9 months, while a negative MMR was found for both deviants at 10-to-12 months (Garcia-Sierra et al., 2011). Interestingly, the strength of the negative MMR was modulated by language exposure in this group: the infants with dominant English exposure showed a stronger negativity for the English contrast while the infants with dominant Spanish exposure showed a stronger negativity for the Spanish contrast. The results for the younger infants are surprising given the fact that 6-month-old bilinguals have been shown to discriminate between the speech contrasts of their native languages in other studies (Burns et al., 2007; Sundara et al., 2008). However, a homogeneous pattern of neurophysiological responses was not even found in monolingual English infants for this English–Spanish voicing contrast (Rivera-Gaxiola et al., 2005). The only study that directly compared monolingual English and bilingual Spanish–English 11-month-olds used MEG (Ferjan Ramirez et al., 2017). For the monolingual group, no difference between the MMR for the English and the Spanish contrast was observed in an earlier time window but

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

the English contrast elicited a larger MMR than the Spanish contrast in a later time window. The bilingual infants showed the opposite pattern with a stronger response for the English contrast in the earlier time window and a stronger response for the Spanish contrast in the later time window. Group comparisons revealed no differences between the two groups in their responses to the English contrast but stronger responses to the Spanish contrast in the bilingual compared to the monolingual group in both time windows. Effects of language exposure were not analyzed in this study.

Taken together, the current results on the neural underpinnings of sound discrimination are hard to interpret as they show similarities but also differences in the neural responses to speech in bilingual and monolingual infants. The authors of these studies suggest that the differences in the brain signatures found between bilingual and monolingual infants may point to an extended phase of acoustic discrimination (which they associate with the activation patterns in the early time window) with a later transition to language specific discrimination. However, two findings indicate effects of language background in 11-month-old bilingual infants (at an age where perceptual attunement in monolingual infants has set in). First, at the end of the first year of life, bilingual infants show similar neurophysiological responses to a sound contrast that they share with a monolingual group but stronger responses to a contrast that is specific to one of their languages (Ferjan Ramirez et al., 2017). Second, the strength of this response is modulated by their language exposure (Garcia-Sierra et al., 2011). Given these apparent inconsistencies, more studies – in particular, studies that fully compare the discrimination of native and non-native consonants in bilingual and monolingual infants of all corresponding languages – will be needed to determine if consonant discrimination and its neural underpinnings are characterized by the same developmental trajectory in bilingual and monolingual infants.

Vowels

The investigation of monolingual infants' discrimination of native and non-native vowels across the first year of life presents a less homogeneous picture on developmental changes with only some studies showing the typical attunement pattern of increasing discrimination for native vowels and decreasing discrimination for non-native vowels (for a recent overview see Tsuji & Cristia, 2014). However, in their meta-analysis, Tsuji and Cristia (2014) come to the conclusion that monolingual infants' ability to discriminate between native and non-native vowels develops into different directions in the second half of the first year of life.

In a first study investigating the development of vowel perception in bilinguals, Spanish and Catalan mono- and bilingual infants were compared on their discrimination of the vowels /ɛ/ vs. /e/ that represent two different phonological categories in Catalan but are not contrastive in Spanish (Bosch & Sebastián-Gallés, 2003). Using the headturn preference procedure, infants were familiarized with one of the vowels and then tested with both vowels. At 4 months of age, all three groups discriminated the contrast. At 8 months, only the monolingual Catalan infants showed a discrimination response. However, at 12 months, the bilingual infants again discriminated between the vowels. This suggests that vowel perception at 4 months was still not affected by language exposure and that at 8 months the monolingual groups had attuned to the vowel systems of their languages. With their U-shaped trajectory, the bilinguals appeared to attune to the Catalan system only by 12 months. Questioning this conclusion, another study tested Catalan–Spanish 8-month-olds with the same materials but another experimental method – an anticipatory eye movement task (Albareda-Castellot, Pons & Sebastián-Gallés, 2011). Catalan monolinguals and Catalan–Spanish bilinguals showed an increase of their correct anticipatory looks on a specific area of the monitor according to the vowel presented, while Spanish monolingual infants did not improve their performance over the experiment. Contrary to the findings of Bosch and Sebastián-Gallés (2003), these new results do not suggest a delay in perceptual attunement in bilinguals. The findings that bilinguals' performance is affected by the use of the specific experimental paradigm may indicate that their ability to discriminate between the sounds tested is still more fragile than for monolinguals, and therefore more strongly affected by specific task demands.

The discrimination of the same vowel contrast – which is also phonemic in English – was tested with monolingual English and bilingual Spanish–English learning 4- and 8-month-olds (Sundara & Scutellaro, 2011). Infants were habituated to one of the vowels and then tested with both vowels in a visual fixation paradigm. The bilingual and the monolingual infants at both ages discriminated between the two vowels. In line with the findings by Albareda-Castellot et al. (2011), these results indicate that bilingual infants maintain their ability to discriminate a vowel contrast even if it is contrastive in only one of their languages.

Phonotactics

Languages differ not only on the repertoire of their consonants and vowels, but also on the combinations of sounds that are either legal or frequent at the lexical level. Studies on monolingual infants have established that they become sensitive to the legality (Friederici & Wessels, 1993; Jusczyk, Friederici, Wessels, Svenkerud & Jusczyk, 1993; Sebastián-Gallés & Bosch, 2002) or frequency (Jusczyk, Luce & Charles-Luce, 1994) of sequences of adjacent sounds between 7 and 10 months of age, and that this developmental pattern also extends to sequences of non-adjacent sounds (Gonzalez-Gomez & Nazzi, 2012; Nazzi, Bertoncini & Bijeljac-Babic, 2009).

Only one study explored phonotactic acquisition in bilingual infants (Sebastián-Gallés & Bosch, 2002), testing sensitivity to phonotactic constraints in Catalan (legality of final consonant cluster of CVCC words) in four groups of 9-month-old infants: Catalan- and Spanish-learning monolinguals, Catalan-dominant and Spanish-dominant Catalan–Spanish bilinguals. Results confirmed that Catalan- but not Spanish-learning monolinguals are sensitive to this Catalan phonotactic property. Catalan-dominant bilinguals performed at the same level as the Catalan-learning monolinguals, establishing their sensitivity to this phonotactic property. In contrast, performance of the Spanish-dominant bilinguals fell between that of Catalan monolinguals and Catalan-dominant bilinguals on the one hand, and that of Spanish monolinguals on the other hand. This suggests that acquisition of phonotactic properties follows a relatively similar developmental time course in bilinguals as compared to monolinguals, although it appears modulated by language balance, and thus probably by the amount of experience with a given structure (for converging evidence of input structure on phonotactic acquisition in monolinguals, see Gonzalez-Gomez, Hayashi, Tsuji, Mazuka & Nazzi, 2014).

Lexical stress

Perceptual attunement does not only affect infants' sensitivity to segmental contrasts but also to suprasegmental prosodic

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

properties. One area, where this has been shown, is the perception of lexical stress that is modulated by the prosodic system of the native language. First indications for this came from findings showing that Spanish adults outperform French adults in their sensitivity for stress information – in particular, at the phonological level when tested with segmentally variable words (Dupoux, Pallier, Sebastián-Gallés & Mehler, 1997; Dupoux, Peperkamp & Sebastián-Gallés, 2001). In accordance with the general developmental trajectory of perceptual attunement, French monolingual infants' sensitivity to lexical stress information has been shown to decrease during the second half of the first year of life (Bijeljac-Babic et al., 2012; Höhle, Bijeljac-Babic, Herold, Weissenborn & Nazzi, 2009; Skoruppa, Pons, Christophe, Bosch, Dupoux, Sebastián-Gallés, Alves Limissuri & Peperkamp, 2009).

Perceptual reorganization of lexical stress was explored in French mono- and bilingual 10-month-olds learning French together with a language that uses lexical stress contrastively (Bijeljac-Babic et al., 2012). The bilingual infants were split into two groups: a balanced one with similar exposure to both languages and another-language dominant one with higher exposure to the language that was not French. Using the headturn preference paradigm, infants were initially familiarized with a simple CVCV bisyllable that was either stressed on the first syllable (trochaic pattern) or on the second syllable (iambic pattern). During testing, both stress patterns were presented. The monolingual 10-month-olds only showed a discrimination response after a long (2-minute) familiarization, but not after a short (1-minute) familiarization. In contrast, the bilingual 10-month-olds showed a discrimination response already after the short familiarization (like the French 6-month-old monolinguals tested in Höhle et al., 2009) but their response was modulated by language exposure, being stronger for the infants with more exposure to the language with lexical stress. Again, these results suggest that sensitivity to a sound property is maintained in bilinguals even when it is contrastive in only one of their languages.

This result was later extended from discrimination at a phonetic level to discrimination at a phonological level, by presenting 10-month-old infants with lists of 16 segmentally different trochaic versus iambic words (Abboub, Bijeljac-Babic, Serres & Nazzi, 2015). Discrimination was found in bilinguals learning French and a language with contrastive stress, but not in French-learning monolinguals. However, contrary to Bijeljac-Babic et al. (2012), no evidence could be found in that study for a modulation of discrimination performance by language balance.

In a further study, Bijeljac-Babic and colleagues (Bijeljac-Babic, Höhle & Nazzi, 2016) tested German–French bilingual 6-month-olds' spontaneous listening preference to trochaic bisyllabic sequences over iambic sequence (trochaic bias) based on a previous study that had revealed this trochaic bias in monolingual German but not in monolingual French 6-month-olds (Höhle et al., 2009). Like their monolingual German and unlike their French monolingual peers, the bilingual infants showed the trochaic bias which was not modulated by the amount of exposure to German. Thus, given bilingual German–French exposure, the bilingual infants show the same developmental trajectory as monolingual German infants. The trochaic bias is probably not an inborn perceptual preference as it was not yet found in German 4-month-olds (Höhle et al., 2009) suggesting that it develops based on exposure to the prosodic properties of the ambient language(s). The finding that it is present independent of language dominance in the bilingual infants indicates that its development is rather robust against variation in the amount of input.

Lexical Tones

Another set of studies compared the development of lexical tone discrimination in mono- and bilingual infants. Previous studies on tone perception in monolingual infants learning a non-tone language depict a rather complex picture, with some studies showing the typical developmental trajectory of decreasing sensitivity to tone contrasts across the first year of life (Götz, Yeung, Krasotkina, Schwarzer & Höhle, 2018; Liu & Kager, 2014; Mattock & Burnham, 2006; Mattock, Molnar, Polka & Burnham, 2008; Yeung, Chen & Werker, 2013), but others finding no change (Ramachers, Brouwer & Fikkert, 2017), increased sensitivity (Chen & Kager, 2016; Chen, Stevens & Kager, 2017; Singh & Fu, 2018), or u-shaped developmental patterns (Götz et al., 2018; Liu & Kager, 2014). So far it is not clear what causes this diverse pattern of experimental findings. However, factors like the acoustic salience of the differences in the tested tones, their relation to the intonational system of the native language and methodological details of the used experimental paradigm seem to contribute (for an overview see Götz et al., 2018).

The developmental trajectory of non-native lexical tone perception was explored in 4-to-18-month-old Dutch-learning monolinguals, and bilingual infants learning Dutch and another non-tone language (Liu & Kager, 2014, 2017). Both the monolingual Dutch-learning infants and the bilingual infants showed a u-shaped developmental pattern for their discrimination of a Mandarin tone contrast (high level vs. high-falling). The major difference between the two groups was that the bilingual infants' only failed to discriminate between the tones at 8-to-9 months and regained discrimination already at age 11–12 months, while the monolingual infants showed a prolonged phase of non-discrimination until the age of 17-to-18 months. The authors suggest that the bilingual infants' earlier rebound in discrimination may be based on either increased general cognitive abilities or enhanced perceptual sensitivities that the bilingual infants may have compared to their monolingual peers.

The development of tone perception in 6- and 9-month-old bilingual infants learning one tone (Mandarin) and one non-tone language (English) was compared to the performance of monolingual English or Mandarin learning infants in another study (Singh, Fu, Seet, Tong, Wang & Best, 2018). The selected tones instantiated an acoustically more salient contrast (high level vs. dipping) and an acoustically more subtle contrast (raising vs. dipping). Infants were first habituated to one tone and then tested with both the habituated tone and one of the non-habituated tones. The result patterns differed for the three groups: at 6 months, none of the groups discriminated the subtle contrast and only the Mandarin monolinguals discriminated the salient contrast. At 9 months, the English monolinguals only discriminated the salient contrast and the Mandarin monolinguals discriminated both the subtle and the salient contrast. At 12 months, the English monolinguals also discriminated both contrasts. In contrast, the bilingual Mandarin–English learning infants did not provide clear evidence of discriminating any of the contrasts at any of the tested ages. These results suggest differences in the development of mono- and bilingual infants in their tone perception but they are hard to interpret, given the heterogeneous picture present even for the development of tone discrimination in monolingual infants.

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

Summary

Overall, the studies on changes in speech perception across the first year of life reveal similar patterns of perceptual attunement in monolingual and bilingual infants. First, the timing of these developmental changes is very similar, suggesting that exposure to multiple language systems does not delay the earliest steps into the acquisition of the phonological system of the ambient language(s). Second, bilingual infants seem to be able to construct different phonological systems in parallel. This is suggested by the fact that their categorization and discrimination of sounds seem to attune to the requirements of both languages simultaneously. However, it remains an open question whether this performance is based on two separate phonological systems for the two languages, or whether this is achieved by a single phonological system that represents phonological properties from both languages. What is also remarkable is that several studies suggest that the larger variation assumed to characterize the input in bilingual infants neither affects the maintenance of the sensitivity to a sound property that is only used in one language, nor does it necessarily delay the acquisition of specific experience-based phonological knowledge. Overall, the findings support a rather robust system of early phonological development, the outcomes of which are rather similar across mono- and bilingual infants. However, there are some indications – especially from studies using neurocognitive measures – that speech processing and their neural underpinnings may not be identical in mono- and bilingual infants.

3. Word form segmentation

Word form segmentation corresponds to the ability to find words, or more precisely word forms, in fluent speech. Since words are usually uttered in sentences rather than in isolation, it is believed to be a crucial requirement for lexical acquisition. Therefore, many studies, starting from the seminal work of Jusczyk and Aslin (1995), have explored the emergence of this ability in monolingual infants learning different native languages, using either behavioral or electrophysiological methods. They have established that this ability emerges around 4-to-8 months of age in infants learning English (Jusczyk & Aslin, 1995; Saffran et al., 1996), Parisian French (Berdasco-Muñoz, Nishibayashi, Baud, Biran & Nazzi, 2018; Nishibayashi, Goyet & Nazzi, 2015), Canadian French (Polka & Sundara, 2012; Shi, Marquis & Gauthier, 2006), Dutch (Houston, Jusczyk, Kuijpers, Coolen & Cutler, 2000; Kooijman, Hagoort & Cutler, 2005) and German (Höhle & Weissenborn, 2003). They have also established that the emergence of this ability, or its strength in infancy, is related to later lexical acquisition, with infants showing the more mature abilities around 7 to 10 months acquiring larger vocabularies (Junge et al., 2012; Kooijman et al., 2013; Newman et al., 2006; Singh et al., 2012; Von Holzen et al., 2018).

Importantly, these studies have also found that infants explore a range of cues that partially mark word boundaries or the internal cohesion of syllables within words, and that most of these cues are language-specific. In particular, these cues include transitional probabilities (TPs, referring to distributional regularities in the order of syllables in the speech signal: Mersad & Nazzi, 2012; Saffran et al., 1996) and the rhythmic unit of the native language (Goyet, Nishibayashi & Nazzi, 2013; Jusczyk, Houston & Newsome, 1999; Nazzi, Iakimova, Bertoncini, Frédonie & Alcantara, 2006; Nishibayashi et al., 2015). Given that the specific instantiations of these cues differ across languages, or even dialects of the same language, these studies have revealed crosslinguistic differences in the developmental trajectory of segmentation abilities, with some differences in timing and in the relative weight given to cues in different languages (and at different ages). This should have important implications for bilingual infants since, depending on the two languages they are acquiring, they will have to learn two distinct sets of cues, and use them appropriately in each of their languages. Another factor that might affect segmentation abilities in bilingual infants is related to the fact that they receive less input than monolinguals in each of their languages, given that early segmentation abilities in monolingual infants appear related to quantity and quality of input (Hoareau, Yeung & Nazzi, 2019; though see Mandel, Rowe & Ratner, 2016, for failure at finding such a link) and babbling abilities (Hoareau et al., 2019).

Only a few studies have started exploring segmentation abilities in bilingual infants. The first of these studies explored how monolingual Catalan-learning, monolingual Spanish-learning, and bilingual Spanish–Catalan 6- and 8-month-olds segment monosyllabic words in their native (for monolinguals) or dominant (for bilinguals) language (Bosch, Figueras, Teixidó & Ramon-Casas, 2013). To do so, they used a classical design in segmentation studies in which infants are familiarized with two passages, each containing a repeated target word, and then tested on recognition of these two target words compared to two other control words. At both ages, all three groups of infants showed evidence of segmentation, and there were no differences between the bilingual group and the two monolingual groups of infants.

These first findings establish early, on-time segmentation abilities in these bilingual infants, who were learning two closely-related languages sharing the same rhythmic properties (rhythm having been found to modulate segmentation abilities across languages), and were tested on the simplest possible type of words, monosyllabic words. Segmentation abilities for monosyllabic words were also found at 7-to-8 months in both English monolinguals and English–Mandarin bilinguals, with some emerging evidence that the target words could be recognized across a change in voice/gender, suggesting robust recognition abilities (Singh, 2018). They were also found at 6 months for French-dominant bilinguals acquiring French and a mixed range of other languages, with rhythms either similar or different from French, whether they were born fullterm or preterm (Berdasco-Muñoz, Nishibayashi & Nazzi, 2018). This suggests that monosyllabic words are segmented through robust but probably basic mechanisms.

Another follow-up study explored how monolingual French-learning, monolingual English-learning, and bilingual French–English 8-month-olds segment more complex, bisyllabic words, in both French and English, two rhythmically different languages (Polka, Orena, Sundara & Worrall, 2017). When tested with both languages in the same experimental session (dual language task), monolingual infants succeeded at segmenting words only in their native language, independently of order of presentation of the languages. In contrast, using the same task, bilingual infants tested in French first segmented French but not English, while those tested in English first showed no evidence of segmenting either language. Yet, bilingual infants could succeed at segmenting the same English bisyllabic words when they were presented with only English: that is, in a situation in which they only have to process one language. Taken together, the findings reveal that French–English bilingual infants can segment bisyllabic words in their two languages, extending previous segmentation evidence to this more complex type of words. Yet, bilinguals and monolinguals did not perform in exactly the same way in the dual task, suggesting some (slight?) differences in early segmentation abilities between monolinguals and bilinguals. Whether such differences relate to this specific language pair (French–English), to cases of languages with different types of rhythm, and whether they are specific to bisyllabic/polysyllabic words or would also be found for monosyllabic words remains to be explored in future research. Note also that in the dual task, some of the infants were French-dominant and others were English-dominant. An analysis of the results taking language dominance into account failed to reveal a modulation of performance by dominance, meaning that these bilinguals succeeded at segmenting French words whether they were French- or English-dominant, and that they failed at segmenting English words whether they were French- or English-dominant.

Lastly, one study compared how 14-month-old monolingual and bilingual infants use TPs to segment words, in a context in which infants, in an exposure period, had to learn TP regularities from two interleaved artificial languages, an exposure condition mimicking bilingual input (Antovich & Graf Estes, 2018). When tested on their learning of these regularities in one of the languages, failure was found in monolinguals and success in bilinguals. This establishes that not only can bilinguals use a specific cue, TPs, to segment words (as found in monolinguals at early as 8 months of age; Saffran et al., 1996), but also that the bilingual input these infants receive outside the laboratory allows them to track such information in two separate languages in parallel when monolinguals cannot.

In summary, evidence so far suggests that some segmentation abilities appear early in development in bilingual infants, probably at the same age, or about the same age, as in monolingual infants. Yet, subtle differences between performance of monolingual and bilingual infants have been found, calling for more studies to be conducted on this issue, in order to determine how emergence of segmentation abilities is modulated by different factors such as the type of cues/words considered, the languages in acquisition, or language dominance, to cite a few.

4. Lexical acquisition

In the previous sections, we have reviewed evidence suggesting that, during the first year of life, bilingual infants have started acquiring the phonological and phonotactic properties of their native language, and have started segmenting word forms from fluent speech, a crucial step towards lexical acquisition. These studies show that although some differences are found between the bilingual and monolingual developmental trajectories, the bilingual developmental trajectories might better be understood as another expression of early crosslinguistic variability found in the acquisition of different languages, reflecting the special input properties of the bilingual environment, rather than a case of difficult or delayed acquisition per se. In the present section, we review what we know of early bilingual acquisition in the lexical domain. We will first discuss general findings on the speed and trajectory of lexical development, then explore how bilingual infants process phonetic/phonological information at the lexical level, and review emerging evidence regarding the development of their semantic knowledge at the word level.

4.1. Trajectory of lexical acquisition

Lexical acquisition starts in the second half of the first year of life, with some evidence for knowledge of a limited number of words as early as 6 months (Tincoff & Jusczyk, 1999, 2012; Bergelson & Swingley, 2012). Word learning then increases, often with a sharp acceleration, in the second year of life (Fenson, Dale, Reznick, Bates, Thal & Pethick, 1994). This early development is characterized by extensive individual variability in the sizes of both receptive and productive vocabularies. Sources of variability are being investigated, and they include individual differences in processing abilities, such as phoneme discrimination (Tsao et al., 2004), sensitivity to phonetic mispronunciation (Von Holzen et al., 2018) or word form segmentation (Junge et al., 2012; Kooijman et al., 2013; Newman et al., 2006; Singh et al., 2012; Von Holzen et al., 2018). Importantly, lexical acquisition in monolinguals also depends on the quantity and quality (e.g., Hurtado, Marchman & Fernald, 2008; Weisleder & Fernald, 2013; Newman, Rowe & Ratner, 2016) of language input in infancy.

Since bilingual infants' input is distributed over their two languages, they are likely to receive less input in each of their languages than monolinguals (when controlling for overall input), which should have an impact on early lexical development. Moreover, since bilingual infants will vary in terms of the relative amount of input they receive in their two languages, the two lexicons might not develop at the same speed. Recent studies support these points. When bilinguals are evaluated on each of their languages separately, many studies report that they lag behind monolinguals starting in the second year of life (for a discussion, see Core, Hoff, Rumiche & Señor, 2013). The picture is less clear at younger ages, given the complex findings of the only study on this issue, which compared English-learning monolinguals, Welsh-learning monolinguals and English–Welsh bilinguals on familiar word form recognition (Vihman, Thierry, Lum, Keren-Portnoy & Martin, 2007). When tested behaviorally, the bilingual and the English monolingual 11-months-olds recognized the English word forms. The bilingual infants, though not the Welsh monolinguals, also showed a tendency to recognize Welsh word forms. A similar picture was found with ERPs: the results indicated that monolingual English-learning infants recognize the English words, that bilingual infants recognize the English and Welsh words, while monolingual Welsh-learning infants failed to show recognition effects. These findings do not suggest a disadvantage of bilingual infants as compared to English monolingual infants, but even an advantage as compared to the Welsh monolingual group. Apparently, the recognition of Welsh words was facilitated by the additional learning of English – an unexpected finding which will have to be investigated in further research.

One crucial aspect when comparing mono- and bilingual infants' trajectories of lexical acquisition is the way of counting vocabulary. One is conceptual vocabulary, counting every referent for which a learner has a word for in either language (a French–German child would get a 1 for knowing either *chien*, *hund*, or both); another one is total vocabulary, counting every word known across both languages (the same child would get 2 for knowing both *chien* and *hund*). Studies using these vocabulary measures obtained diverse results. For example, no significant differences were found between bilinguals' total vocabularies, bilinguals' conceptual vocabularies, and monolingual vocabularies in a study comparing the productions of Spanish–English and English-learning children ranging in age between 14 and 30 months (Pearson, Fernández & Oller, 1993). In contrast, a study comparing English–German and English-learning 24-to-27-month-olds found that the bilinguals' total vocabularies were significantly larger than both their conceptual vocabularies

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

and the English vocabularies of English-learning children, which did not differ (Junker & Stockman, 2002). Yet a third pattern emerged, suggesting that total vocabularies might be the more appropriate measure of lexical development in bilingual infants. This was found in a larger-scale study of English–Spanish bilinguals and English-speaking monolinguals tested at 3 ages, which revealed that bilinguals' total vocabularies matched monolinguals' vocabularies, while bilinguals' conceptual vocabularies matched monolinguals' vocabularies at 22 and 25 months but lagged behind at 30 months due to slower rates of increase of conceptual compared to total vocabularies (Core et al., 2013). Although it is unclear why these differences in pattern were found, the studies converge in showing that, when bilinguals' vocabulary levels are evaluated using measures (total or conceptual vocabularies) that take into account both of their languages, they fall within the same range as monolingual infants.

Evidence also suggests that vocabulary growth is modulated by language dominance, with higher vocabulary scores in the dominant as compared to the non-dominant language and with scores that often do not correlate between the two languages. These effects have been found early in lexical acquisition, by 14 and 30 months at the latest (e.g., Pearson, Fernandez, Lewedeg & Oller, 1997, and Hoff, Core, Place, Rumiche, Señor & Parra, 2012, for data on Spanish–English bilinguals).

Lastly, a recent study on 372 2-year-old bilinguals, growing up in the UK and learning British English and one of 13 other languages (with either one or both parents having the other language as their native language), explored a range of factors that might impact vocabulary acquisition, including predictors related to infants' demographics, linguistic background and linguistic distance between their two languages (Floccia, Sambrook, Delle Luche, Kwok, Goslin, White, Cattani, Sullivan, Abbot-Smith, Krott, Mills, Rowland, Gervain & Plunkett, 2018). Independently of language use in the family, word comprehension and production were predicted both by the relative amount of exposure to each language in speech directed at the infant and by the proportion of English in overheard parental speech, with more English leading to larger English vocabularies. Importantly, linguistic distance between the infants' two languages also impacted lexical acquisition in the language other than English. This was found for comprehension vocabularies when distance was measured in terms of word order typology or degree of morphological complexity, and for production vocabularies when distance was measured in terms of lexical/phonological overlap. In all cases, infants learning closer languages had larger comprehension vocabularies in their other-than-English languages; no effect of these measures were found on English vocabularies.

Besides charting the trajectory of lexical acquisition, some studies have explored lexical processing, investigating the speed at which bilingual infants recognize words in each of their native languages, given evidence that speed of processing is related to vocabulary size in monolinguals (Fernald, Perfors & Marchman, 2006; Hurtado, Marchman & Fernald, 2007). In a first study on English–Spanish 30-month-olds, speed of lexical processing was found not to be correlated across the infants' two languages, but it was modulated within each language: by language dominance, vocabulary size in the same language, and to a lesser extent by total and conceptual vocabulary sizes (Marchman, Fernald & Hurtado, 2010). Similar effects were also found in 16- and 22-month-old English–Spanish bilinguals (DeAnda, Hendrickson, Zesiger, Poulin-Dubois & Friend, 2018). This establishes that word recognition speed and vocabulary acquisition are linked in bilinguals, as had been found in monolinguals, but that this link is language specific. Moreover, 24-month-old Mandarin–English bilinguals and Mandarin-learning monolinguals recognized words in Mandarin equally well, although the bilinguals were slower at shifting to the target objects (Wewalaarachchi, Wong & Singh, 2017). Lastly, Conboy and Mills (2006) found that ERPs to known versus unknown words differed in bilingual 19-to-22-month-olds, and that this ERP effect occurred earlier and with a different scalp distribution for the dominant language, suggesting that the two languages might be processed at different speeds and through partly different neural networks. These studies show some effects of bilingualism on the recognition of known words – in particular, in speed of processing – which are likely to signal the specific task of acquiring two lexicons in parallel rather than attesting a general delay in acquisition.

Learning more than one language also affects infants' use of mutual exclusivity: the bias of attaching a novel label to a novel rather than a familiar object that already has a label. This bias had been demonstrated by 16-to-18 months in monolingual infants (Halberda, 2003). Using a similar task, two studies replicated the effect in monolinguals; yet, neither bilinguals nor trilinguals showed reliable use of mutual exclusivity in learning new nouns (Byers-Heinlein & Werker, 2009; Houston-Price, Caloghiris & Raviglione, 2010), though a marginal effect for bilinguals was found in Byers-Heinlein and Werker (2009). To further explore the effects in bilinguals, Byers-Heinlein and Werker (2013) tested a new group of English–Chinese bilinguals. They again failed to show an overall mutual exclusivity effect in bilinguals. However, bilinguals' performance was modulated by the percentage of translation equivalents they knew, as significant mutual exclusivity effects could be found in the bilinguals who had fewer translation equivalents. This effect (not found in Houston-Price et al., 2010) suggests a link between characteristics of lexical acquisition (whether it corresponds to the acquisition of one-to-one mappings between concepts and word forms in monolinguals, or of one-to-many mappings in bilinguals) and the use of mutual exclusivity. Lastly, to determine whether the impact of bilingualism on how infants link labels and objects can be found earlier in development (i.e., before they have acquired a sizeable lexicon), Byers-Heinlein (2017) used a different task based on Dewar and Xu (2007). This task tests whether 9-month-old infants hearing one label versus two different labels will expect to see one object versus two different objects. This effect was found only in monolinguals, suggesting that already by 9 months of age, bilinguals do not share monolinguals' expectations that distinct labels refer to distinct object kinds.

4.2. Phonological processing at the lexical level

Besides evaluating general vocabulary growth and word recognition abilities, several studies have explored the format of lexical representations in both monolingual and bilingual acquisition. This issue has been investigated in monolinguals in various experimental designs, from word form recognition and segmentation in the first year of life, to the impact of mispronunciations on word recognition and the use of phonetic information while learning new words in the second year of life. These studies establish that some (probably not fully-adult-like) phonological detail is already present in early word representations, as revealed by tasks looking at effects of mispronunciations on the auditory recognition of familiar word forms (by 5 months for vowels: Bouchon, Floccia, Fux, Adda-Decker & Nazzi, 2015; by 11

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

months for consonants in stressed positions and lexical stress pattern: Hallé & de Boysson-Bardies, 1996; Poltrock & Nazzi, 2015; Swingley, 2005; Vihman, Nakai, DePaolis & Hallé, 2004), and on comprehension of familiar words (at least by 18 months: e.g., Mani & Plunkett, 2007; Swingley & Aslin, 2000).

Less is known on familiar word processing in bilingual infants. One study on this issue found that Spanish–Catalan infants have difficulties in detecting mispronunciations of familiar words for the Catalan /e/-/ɛ/ contrast by 18-to-24 months (Ramon-Casas, Swingley, Sebastián-Gallés & Bosch, 2009), showing intermediate performance between Catalan-learning monolingual infants who succeeded at the task, and Spanish-learning monolinguals who failed. Performance was also better in Catalan- than Spanish-dominant bilinguals. This weak reaction to the /e/-/ɛ/ contrast, also found in bilingual adults (e.g., Pallier, Colomé & Sebastián-Gallés, 2001), is interpreted as potentially resulting from bilinguals hearing accented pronunciations of the Catalan vowels by native Spanish speakers, or from the use of cognates as stimuli, cognates that differ on the /e/-/ɛ/ contrast across the two languages. A second study on this issue showed that, around 24 months of age, Mandarin–English bilingual learners have reduced sensitivity to tone mispronunciations relative to Mandarin monolingual toddlers. Moreover, the relative cost of the different types of mispronunciation differed across populations, with bilingual toddlers demonstrating least sensitivity to tones, followed by consonants and then by vowels while monolinguals demonstrated least sensitivity to consonants followed by vowels and tones (Wewalaarachchi et al., 2017).

Other studies have explored the use of phonetic information while learning new words. The first study on this issue explored whether similarity in the realization of a phonological contrast across languages affects the acquisition of new words (Fennell, Byers-Heinlein & Werker, 2007), using a task known as the switch task in which infants are habituated with two new object-label pairings, and then tested on whether they have learned the associations. In this study, infants were simultaneously taught two minimally different words (e.g., /bih/ –/dih/). While confirming that English-learning monolinguals succeed by 17 months (Werker, Fennell, Corcoran & Stager, 2002), English–French or English–Chinese bilinguals failed in this task before 20 months. Importantly, there was no significant difference in performance between the two groups of bilingual infants, although the phonetic realization of the phonological contrast was aligned in English and Chinese but misaligned in English and French (place of articulation for /b/ is the same for all 3 languages; place of articulation for /d/ is identical for English and Mandarin, but slightly different for French).

The above findings suggest that similarities or differences in the phonological properties of the two languages of the bilingual infants do not play a role in their ability to process the detail of word forms. However, this possibility was not confirmed by Havy, Bouchon and Nazzi (2016), who used an object manipulation task to test 16-month-old bilingual infants on their capacity to learn pairs of new French-like pseudowords, differing by one phonetic feature (either voicing, e.g. /p/-/b/, or place, e.g., /p/-/t/) in their initial consonant. Two groups of infants were considered: bilinguals exposed to languages (French and either Spanish, Italian or European Portuguese) in which the phonemes tested are realized relatively similarly ("similar contrast" group) and bilinguals exposed to languages (French and either English or German) in which the phonemes are realized more differently ("different contrast" group) in terms of VOT values. The "similar contrast" bilinguals successfully processed the relevant phonetic detail of the word forms, while the "different contrast" bilinguals failed, a pattern of results supporting the impact of phonological differences between the two languages on word learning, thus establishing that linguistic similarity or difference in the two languages of a bilingual may influence their acquisition. Future research will have to clarify why similarity in acoustic realization of contrasts led to success in Havy et al. (2016) but not in Fennell et al. (2007).

Moreover, using the switch task with slight methodological changes, several follow-ups to Fennell et al. (2007) could establish the acquisition of pairs of phonetically similar new words by English–French 17-month-olds (/kem/-/gem/, Fennell & Byers-Heinlein, 2014; /bos/-/gos/, Mattock, Polka, Rvachew & Krehm, 2010), by English–Mandarin 18-month-olds (/mIn/-/mən/, Singh, Fu, Tay & Golinkoff, 2018a), and by Spanish–Catalan 22-month-olds (/bepi/-/bɛpi/, Ramon-Casas, Fennell & Bosch, 2017). Several factors could explain success in these follow-ups. The first one relates to the magnitude of the contrast tested (a 1- versus 2-feature place contrast in Fennell et al., 2007, versus Mattock et al., 2010). The second factor is linked to the feature manipulated (consonant place in Fennell et al., 2007; consonant voicing in Fennell & Byers-Heinlein, 2014; vowel contrast in Ramon-Casas et al., 2017 and Singh et al., 2018a). Note that the vowel contrast in Ramon-Casas et al. (2017) is the same contrast Catalan–Spanish bilingual 18-to-24-month-olds appeared to fail to process in familiar word form recognition, which suggests that the use of a contrast can be modulated by task demands. Third, it also appeared that success in Mattock et al. (2010) and Fennell and Byers-Heinlein (2014) might have been supported by their use of bilingual word instantiations (words pronounced by a bilingual speaker) matching infants' language-learning environment, compared to the use of monolingual instantiations (words pronounced by a monolingual speaker) in Fennell et al. (2007). Consistent with this, Fennell and Byers-Heinlein (2014) found that bilinguals better process phonetic information from bilingual input and monolinguals better process phonetic information from monolingual input.

Two studies looked at how tonal information is used when learning new words. Using the switch paradigm, Singh, Poh, and Fu (2016) tested monolingual Mandarin and bilingual Mandarin–English learners on their ability to integrate lexical tones when learning new words embedded in Mandarin carrier sentences. Their study revealed that bilingual 12-to-13-month-olds were able to integrate both salient and subtle tone contrasts into newly learned words; by contrast, Mandarin monolingual infants did not integrate either type of tone contrast into newly learned words until 18 months. In a similar paradigm, Dutch-learning monolinguals and Dutch-other non-tone language bilinguals were able to use and integrate tone information in learning pairs of words at 14-to-15 months, but failed three months later, at 17-to-18 months (Liu & Kager, 2018). This suggests that the ability to use tonal information deteriorates in the second year of life in infants learning one or two languages that do not use tones at the lexical level. This ability is however probably not entirely lost, as suggested by studies showing that adults of non-tone languages can use tonal information when learning new words (e.g., Poltrock, Chen, Kwok, Cheung & Nazzi, 2018).

In summary, these findings suggest that bilingual infants process detailed phonetic information while recognizing and learning words, as had been found in monolinguals. Their performance was found to vary as a function of the contrasts tested, and the

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

way they are pronounced (with better outcomes if pronounced by a bilingual speaker). Some differences were found between bilinguals and monolinguals (differential sensitivities to acoustic information), which are likely to result from the task for bilinguals of learning two phonological systems and two lexicons in parallel.

What is interesting is that larger differences between bilingual and monolingual infants seem to be present when it comes to the processing of phonological information at the lexical level, either in word learning or in word recognition. Here, some studies seem to suggest a delay in bilingual infants. These results can be taken as additional support for the assumption that there is no strict continuity between the detection of language specific phonological categories during the first year of life and the use of this knowledge in lexical processing. These results also support the view that lexical development itself contributes to the fine-tuning of the phonological system (as proposed by PRIMIR by Werker & Curtin, 2005, for monolinguals, and Curtin, Byers-Heinlein & Werker, 2011, for bilinguals) which then – given the slower growth of the vocabularies in each of the languages in bilingual infants – may in turn hinder the use of phonetic details in word learning.

5. Conclusions

The review presented here allowed us to start understanding the impact of bilingualism on early language acquisition, and we have outlined similarities and differences in the bilingual versus monolingual developmental trajectory. One important finding from this comparative research is that early bilingual acquisition does not constitute a major challenge, resulting in severe delays or processing and learning difficulties. Rather, bilingual infants have an early developmental trajectory that appears rather similar to the one found for monolingual infants (when confounding factors such as SES are roughly controlled for), in terms of the ages at which various early abilities are found. This suggests that the abilities that infants are born with (the "language acquisition device") allow them to learn the core properties of two languages in parallel, without major disruptions compared to situations in which they are only learning one language, and at about the same pace.

That being said, results also revealed differences between monolingual and bilingual acquisition, so that learning two languages appears not to be equivalent to learning each separately. At some level, this can be seen as another case of crosslinguistic variation in acquisition: learning French results in a trajectory that is not exactly the same as learning German, and learning both together would be another case of variation highlighting the role of linguistic input. Yet, there are crucial differences in the case of bilingualism compared to monolingualism. One is that bilingual infants have to cope with a dual language environment, resulting in less exposure to each language overall, and with various interactions between the two languages due to, for example, code switching or accented speech by non-native speakers. Effects of this can be seen in smaller vocabularies in each individual language, or a different use of fine phonetic details when learning new words. A second crucial difference is that bilingual infants have to learn two sets of properties (two native language systems), that will partly overlap and partly differ, at every level of the linguistic system. Bilingual infants often have to cope with differences in phonological inventories, lexical prosody or cues to word form segmentation between their two languages, which modify the acquisition compared to learning only one set of cues. As a consequence of these differences, bilingual infants have to be able to immediately identify the language to which the speech they hear belongs, in order to process the input in the right way, be it to learn properties in that language or later to process them during language comprehension. Hence, bilingual infants (often) face a task that is different from monolinguals. However, as we have seen, the development of the basic phonological properties does not seem to be dramatically affected by this supposed larger input complexity to which bilingual infants are exposed. Apparently, infants are equipped with rather robust learning mechanisms (allowing for the creation of stable linguistic representations) that are able to cope with diverse input conditions. But in some respects these more complex conditions seem to create specific challenges to speech and language processing, which can sometimes be seen using behavioral tasks, but more often when using tasks targeting the neural underpinnings of language processing.

The research that we presented in this review has mainly focused on phonological aspects of bilingual language acquisition and lexical development. This focus does not result from the specific research interests of the authors of this paper but reflects the state of the research: studies on early developmental trajectory in other linguistic areas like (lexical) semantics, morphology and syntax is almost absent for bilingual language acquisition. To the best of our knowledge there are only three exceptions here. One study tested semantic priming effects in 18-month-old French monolinguals and French/mixed other language bilinguals and found an increased ERP response to unrelated in comparison to related words in both populations, compatible with the notion that semantic acquisition is not delayed in bilingual as compared to monolingual infants. However, the results further suggested that, at that age, semantic activation in the bilinguals was less automatized or slower than in monolinguals (Rämä, Sirri & Goyet, 2018). Another study tested the sensitivity of 7-month-old bilingual infants learning one language with Verb-Object order (English) and another language with Object-Verb word order (such as e.g., Japanese and Turkish), to the link between prosodic information and word order (Gervain & Werker, 2013). The bilingual infants' preference for different word orders (instantiated as sequences of alternating frequent and infrequent elements, starting either with a frequent or infrequent one) was modulated by the prosodic properties of the sequences while this was not the case for English or French monolingual infants (Gervain & Werker, 2013; Bernard & Gervain, 2012). These findings suggest that also, in the acquisition of syntax, bilingual infants seem to be predisposed to make rather selective use of the specific cues that each of their languages provide. Lastly, one study compared the simultaneous learning of two structural rules by monolingual and bilingual 12-month-old infants (Kovács & Mehler, 2009). One rule consisted in the repetition of the first two syllables of trisyllabic sequences (AAB), while the second rule consisted of the repetition of the first and last syllables of trisyllabic sequences (ABA). Bilingual infants could learn both rules while monolingual infants only learned the AAB rule. This study suggests that bilingualism might confer upon infants more flexibility at learning multiple rules. Given the crosslinguistic variation that characterizes these linguistic domains, bilingual infants again may face considerable challenges and future research should definitely extend its focus on these areas as well.

In this effort to characterize bilingual acquisition, many important issues remain to be further explored and more strictly considered in future research. In the following, we discuss a few of these. One issue that may be related to the not always homogeneous outcome between different studies is the question about who is considered a bilingual infant. As mentioned before, bilingualism in infancy is determined via an estimation of infants' exposure to different languages, in most cases obtained through parents' questionnaires. In addition to the fact that this source of information can only be a rough approximation of infants' exposure to the languages, there is some disagreement across different researchers where the boundary between mono- and bilingual development should be set. In some studies, 20% of exposure to another language is considered as the upper limit for being treated as a monolingual infant (Garcia et al., 2018), other studies take 20% exposure to another language as the lower limit of being considered a bilingual infant (Liu & Kager, 2017). Future research in infant bilingualism should use a common criterion and more comparable assessments of exposure.

A second issue that will deserve closer scrutiny also has to do with the relative amount of input in the two languages, and how it impacts the acquisition of both languages. There are many difficulties in evaluating this factor. One is that studies rely on parental questionnaires to do so, even though we know that parents encounter difficulties accurately reporting a complex environment. Efforts to provide nevertheless reliable data range from using adaptations of the same questionnaire across research groups, setting up and validating new questionnaires with precise guidelines on how to use them to evaluate language balance in the input (MAPLE, Byers-Heinlein, Schott, Gonzalez-Barrero, Brouillard, Dubé, Laoun-Rubsenstein, Morin-Lessard, Mastroberardino, Jardak, Pour Iliaei, Salama-Siroishka & Tamayo, accepted), language mixing in the input (Language Mixing Scale questionnaire, Byers-Heinlein, 2013), or vocabulary acquisition (UKBTAT tool, Floccia et al., 2018), and to use automated home recordings (e.g., the LENA system) to obtain input-based estimates (Orena, Byers-Heinlein & Polka, accepted). However, there are additional difficulties in evaluating the input of bilingual infants. For example, should direct and indirect/overheard speech be analyzed together or separately? How should accented speech be considered? Moreover, the linguistic environment of a bilingual is often changing, with variations within days or weeks, but also during vacations (when parents visit their various families), or in the longer term when the composition of the environment changes (caregivers going back to work, grand-parents or nanny starting to take care of infant, schooling). Making use of linguistic balance as an experimental variable is thus highly complex, as decisions have to be made on the weight given to current versus past exposure. All these issues lead to approximate measures of linguistic balance, in terms of relative percentage of each language, which then impact whether an infant is considered a balanced bilingual, a bilingual dominant in one of her languages, or more like a monolingual infant receiving some (anecdotal?) input in another language.

In spite of all these difficulties in estimating language balance/dominance, this factor has been found to play a role for consonant (Garcia-Sierra et al., 2011) and lexical stress discrimination (Bijeljac-Babic et al., 2012; though not Abboub et al., 2015), phonotactic acquisition (Sebastián-Gallés & Bosch, 2002), word learning (Hoff et al., 2012; Conboy & Mills, 2006) and semantic processing (Sirri & Rämä, 2015). But there are other areas where impact of balance/dominance have not been found, such as the development of the trochaic bias (Bijeljac-Babic et al., 2016) and word segmentation (Polka et al., 2017). Given that reliable measurements of language balance/dominance can be established (using daily audio-recordings, Orena et al., accepted), future closer investigations of their impact on early language acquisition might provide important insights into the contribution of language experience (more affected by balance/dominance) and inborn biases or processing preferences (less affected by balance/dominance) to early language acquisition, although the issue of developmental changes in language environment would be difficult to take into account.

Another issue that will need to receive closer scrutiny pertains to the status of the languages of the bilingual infant, both within and outside the home. At home, is it the case that each language is spoken by a different parent; in which case, what is the language in which parents communicate? Or do they both speak both; in which case, how proficient are they in each? Do they have a foreign accent or not? And how often do they mix both languages, given a recent study showing that language mixing negatively affects the size of comprehension vocabularies at 18 months (and marginally so for the size of production vocabularies at 24 months, Byers-Heinlein, 2013)? Or is it the case that one language is the native language of both parents, and the sole language spoken at home, while the second language is the language of the outside world? How many speakers speak each language in the infant's presence? If the home language is different from the language of the outside, what is the status of that language in the global community? Is it a valued language (as English is in many contemporary societies, where monolingual parents would sometimes/often try to teach it to their infants), or is it a language (such as regional dialects, or the native language of immigrant parents) that is not valued by the larger community that will encourage parents not to transmit it to their infants, no matter whether it is spoken by small or large communities abroad (such as Arabic or Mandarin Chinese in France, Turkish in Germany).

One further issue pertains to the linguistic distance between the two languages in acquisition. At an intuitive level, it might seem that learning German and Dutch might be easier than learning German and French, or even German and Japanese. But is that the case when both languages are acquired in early infancy? Havy et al. (2016) (though not found in Fennell et al., 2007) showed that, at 16 months, processing of consonant contrasts is easier when the phonemes are realized acoustically in the same way in the two languages of the infant (e.g., for French–Italian, compared to French–English), which suggests an effect of phonetic distance at this linguistic level. Birulés et al. (2018) found that language distance based on rhythmic properties influences proportion of eye/mouth looking at both 15 months and 4-to-6 years of age. Would this advantage extend to other linguistic levels? Not necessarily, because linguistic distance needs to be defined at different levels (comparing phonological inventories, analyzing lexical overlap, considering morphological complexity or syntactic rules such as word order), and proximity/distance on these various levels are not necessarily related, and might have distinct effects on acquisition (see the earlier discussion of Floccia et al., 2018). Moreover, it could be that in some cases, linguistic proximity could be problematic as, for example, infants fail to discriminate between languages with similar rhythms in the first months of life. While acquiring such a language pair might facilitate the early acquisition of shared prosodic properties, what effects does this have on the acquisition of other linguistic levels?

Future research should also explore effects of age of onset on early language acquisition. Our review considered research on

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

the first two years of life based on the (sometimes) implicit assumption that all infants tested in the reported studies were exposed to more than one language from birth on. So far, there is no systematic research on the question as to how the developmental processes that we have described in this review proceed in successive bilingual acquisition, i.e., when exposure to a second language starts after exposure to the first language. For example, would an infant that is regularly exposed to another language only from the beginning of the second year of life on (when the major steps of perceptual attunement have been completed in monolingual infants) still show the same – but only delayed – developmental trajectory than infants with simultaneous bilingual development, establishing the same processing mechanisms and linguistic representations, and achieving the same competence? Stated another way, is there continuity or not between simultaneous and sequential bilingualism, when talking about early development? Research in this area would allow further insights into the timing of sensitive periods for language acquisition.

The impact of all of these factors on acquisition will have to be carefully studied in the future to better understand how bilingual language acquisition is modulated and specifies the best conditions for a bilingual infant to learn his or her two languages. One must also not forget the fact that in many societies (think of India, with 22 major languages in India, written in 13 different scripts, with over 720 dialects, or Nigeria, where up to 520 languages are spoken), bilingualism might just be the name of multilingualism in which some individuals will have (more or less extended) knowledge of more than two languages. As far as we know, no study has looked at early language acquisition in infants growing up in such multilinguistic environments.

Author ORCIDs. Barbara Höhle, 0000-0002-9240-6117

Acknowledgements. Work on this paper was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project number 317633480 - SFB 1287, Project C03 (BH), by the EU Horizon 2020 research and innovation program (H2020-MSCA-ITN-2014, N°641858; BH and TN), by ANR-15-CE28-0011to TN, and by Labex EFL (ANR-10-LABX-0083) grant to RBB and TN.

References

Abboub N, Bijeljac-Babic R, Serres J and Nazzi T (2015). On the importance of being bilingual: Word stress processing in a context of segmental variability. *Journal of Experimental Child Psychology*, **132**, 111–120. doi:10.1016/j.jecp.2014.12.004

Albareda-Castellot B, Pons F and Sebastián-Gallés N (2011). The acquisition of phonetic categories in bilingual infants: new data from an anticipatory eye movement paradigm. *Developmental Science*, **14**, 395–401. doi:10.1111/j.1467-7687-2010.00989.x

Antovich D and Graf Estes K (2018). Learning across languages: bilingual experience supports dual language statistical word segmentation. *Developmental Science*, **21**, e12548. doi:10.1111/desc.12548

Berdasco-Muñoz, Nishibayashi L-L, Baud O, Biran V and Nazzi T (2018). Early segmentation abilities in preterm infants. *Infancy*, **23**, 268–287. doi:10.1111/infa.12217

Berdasco-Muñoz E, Nishibayashi LL and Nazzi T (2018). Early word segmentation abilities in full-term and preterm bilingual infants. Paper presented at the *International Workshop on Bilingualism and Cognition*, Goa, India, 1–3 November.

Bergelson E and Swingley D (2012). At 6–9 months, human infants know the meanings of many common nouns. *Proceedings of the National Academy of Sciences, USA*, **109**, 3253–3258. doi:10.1073/pnas.1113380109

Bernard C and Gervain J (2012). Prosodic bootstrapping of word order: what level of representation? *Frontiers in Psychology*, **3**, 451. doi:10.3389/fpsyg.2012.00451

Best CT, McRoberts GW and Sithole NM (1988). Examination of perceptual reorganization for non-native speech contrasts: Zulu click discrimination by English-speaking adults and infants. *Journal of Experimental Psychology: Human Perception and Performance*, **14**, 345–360. doi:10.1037.0096-1523.14.3.345

Bijeljac-Babic R, Höhle B and Nazzi T (2016). Early prosodic acquisition in bilingual infants: The case of the perceptual trochaic bias. *Frontiers in Psychology*, **7**, 210. doi:10.3389/fpsyg.2016.00210

Bijeljac-Babic R, Serres J, Höhle B and Nazzi T (2012). Effect of bililngualism on lexical stress pattern discrimination in French-learning infants. *PLoS ONE*, **7**(2), e30843. doi:10.1371/journal.pone.0030843

Birulés J, Bosch L, Brieke R, Pons F and Lewkowicz DJ (2018). Inside bilingualism: Language background modulates selective attention to a talker's mouth. *Developmental Science*. doi:10.1111/desc.12755

Bouchon C, Floccia C, Fux T, Adda-Decker M and Nazzi T (2015). Call me Alix, not Elix: Vowels are more important than consonants in own-name recognition at 5 months. *Developmental Science*, **18**, 587–598. doi:10.1111/desc.12242

Bosch L, Figueras F, Teixidó M and Ramon-Casas M (2013). Rapid gains in segmenting fluent speech when words match the rhythmic unit: evidence from infants acquiring syllable-timed languages. *Frontiers in Psychology*, **4**, 106. doi:10.3389/fpsyg.2013.00106

Bosch L and Sebastián-Gallés N (1997). Native-language recognition abilities in 4-month-old-infants from monolingual and bilingual environments. *Cognition*, **65**, 33–69. doi:10.1016/S0010-0277(97)00040-1

Bosch L and Sebastián-Gallés N (2001). Evidence of early language discrimination abilities in infants from bilingual environments. *Infancy*, **2**, 29–49. doi:10.1207/S15327078IN0201_3

Bosch L and Sebastián-Gallés N (2003). Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. *Language and Speech*, **46**, 217–243. doi:10.1177/00238309030460020801

Burns TC, Yoshida KA, Hill K and Werker JF (2007). The development of phonetic representation in bilingual and monolingual infants. *Applied Psycholinguistics*, **28**, 455–474. doi:10.1017.S0142716407070257

Byers-Heinlein K (2013). Parental language mixing: Its measurement and the relation of mixed input to young bilingual children's vocabulary size. *Bilingualism: Language and Cognition*, **16**, 32–48. doi:10.1017/S1366728912000120

Byers-Heinlein K (2017). Bilingualism affects 9-month-old infants' expectations about how words refer to kinds. *Developmental Science*, **20**, e12486. doi:10.1111/desc.12486

Byers-Heinlein K, Burns TC and Werker JF (2010). The roots of bilingualism in newborns. *Psychological Science*, **21**, 343–348. doi:10.1177/0956797609360758

Byers-Heinlein K, Schott E, Gonzalez-Barrero AM, Brouillard M, Dubé D, Laoun-Rubsenstein A, Morin-Lessard E, Mastroberardino M, Jardak A, Pour Iliaei S, Salama-Siroishka N and Tamayo MP (accepted). MAPLE: A Multilingual Approach to Parent Language Estimates. *Bilingualism: Language and Cognition*.

Byers-Heinlein K and Werker JF (2009). Monolingual, bilingual, trilingual: infants' language experience influences the development of a word-learning heuristic. *Developmental Science*, **12**, 815–823. doi:10.1111/j.1467-7687.2009.00902.x

Byers-Heinlein K and Werker JF (2013). Lexicon structure and the disambiguation of novel words: Evidence from bilingual infants. *Cognition*, **128**, 407–416. doi.org/10.1016/j.cognition.2013.05.010

Chen A and Kager R (2016). Discrimination of lexical tones in the first year of life. *Infant and* Child Development, **25**, 426–439. doi:10.1002/icd.1944

Chen A, Stevens CJ and Kager R (2017). Pitch perception in the first year of life, a comparison of lexical tones and musical pitch. *Frontiers in Psychology*, **8**, 279. doi:10.3389/fpsyg.2017.00297

Chong AJ, Vicenik C and Sundara M (2018). Intonation plays a role in language discrimination by infants. *Infancy*, **23**, 795–819. doi:10.1111/infa.12257

Conboy BT and Mills DL (2006). Two languages, one developing brain: Event-related potentials to words in bilingual toddlers. *Developmental Science*, **9**, F1–F12. doi:10.1111/j.1467-7687.2005.00453.x

https://doi.org/10.1017/S1366728919000348 Published online by Cambridge University Press

Core C, Hoff E, Rumiche R and Señor M (2013). Total and Conceptual vocabulary in Spanish–English bilinguals from 22 to 30 months: Implications for assessment. Journal of Speech, Language, and Hearing Research, **56**, 1637–1649. doi:10.1044/1092-4388(2013/11-0044)

Curtin S, Byers-Heinlein K and Werker JF (2011). Bilingual beginnings as a lens for theory development: PRIMIR in focus. *Journal of Phonetics*, **39**, 492–504. doi:10.1016/j.wocn.2010.12.002

DeAnda S, Hendrickson K, Zesiger P, Poulain-Dubois D and French M (2018). Lexical access in the second year: a study of monolingual and bilingual vocabulary development. *Bilingualism: Language and Cognition*, **21**, 314–327. doi:10.1017/S1366728917000220

Dewar K and Xu F (2007). Do 9-month-old infants expect distinct words to refer to kinds? *Developmental Psychology*, **34**, 1227–1238. doi:10.1037/0012-1649.43.5.1227

Dupoux E, Pallier C, Sebastián-Gallés N and Mehler J (1997). A destressing 'deafness' in French? *Journal of Memory and Language*, **36**, 406–421. doi:10.1006/jmla.1996.2500

Dupoux E, Peperkamp S and Sebastián-Gallés N (2001). A robust method to study stress 'deafness'. *The Journal of the Acoustical Society of America*, **110**, 1606–1618. doi:10.1121/1.1380437

Dupoux E, Peperkamp S and Sebastián-Gallés N (2010) Limits on bilingualism revisited: Stress 'deafness' in simultaneous French-Spanish bilinguals. *Cognition*, **114**, 266–275. doi:10.1016/j.cognition.2009.10.001

Dye C, Kedar Y and Lust B (2019) From lexical to functional categories: New foundations for the study of language development. *First Language*, **39**, 9–32. doi:10.1177/0142723718809175

Fennell CT and Byers-Heinlein K (2014). You sound like Mommy: Bilingual and monolingual infants learn words best from speakers typical of their language environments. *International Journal of Behavioral Development*, **38**, 309–316. doi:10.1177/0165025414530631

Fennell CT, Byers-Heinlein K and Werker JF (2007). Using speech sounds to guide word learning: The case of bilingual infants. *Child Development*, **78**, 1510–1525. doi:10.1111/j.1467-8624.2007. 01080.x

Fenson L, Dale PS, Reznick JS, Bates E, Thal DJ and Pethick SJ (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, **59**(5, Serial No. 242).

Ferjan Ramirez N, Ramirez RR, Clarke M, Taulu S and Kuhl PK (2017). Speech discrimination in 11-month-old bilingual and monolingual infants: a magnetoencephalography study. *Developmental Science*, **20**, e12427. doi:10.1111./dessc.12427

Fernald A, Perfors A and Marchman VA (2006). Picking up speed in understanding: Speech processing efficiency and vocabulary growth across the second year. *Developmental Psychology*, **42**, 98–116. doi:10.1037/0012-1649.42.1.98

Floccia C, Sambrook TD, Delle Luche C, Kwok R, Goslin J, White L, Cattani A, Sullivan E, Abbot-Smith K, Krott A, Mills D, Rowland C, Gervain J and Plunkett K (2018). Vocabulary of 2-year-olds learning English and an additional language: Norms and effects of linguistic distance. Monographs of the Society for Research in Child Development, *83, 328*. doi: 10.1111/mono.12348

Friederici AD and Wessels JMI (1993). Phonotactic knowledge and its use in infant speech perception. *Perception and Psychophysics*, **54**, 287–95. doi:10.3758/BF03205263

Garcia-Sierra A, Rivera-Gaxiola M, Percaccia CR, Conboy BT, Romo H, Klarman L, Ortiz S and Kuhl PK (2011). Bilingual language learning: An ERP study relating early brain responses to speech, language input, and later word production. *Journal of Phonetics*, **39**, 546–557. doi:10.1016/j.wocn.2011.07.002

Gervain J and Werker JF (2013). Prosody cues word order in 7-month-old bilingual infants. *Nature Communications*, **4**, 1490. doi:10.1038/ncomms2430

Gonzalez-Gomez N, Hayashi A, Tsuji S, Mazuka R and Nazzi T (2014). The role of the input on the development of the LC bias: a crosslinguistic comparison. *Cognition*, **132**, 301–311. doi:10.1016/j.cognition.2014.04.004

Gonzalez-Gomez N and Nazzi T (2012). Acquisition of nonadjacent phonological dependencies in the native language during the first year of life. *Infancy*, **17**, 498–524. doi:10.1111/j.1532-7078.2011.00104.x

Götz A, Yeung H, Krasotkina A, Schwarzer G and Höhle B (2018). Perceptual reorganization of lexical tones: Effects of age and experimental procedure. *Frontiers in Psychology*, **9**, 477. doi:10.3389/fpsyg.2018.00477

Goyet L, Nishibayashi L-L and Nazzi T (2013). Early syllabic segmentation of fluent speech by infants acquiring French. *PlosOne*, **8**(11), e79646. doi:10.1371/journal.pone.0079646

Grosjean F (1989). Neurolinguist beware! The bilingual is not two monolinguals in one person. *Brain and Language*, **36**, 3–15. doi:10.1016/0093-934X(89)90048-5

Grosjean F and Byers-Heinlein K (2018). Bilingual children and adults: A short introduction. In F Grosjean and K Byers-Heinlein (eds.) *The Listening Bilingual: Speech Perception, Comprehension and Bilingualism*. Hoboken, NJ: Wiley.

Halberda J (2003). The development of a word-learning strategy. *Cognition*, **87**, B23–B34. doi:10.1016/S0010-0277(02)00186-5

Hallé PA and de Boysson-Bardies B (1996). The format of representation of recognized words in infants' early receptive lexicon. *Infant Behavior and Development*, **19**, 463–481. doi:10.1016/S0163-6383(96)90007-7

Havy M, Bouchon C and Nazzi T (2016). Phonetic processing when learning words: The case of bilingual infants. *International Journal of Behavioral Development*, **40**, 41–52. doi:10.1177/0165025415570646

Hoareau M, Yeung H and Nazzi T (2019). Infants' statistical word segmentation in an artificial language is linked to both parental speech input and reported production abilities. *Developmental Science*, e12803. doi:10.1111/desc.12803

Hoff E, Core C, Place S, Rumiche R, Señor M and Parra M (2012). Dual language exposure and early bilingual development. *Child Language*, **39**, 1–27. doi:10.1017/S0305000910000759

Höhle B, Bijeljac-Babic R, Herold B, Weissenborn J and Nazzi T (2009). Language specific prosodic preferences during the first half year of life: Evidence from German and French infants. *Infant Behavior and Development*, **32**, 262–274. doi:10.1016/j.infbeh.2009.03.004

Höhle B, Pauen S, Hesse V and Weissenborn J (2014) Discrimination of rhythmic patterns at 4 months and language performance at 5 years: A longitudinal analysis of data from German-learning children. *Language Learning*, **64**, 141–164. doi:10.1111/lang.12075

Höhle B and Weissenborn J (2003). German-learning infants' ability to detect unstressed closed-class elements in continuous speech. *Developmental Science*, **6**, 122–127. doi:10.1111/1467-7687.00261

Houston DM, Jusczyk PW, Kuijpers C, Coolen R and Cutler A (2000). Cross-language word segmen- tation by 9-month-olds. *Psychological Bulletin & Review*, **7**, 504–509. doi:10.3758/BF03214363

Houston-Price C, Caloghiris Z and Raviglione E (2010). Language experience shapes the development of the mutual exclusivity bias. *Infancy*, **15**, 125–150. doi:10.1111/j.1532-7078.2009.00009.x

Hurtado N, Marchman VA and Fernald A (2007). Spoken word recognition by Latino children learning Spanish as their first language. *Journal of Child Language*, **33**, 227–249. doi:10.1017/S0305000906007896

Hurtado N, Marchman VA and Fernald A (2008). Does input influence uptake? Links between maternal talk, processing speed and vocabulary size in Spanish-learning children. *Developmental Science*, **11**, F31–39. doi:10.1111/j.1467-7687.2008.00768.x

Junge C, Kooijman V, Hagoort P and Cutler A (2012). Rapid recognition at 10 months as a predictor of language development. *Developmental Science*, **15**, 463–473. doi:10.1111/j.1467-7687.2012.1144.x

Junker DA and Stockman IJ (2002). Expressive vocabulary of German–English bilingual toddlers. *American Journal of Speech-Language Pathology*, **11**, 381–394. doi:10.1044/1058-0360 (2002/042)

Jusczyk PW and Aslin RN (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive Psychology*, **29**, 1–23. doi:10.1006/cogp.1995.1010

Jusczyk PW, Friederici A, Wessels J, Svenkerud V and Jusczyk AM (1993). Infants' sensibility to the sound patterns of native language words. *Journal of Memory and Language*, **32**, 402–420. doi:10.1006/jmla.1993.1022

Jusczyk PW, Houston DM and Newsome M (1999). The beginnings of word segmentation in English-learning infants. *Cognitive Psychology*, **39**, 159–207. doi:10.1006/cogp.1999.0716

Jusczyk PW, Luce PA and Charles-Luce J (1994). Infants' sensibility to phonotactic patterns in the native language. *Journal of Memory and Language*, **33**, 630–45. doi:10.1006/jmla.1994.1030

Kooijman V, Junge C, Johnson EK, Hagoort P and Cutler A (2013). Predictive brain signals of linguistic development. *Frontiers in Psychology*, **4**, 25. doi:10.3389/fpsyg.2013.00025

Kooijman V, Hagoort P and Cutler A (2005). Electrophysiological evidence for prelinguistic infants' word recognition in continuous speech. *Cognitive Brain Research*, **24**, 109–116. doi:10.1016/j.cogbrainres.2004.12.009

Kovács AM and Mehler J (2009) Flexible learning of multiple speech structures in bilingual infants. *Science*, **325**, 611–612. doi:10.1126/science.1173947

Kuhl P (1993). Innate predispositions and the effects of experience in speech perception: The native language magnet theory. In de Boysson-Bardies B, de Schonen S, Jusczyk P, McNeilage P and Morton J (Eds.), *Developmental Neurocognition: Speech and Face Processing in the First Year of Life*. Dordrecht: Springer.

Liu L and Kager R (2014). Perception of tones by infants learning a non-tone language. *Cognition*, **133**, 385–394. doi:10.1016/j.cognition. 2014.06.004

Liu L and Kager R (2017). Perception of tones by bilingual infants learning non-tone languages. *Bilingualism: Language and Cognition*, **20**, 561–575. doi:10.1017/S1366728916000183

Liu L and Kager R (2018). Monolingual and bilingual infants' ability to use non-native tone for word learning deteriorates by the second year after birth. *Frontiers in Psychology*, **9**, 117. doi:10.3389/fpsyg.2018.00117

Low EL, Grabe E and Nolan F (2000). Quantitative characterization of speech rhythm: syllable timing in Singapore English. *Language and Speech*, **43**, 377–401. doi:10.1177/00238309000430040301

Mani N and Plunkett K (2007). Phonological specificity of vowels and consonants in early lexical representations. *Journal of Memory and Language*, **57**, 252–272. doi:10.1016/j.jml.2007.03.005

Marchman VA, Fernald A and Hurtado N (2010). How vocabulary size in two languages relates to efficiency in spoken word recognition by young Spanish-English bilinguals. *Journal of Child Language*, **37**, 817–840. doi:10.1017/S0305000909990055

Mattock K and Burnham D (2006). Chinese and English infants' tone perception: Evidence for perceptual reorganization. *Infancy*, **10**, 241–265. doi:10.1207/s15327078in1003_3

Mattock K, Molnar M, Polka L and Burnham D (2008). The developmental course of lexical tone perception in the first year of life. *Cognition*, **106**, 1367–1381. doi:10.1016/j.cognition.2007.07.002

Mattock K, Polka L, Rvachew S and Krehm M (2010). The first steps in word learning are easier when the shoes fit: Comparing monolingual and bilingual infants. *Developmental Science*, **13**, 229–243. doi:10.1111/j.1467-7687.2009.00891.x

Maye J, Werker JF and Gerken LA (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, **82**, B101-B111. doi:10.1016/S0010-0277(01)00157-3

Mersad K and Nazzi T (2012). When Mommy comes to the rescue of statistics: Infants combine top-down and bottom-up cues to segment speech. *Language Learning and Development*, **8**, 303–315. doi:10.1080/15475441.2011.609106

Newman R, Ratner NB, Jusczyk AM, Jusczyk PW and Dow KA (2006). Infants' early ability to segment the conversational speech signal predicts later language development: A retrospective analysis. *Developmental Psychology*, **42**, 643–655. doi:10.1037/0012-1649.42.4.643

Molnar M, Gervain J and Carreiras M (2013). Within-rhythm class native language discrimination abilities of Basque-Spanish monolingual and bilingual infants at 3.5 months of age. *Infancy*, **19**, 326–337. doi:10.1111/infa.12041

Narca Garcia LN, Guerrero-Mosquera C, Colomer M and Sebastián-Gallés N (2018). Evoked and oscillatory EEG activity differentiates language discrimination in young monolingual and bilingual infants. *Scientific Reports*, **8**, 2770. doi:10.1038/s41598-018-20824-0

Nazzi T, Bertoncini J and Bijeljac-Babic R (2009). A perceptual equivalent of the labial-coronal effect in the first year of life. *Journal of the Acoustical Society of America*, **126**, 1440–1446. doi:10.1121/1.3158931

Nazzi T, Bertoncini J and Mehler J (1998). Language discrimination by newborns: Toward an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance*, **24**, 756–766. doi:10.1037/0096-1523.24.3.756

Nazzi T, Iakimova G, Bertoncini J, Frédonie S and Alcantara C (2006). Early segmentation of fluent speech by infants acquiring French: Emerging evidence for crosslinguistic differences. *Journal of Memory and Language*, **54**, 283–299. doi:10.1016/j. jml.2005.10.004

Nazzi T, Jusczyk PW and Johnson EK (2000). Language discrimination by English-learning 5-month-olds: Effects of rhythm and familiarity. *Journal of Memory and Language*, **43**, 1–19. doi:10.1006/jmla.2000.2698

Nespor M, Shukla M and Mehler J (2011). Stress-timed vs. syllable timed languages. In M van Oostendorp, CJ Ewen, E Hume and K Rice (Eds.), *The Blackwell Companion to Phonology*. Wiley-Blackwell. pp. 1147–1159. doi:10.1002/9781444335262

Newman RS, Rowe ML and Ratner NB (2016). Input and uptake at 7 months predicts toddler vocabulary: The role of child-directed speech and infant processing skills in language development. *Journal of Child Language*, **43**, 1158–1173. doi:10.1017/S0305000915000446

Nishibayashi LL, Goyet L and Nazzi T (2015). Early speech segmentation in French-learning infants: Monosyllabic words versus embedded syllables. *Language and Speech*, **58**, 334–350. doi:10.1177/0023830914551375

Orena AJ, Byers-Heinlein K and Polka L (accepted, pending minor revisions). Reliability of the Language Environment Analysis (LENA) in French-English bilingual speech. *Journal of Speech, Language, and Hearing Research*.

Pallier C, Colomé A and Sebastián-Gallés N (2001). The influence of native-language phonology on lexical access: Exemplar-based versus abstract lexical entries. *Psychological Science*, **12**, 445–449. doi:10.1111/1467-9280.00383

Pearson BZ, Fernández SC and Oller DK (1993). Lexical development in bilingual infants and toddlers: Comparison to monolingual norms. *Language Learning*, **43**, 93–120. doi:10.1111/j.1467-1770.1993.tb00174.x

Pearson BZ, Fernandez SC, Lewedeg V and Oller DK (1997). The relation of input factors to lexical learning by bilingual infants. *Applied Psycholinguistics*, **18**, 41–58. doi:10.1017/S0142716400009863

Polka L, Orena AJ, Sundara M and Worrall J (2017). Segmenting words from fluent speech during infancy – challenges and opportunities in a bilingual context. *Developmental Science*, **20**, e12419. doi:10.1111/desc.12419

Polka L and Sundara M (2012). Word segmentation in monolingual infants acquiring Canadian English and Canadian French: Native language, cross-dialect, and cross-language comparisons. *Infancy*, **17**, 1–35. doi:10.1111/j.1532-7078.2011.00075.x

Poltrock S, Chen H, Kwok C, Cheung H and Nazzi T (2018). Adult learning of words in a nonnative language: Consonants, vowels, and tones. *Frontiers in Psychology*, **9**, 1211. doi: 10.3389/fpsyg.2018.01211.

Poltrock S and Nazzi T (2015). Consonant/vowel asymmetry in early word form recognition. *Journal of Experimental Child Psychology*, **131**, 135–148. doi:10.1016/j.jecp.2014.11.011

Pons F, Bosch L and Lewkowicz DJ (2015). Bilingualism modulates infants' selective attention to the mouth of a talking face. *Psychological Science*, **26**, 490–498. doi:10.1177/0956797614568320

Rämä P, Sirri L and Goyet L (2018). Event-related potentials associated with cognitive mechanisms underlying lexical-semantic processing in monolingual and bilingual 18-month-old children. *Journal of Neurolinguistics*, **47**, 123–130. doi:10.1016/j.jneuroling.2018.04.012

Ramachers S, Brouwer S and Fikkert P (2017). No perceptual reorganization for Limgurgian tones ? A cross-linguistic investigation with 6- to 12-month-old infants. *Journal of Child Language*, **45**, 290–318. doi:10.1017/S0305000917000228

Ramon-Casas M, Fennell C and Bosch L (2017). Minimal-pair word learning by bilingual toddlers: The Catalan /e/-/ɛ/ contrast revisited. *Bilingualism: Language and Cognition*, **20**, 649–656. doi:10.1017/S1366728916001115

Ramon-Casas M, Swingley D, Sebastian-Gallès N and Bosch L (2009). Vowel categorization during word recognition in bilingual toddlers. *Cognitive Psychology*, **59**, 96–121. doi:10.1016/j.cogp- sych.2009.02.002

Ramus F, Nespor M and Mehler J (1999). Correlates of linguistic rhythm in the speech signal. *Cognition*, **73**, 265–292. doi:10.1016/S0010-0277(99)00058-X

Ramus F, Hauser MD, Miller C, Morris D and Mehler J (2000). Language discrimination by human newborns and by cotton-top tamarin monkeys. *Science*, **288**, 349–351. doi:10.1126/science.288.5464.349

Rivera-Gaxiola M, Silva-Pereyra J and Kuhl PK (2005) Brain potentials to native and non-native speech contrasts in 7- and 11-month-old American infants. *Developmental Science*, **8**, 162–172.

Saffran JR, Aslin RN and Newport EL (1996). Statistical learning by 8-month-old infants. *Science*, **274**, 1926–1928. doi:10.1126/science.274.5294.1926

Sebastián-Gallés N, Albareda-Castellot B, Weikum WM and Werker JF (2012). A bilingual advantage in visual language discrimination in infancy. *Psychological Science*, **23**, 994–999. doi:10.1177/095679712436817

Sebastián-Gallés N and Bosch L (2002). Building phonotactic knowledge in bilinguals: Role of early exposure. *Journal of Experimental Psychology: Human Perception and Performance*, **28**, 974–989. doi:10.1037/0096-1523.28.4.974

Sebastián-Gallés N, Echeverria S and Bosch L (2005). The influence of initial exposure on lexical representation: Comparing early and simultaneous bilinguals. *Journal of Memory and Language*, **52**, 240–255. doi:10.1016/j.jml.2004.11.001

Shi R, Marquis A and Gauthier B (2006). Segmentation and representation of function words in preverbal French-learning infants. In D Bamman, T Magnitskaia and C Zaller (Eds.), *BUCLD 30: Proceedings of the 30th annual Boston University conference on language development* (vol. 2, pp. 549–560). Boston, MA: Cascadilla Press.

Singh L (2018). He said, she said: Effects of bilingualism on cross-talker word recognition in infancy. *Journal of Child Language*, **45**, 498–510. doi:10.1017/S0305000917000186

Singh L, Fu CSL, Seet XH, Tong APY, Wang JL and Best CT (2018). Developmental change in tone perception in Mandarin monolingual, English monolingual, and Mandarin-English bilingual infants. Divergence between monolingual and bilingual learners. *Journal of Experimental Child Psychology*, **173**, 59–77, doi:10.1016/j.jecp.2018.03.012

Singh L, Fu SL, Tay ZW and Golinkoff RM (2018a). Novel word learning in bilingual and monolingual infants: Evidence for a bilingual advantage. *Child Development*, **89**, e183–e198. doi:10.1111/cdev.12747

Singh L, Poh FLS and Fu CSL (2016). Limits on monolingualism? A comparison of monolingual and bilingual infants' abilities to integrate lexical tone in novel word learning. *Frontiers in Psychology*, **7**, 992. doi:10.3389/fpsyg.2016.00992

Singh L, Reznick JS and Xuehua L (2012). Infant word segmentation and childhood vocabulary development: A longitudinal analysis. *Developmental Science*, **15**, 482–495. doi:10.1111/j.1467-7687.2012.01141.x

Skoruppa K, Pons F, Christophe A, Bosch L, Dupoux E, Sebastián-Gallés N, Alves Limissuri R and Peperkamp S (2009). Language-specific stress perception by 9-month-old French and Spanish infants. *Developmental Science*, **12**, 914–919. doi:10.1111/j.1467-7686.2009.00835.x

Sundara M and Polka L (2008) Discrimination of coronal stops by bilingual adults:The timing and nature of language interaction. *Cognition*, **106**, 234–258. doi:10.1016/j.cognition.2007.01.011

Sundara M, Polka L and Molnar M (2008). Development of coronal stop perception: Bilingual infants keep pace with their monolingual peer. *Cognition*, **108**, 232–242. doi:10.1016/j.cognition.2007.12.013

Sundara M and Scutellaro A (2011). Rhythmic distance between languages affects the development of speech perception in bilingual infants. *Journal of Phonetics*, **39**, 505–513. doi:10.1016/j.wocn.2010.08.006

Swingley D (2005). 11-month-olds' knowledge of how familiar words sound. *Developmental Science*, **8**, 432–443. doi:10.1111/j.1467-7687.2005.00432.x

Swingley D and Aslin RN (2000). Spoken word recognition and lexical representation in very young children. *Cognition*, **76**, 147–166. doi:10.1016/S0010-0277(00)00081-0

Tincoff R and Jusczyk PW (1999). Some beginnings of word comprehension in 6-month-olds. *Psychological Science*, **10**, 172–175. doi:10.1111/1467-9280.00127

Tincoff R and Jusczyk PW (2012). Six-month-olds comprehend words that refer to parts of the body. *Infancy*, **17**, 432–444. doi:10.1111/j.1532-7078.2011.00084.x

Tsao F-M, Liu H-M. and Kuhl PK (2004). Speech perception in infancy predicts language development in the second year of life: a longitudinal study. *Child Development*, **75**, 1067–1084. doi:10.1111/j.1467-8624.2004.00726.x

Tsao F-M, Liu H-M. and Kuhl PM (2006). Perception of native and non-native affricate-fricative contrasts: Cross-language tests on adults and infants. *Journal of the Acoustical Society of America* **120**, 2285–2294. doi:10.1121/1.2338920

Tsuji S and Cristia A (2014). Perceptual attunement in vowels: A meta-analysis. *Developmental Psychobiology*, **56**, 179–191. doi:10.1002/dev.21179

Vihman MM, Nakai S, DePaolis RA and Hallé P (2004). The role of accentual pattern in early lexical representation. *Journal of Memory and Language*, **50**, 336–353. doi:10.1016/j.jml.2003.11.004

Vihman MM, Thierry G, Lum J, Keren-Portnoy T and Martin P (2007). Onset of word form recognition in English, Welsh, and English-Welsh bilingual infants. *Applied Psycholinguistics*, **28**, 475–493. doi:10.1017/S0142716407070269

Von Holzen K, Nishibayashi LL and Nazzi T (2018). Consonant and vowel processing in word form segmentation: An infant ERP study. *Brain Sciences*, **8**, 24. doi:10.3390/brainsci8020024

Weikum WM, Vouloumanos A, Navarra J, Soto-Faraco S, Sebastián-Gallés N and Werker JF (2007). Visual language discrimination in infancy. *Science*, **316**(5828), 1159. doi:10.1126/science.1137686

Weisleder A and Fernald A (2013). Talking to children matters: early language experience strengthens processing and builds vocabulary. *Psychological Science*, **24**, 2143–52. doi:10.1177/0956797613488145

Werker JF (2018). Perceptual beginnings to language acquisition. *Applied Psycholinguistics*, **39**, 703–328. doi:10.1017/S0142716418000152

Werker JF and Curtin S (2005). PRIMIR: A developmental framework of infant speech processing. *Language Learning and Development*, **1**, 197–234. doi:10.1080/15475441.2005.9684216

Werker JF, Fennell CT, Corcoran KM and Stager CL (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary. *Infancy*, **3**, 1–30. doi:10.1207/S15327078IN0301_1

Werker JF and Tees RC (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development*, **4**, 49–63. doi:10.1016/S0163-6383(84)80022-3

Wewalaarachchi TD, Wong LH and Singh L (2017). Vowels, consonants, and lexical tones: Sensitivity to phonological variation in monolingual Mandarin and bilingual English – Mandarin toddlers. *Journal of Experimental Child Psychology*, **159**, 16–33. doi:10.1016/j.jecp.2017.01.009

Yeung H, Chen KH and Werker JF (2013). When does native language input affect phonetic perception? The precocious case of lexical tone. *Journal of Memory and Language*, **68**, 123–139. doi:10.1016/j.jml.2012.09.004

Yoshida KA, Pons F, Maye J and Werker JF (2010). Distributional phonetic learning at 10 months of age. *Infancy*, **15**, 420–433. doi:10.1111/j.532.7078.2009.00024.x