Challenges of infant language acquisition in bilingual environments

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ABSTRACT

Many infants around the world grow up bilingual, learning two languages simultaneously from birth. What are these early bilingual environments like, and how do infants successfully navigate them? In this paper, I first describe the variety of ways that bilingual infants can encounter two languages during their early development. I then review how infants surmount unique challenges that they face during bilingual language acquisition. These include detecting and processing language switches, learning two sets of sounds and words, separating the languages, and processing speech in language-specific ways. I conclude by elucidating some of the most pressing methodological challenges in infant bilingualism research. I argue that Open Science approaches such as data sharing and large-scale collaborations will be essential to progress in our understanding of bilingualism in infancy.

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Infants' capacity for language learning is impressive. From the rich input of their language environment, infants quickly begin to work out the sounds, words, and grammar that characterize the speech they hear. Remarkably, infants who grow up in a bilingual environment can learn two languages simultaneously. To do so, they must detect and track two language systems, and acquire the rules and structures for each, all while encountering regular switches between their languages. Moreover, they appear to navigate this complex language-learning challenge while meeting many of the same early language milestones as monolinguals (e.g., first babbles, words, and two-word combinations; Werker & Byers-Heinlein, 2008).

This paper focuses on how bilingual infants – from birth to age three – learn two distinct languages as separable systems. While bilingual language acquisition has many commonalities with monolingual acquisition, here I focus on aspects of input, processing, and representation that are unique to infants growing up bilingual. I conclude with a discussion of methodological challenges facing this field, and a vision for the future of research on bilingual infants.

LANGUAGE INPUT IN BILINGUAL ENVIRONMENTS

There are many ways to grow up bilingual. Throughout this paper, I use the term “bilingual infant” to broadly refer to infants who hear two or more languages regularly, including trilinguals and multilinguals. This section will discuss input to bilingual infants, and how bilingual environments are assessed.

Bilingual infants vary in the specific languages they encounter, be they spoken or signed. These languages can be similar or different from each other on many different dimensions, such as their rhythmicity, speech sound inventories, and word order, to name a few. Languages from the same family (e.g, Romance languages) tend to be similar on multiple dimensions. Infants are flexible in their ability to learn any language combination, but some language pairs may be easier

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to learn than others. If infants can transfer knowledge from one language to the other, then similar language pairs may be easier to learn. On the other hand, if similar languages are more confusable, then more distant language pairs may be easier to learn. Although there are limited studies on this topic, one study found that bilingual infants learning closely-related languages (as a function of phonological overlap, word order typology, and morphological complexity) had larger parent-reported vocabularies than those learning more distant languages (Floccia et al., 2018).

Second, bilingual infants vary in the contexts in which they encounter their languages. Some bilinguals hear both of their languages across the same contexts, while others hear different languages inside versus outside the home. Many bilinguals grow up in families that follow a one-person-one-language approach. However, even parents who aim for the one-parent-one-language strategy are rarely totally strict, and there is no evidence that this approach is necessary for successful bilingual acquisition (De Houwer, 2011). Indeed, emerging experimental evidence suggests that infants do not necessarily notice a speaker's language (Schott et al., 2020).

Third, bilingual infants vary in how much they hear one language relative to the other; only a tiny minority of bilingual infants hear their languages equally. Yet, measuring infants' language input is a methodological challenge. Children's early bilingual exposure is often assessed via parent report, a fast and inexpensive approach. Pioneering work used daily diaries (De Houwer, 1990; Place & Hoff, 2011), and more recently standardized questionnaires have been developed to quantify language input (Byers-Heinlein et al., 2019). Technological advances have allowed researchers to gather more detailed information on infants' everyday experiences, through the use of digital audio recorders that capture up to 16 hours of infants' experience.

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Computer algorithms have been developed that automatically count how many words the infant hears, but for bilinguals, human coders are currently needed to determine the language being spoken (Orena et al., 2020). Validation studies show that direct observations of infants' home language environments align well with parent-reported language exposure in some cases (Orena et al., 2020), although this result is not consistent across all studies (Marchman et al., 2017).

Given infants' limited language skills, researchers usually use language exposure – rather than use or proficiency – to determine whether an infant is considered bilingual. Studies in the literature vary a lot in the amount of second language exposure that qualifies an infant as bilingual, with some setting a strict minimum of 40% exposure to the least-heard language and others setting a looser minimum of 10%, although 25% is a common cut-off (Byers-Heinlein, 2015). Patterns of language input change dynamically over time, and as infants grow both their input and their speech output contribute to language development (Ribot et al., 2018; Surrain & Luk, 2019). Newer approaches are moving beyond dichotomies of monolingual vs. bilingual groups, and incorporating continuous quantifications of bilingualism (Kaushanskaya & Prior, 2015; Kremin & Byers-Heinlein, 2020).

Finally, the quality of speech in each language likely makes an important contribution to bilingual development. Rich and varied speech, especially from native speakers, has been linked to stronger language outcomes in bilingual infants and children (Place & Hoff, 2011; Unsworth, 2016). For example, a recent intervention study showed that Spanish-learning infants who received high-quantity, high-quality exposure to English in a childcare setting (intensive, play-based, social-responsive exposure to multiple native English speakers who used infant-directed speech) were able to gain and retain knowledge of their new language (Ramirez & Kuhl, 2017).

LANGUAGE PROCESSING IN BILINGUAL ENVIRONMENTS

Detecting language switches over longer and shorter timescales

Bilingual infants necessarily encounter language switches on a regular basis – a challenge not faced by monolinguals. For some bilinguals, switches occur across long periods of single-language exposure, for example if they hear one language at home and another language at daycare. For others who spend time in highly bilingual settings, switches occur over shorter timescales, such as within a conversation or a sentence. This language switching (also called language mixing or code switching) is frequent in speech to bilingual infants in some communities (Bail et al., 2015; Byers-Heinlein, 2013), although less frequent in others (Orena et al., 2020). Whatever their particular environments, bilingual infants must detect when language switches occur in order to acquire each language as a distinct system.

As early as from birth, infants show sensitivity to some kinds of language switches. When they are habituated to long passages of one language until their interest declines, both monolinguals and bilinguals show renewed interest if they hear a change to a rhythmically different language (Byers-Heinlein et al., 2010). By age 3–4 months, bilinguals acquiring rhythmically-similar languages can detect a change from one of their native languages to the other (Bosch & Sebastián-Gallés, 2001; Molnar et al., 2014). There is also some evidence that it is challenging for infant to detect language switches at shorter timescales, such as at the level of a single word. A recent study using a preference paradigm found that neither monolingual and bilingual 8–10-month-olds detected this type of switch in the naturalistic context of a sentence (e.g. “Do you like the *chien* [fr. dog]?”), nor in the more artificial context of isolated words switching language (e.g. ““Dog... *Lait* [fr. milk]... Dog... *Lait*”) (Schott et al., 2020). Thus, by

the end of the first year of life, bilingual infants can detect language switches that occur across long passages of speech, but may be less sensitive to switches that occur across single words.

Recognizing and learning words in the context of language switches

Bilingual infants must not only identify words from two different languages in the bilingual speech stream, but they must also link these words to meaning, and subsequently retrieve these meanings when encountering familiar words. How is this affected by language switching? Some types of language switching are more challenging for infants than others. For example, when the language switches mid-sentence (“Find the *chien* [fr. dog]!”), bilingual 1.5–2-year-olds have more difficulty comprehending familiar words (Byers-Heinlein et al., 2017; Morini & Newman, 2019; Potter et al., 2019) and learning new words (Byers-Heinlein, Jardak, et al., 2020) than when the same words are encountered in single-language contexts (“Find the dog!”). However, when language switches occur between sentences (“I like that one! *Le chien* [fr. dog]!”), comprehension appears unimpaired, possibly because sentence boundaries provide a natural break in processing. Moreover, toddlers show worse comprehension when the switch is from their dominant to their non-dominant language than vice-versa (Byers-Heinlein et al., 2017; Potter et al., 2019). These laboratory studies indicate that some types of language switching can—at least temporarily—derail aspects of word comprehension and learning.

Recent studies on bilingual infants’ real-world experiences contextualize laboratory findings. Research has shown that in everyday speech to their infants, French–English and Spanish–English bilingual parents are more likely to switch languages between sentences (which toddlers more easily process) than within sentences (Bail et al., 2015; Kremin et al., 2020). Indeed, both self-report and observational data suggest that parents do not switch languages haphazardly, but often use language switching pedagogically, to boost their children’s learning

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and comprehension (Byers-Heinlein, 2013; Kremin et al., 2020). Moreover, results from correlational studies of language outcomes are mixed, with some studies reporting that infants who encounter more frequent language switching have smaller vocabulary sizes (Byers-Heinlein, 2013; Carbajal & Peperkamp, 2020), and others reporting either no association or a positive association between switching and vocabulary size (Bail et al., 2015; Place & Hoff, 2011, 2016). Thus, while laboratory studies of language switching are useful to delineate the limits of bilingual infants' processing abilities, their results do not necessarily generalize to the impacts of parents' typical language switching on infants' language acquisition.

LANGUAGE REPRESENTATION IN THE DEVELOPING BILINGUAL MIND

The previous sections have overviewed the various ways that bilingual infants encounter their two languages, and shown that infants have the perceptual capabilities to detect when their different languages are spoken. Ultimately, however, infants must use their skills to learn and represent their languages as distinct communicative systems (Byers-Heinlein, 2014). This is called language separation. It is relatively trivial to demonstrate that bilingual adults can functionally separate their languages on multiple levels. For example, proficient French–English bilinguals know that “apple” is English and “*pomme*” is its French translation, can report whether a nonsense word sounds more French-like or more English-like, and can choose to have a conversation in just one of their languages. The question of how and when young bilinguals achieve language separation is one of the oldest and thorniest questions in the field.

Some of the earliest theories of language separation assumed that young bilinguals initially “fuse” their two languages within a single system (Volterra & Taeschner, 1978), while subsequent theories postulated that bilingual infants have two separate language systems from the get-go (Genesee, 1989). These initial theories were largely based on observations of bilingual

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children's early productions, which are limited during infancy, and may not always reflect children's underlying competence. More recent work has tested language separation using experimental studies that tap into receptive language skills. Emerging evidence supports a more nuanced, developmental view, which I call the "Gradual Language Separation Hypothesis". This hypothesis posits that language separation occurs gradually during the first years of life, as infants become increasingly able to apply their perceptual sensitivities to different aspects of language processing and representation. I review some of this evidence below.

Building a phonetic system in two languages

Different languages are characterized by different speech sounds (phonemes). Like monolinguals, bilingual infants must learn the phonemes of their languages, but uniquely they must learn to apply their phonetic sensitivities in a language-specific way. For example, proficient bilingual adults perceive an identical sound to be a different phoneme (e.g., an ambiguous sound is consistently perceived as either a /p/ or a /b/), depending only on which language they think they're hearing (Gonzales et al., 2019). Bilingual and monolingual infants show a largely similar developmental trajectory in their phonetic perception (i.e., by the end of the first year of life, increased sensitivity to native contrasts, and decreased sensitivity to non-native contrasts), although some studies have reported unique developmental patterns in bilinguals, such as transient declines in sensitivity to native-language contrasts, or prolonged sensitivity to non-native language contrasts (for a review, see Byers-Heinlein, 2018). Studies are beginning to test whether bilingual infants can adjust their perception to match the language they are processing, for example in bilinguals who are learning one language where tone is meaningful (such as Mandarin) and a second where it is not (such as English). Current work has suggested that even 18-month-old Mandarin–English bilinguals treat tone as meaningful in both

languages, and that the ability to use tone selectively in Mandarin may not develop until 24 months, at least in some tasks (Singh et al., 2014). These findings suggest that language separation at the phonetic level may have a protracted developmental course: bilingual infants acquire native-like perception of phonetic categories before they are able to apply them appropriately in language-specific ways.

Building a lexicon in two languages

Bilingual infants typically learn two words for every concept that they encounter, one in each language. This splits their experience: a monolingual English-learning infant hears “cat” every time a fluffy feline is labeled, while a French–English bilingual sometimes hears “cat” and sometimes hears “*chat*”. Bilingual and multilingual infants’ vocabularies in individual languages seem to roughly track the proportion of time that they encounter each language (Côté et al., 2020), such that on average they know fewer words than a same-aged monolingual in each language, but a similar number of words in both languages combined (Hoff et al., 2012).

How do bilingual infants mentally organize these words? How intertwined versus independent are bilinguals’ vocabularies in their two languages? On one hand, there is evidence that indicates that vocabularies in the two languages develop somewhat independently. For example, researchers have conducted looking-while-listening studies, where infants see two images (e.g., a dog and a car), and are asked to “Look at the car!”. In a sample of Spanish–English bilingual children, reaction times in each language were related to vocabulary size and exposure to that language, but not to the other language (Marchman et al., 2010). Moreover, research on infants’ comprehension of code-switching indicates that translation equivalents (cross-language synonyms) such as English “cat” and French “*chat*” are not represented

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interchangeably, as children are slower to process sentences with a language-switch than those in a single language (Byers-Heinlein et al., 2017; Morini & Newman, 2019; Potter et al., 2019).

On the other hand, research using semantic priming tasks suggests that the two languages have linked mental representations. For example, infants are more accurate at looking toward a target when it is preceded by a related word (“I like the cat! Dog!”) than an unrelated word (“I like the book! Dog!”), including when that word is in the bilinguals’ other language (“I like the *chat* [fr. Cat]! Dog!”) (Flocchia et al., 2020; Jardak & Byers-Heinlein, 2019; Singh, 2014). These results suggest that bilinguals form mental links between words with related meanings, both within and across their languages. Taken together, this research suggests that young bilinguals build a lexical system in which the two languages are linked yet separable.

METHODOLOGICAL CHALLENGES AND SOLUTIONS

Research with bilingual infants has come a long way since its beginnings more than 100 years ago, from initial case-studies (Ronjat, 1913), to the first experimental studies (Bosch & Sebastián-Gallés, 1997), to the diversity of today’s observational, experimental, and neuroimaging research methods (Byers-Heinlein, 2015). Nonetheless, the field faces major challenges in achieving a full understanding of bilingualism in infancy.

One important challenge is that infants’ early language environments are not randomly assigned. Infants grow up bilingual for systematic reasons, for example due to migration, living in a bilingual community, or parental choice. Moreover, across two different bilingual communities, infants may not only differ in the language pair they are learning, but also on a host of other cultural variables, as well as their socioeconomic status. This makes it challenging to establish causal relationships between different types of early language environments and language outcomes.

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A second important issue is generalizability. For example, how similar is the problem of acquiring two close languages like Spanish and Catalan, to the problem of acquiring two distant languages like English and Mandarin? As most studies of bilingualism are conducted with only one population, it is difficult to know how much results generalize to other bilingual populations.

Addressing such challenges is particularly difficult in the context of the small sample sizes typical of infant research, which has generally been 16–24 infants per group (Oakes, 2017). Small samples have been the norm because infants (particularly bilinguals) are notoriously difficult to recruit and test, and experimental studies with infants often have an attrition rates as high as 50%. This is also a barrier to replicating study results across different bilingual populations. Concerningly, small samples increase the chance of spurious, non-replicable results. Detecting the signal within noisy bilingual infant samples is a serious challenge.

The Open Science movement provides several promising directions for surmounting these challenges. Openly sharing research materials and datasets on platforms such as the Open Science Framework (osf.io) and Wordbank (Frank et al., 2017) allows researchers to more closely replicate each other's work, and to synthesize and analyze datasets in new ways.

Large-scale open collaborations enable data collection at an unprecedented scale. As part of the larger ManyBabies collaboration, 17 labs from 7 countries tested 333 bilingual infants in the ManyBabies 1 Bilingual project (Byers-Heinlein, Tsui, Bergmann, et al., 2020). The study investigated whether bilingualism affects infants' preference for infant-directed speech compared to adult-directed speech. Results showed that bilingualism itself did not impact infants' preference, but bilinguals with more exposure to North American English (the stimulus language) had a stronger preference than those with less exposure.

Figure 1 illustrates the results from this study for labs that tested age-matched monolingual and bilingual samples, highlighting the variability of the monolingual–bilingual difference observed across labs. Each lab tested relatively small samples, ranging from 10 to 30 infants per group. If infants had only been tested in my lab (Concordia) and at the University of British Columbia (Werker), we might have erroneously concluded that bilinguals in Vancouver show a greater IDS preference than bilinguals in Montreal. However, in the context of the full dataset, these labs are simply at the tails of a distribution that is not different from chance.

Figure 1: Results from the ManyBabies 1 Bilingual project (Byers-Heinlein, Tsui, Bergmann, et al., 2020). Looking time difference in seconds between monolinguals and bilinguals tested by each lab, plotted by age group. Bars represent 95% confidence interval. Labs show variability in the magnitude of the difference observed between monolinguals and bilinguals. However, this can be attributed to sampling error in the context of small sample sizes. Analyses of the entire sample of infants revealed no overall effect of bilingualism.

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Large-scale collaborations provide additional benefits beyond increasing sample size: researchers can agree on a common definition of bilingualism, and test infants from a variety of bilingual backgrounds using identical stimuli and a common protocol (see also Byers-Heinlein, Tsui, Black, et al., 2020), for a second example of a large-scale collaboration testing bilingual infants). While research questions for initial large-scale collaborations were chosen for reasons of feasibility, future studies can investigate questions that are more central to infant bilingualism researchers, such as how performance in a language task varies according to language pair or amount of input. Large-scale collaborations require a high investment of resources, and should not supplant carefully-planned single-laboratory studies. Nonetheless, they provide an important new tool for building robust and generalizable theories of bilingual development.

CONCLUSION

Bilingual infants vary in the amount, type, and context of exposure to their languages. Yet, they all face the same unique challenge of acquiring and separating their two languages, while navigating switches in language that are inherent to bilingual environments. The field has made exciting discoveries that have deepened our understanding of early bilingual development, but nonetheless faces important methodological challenges. Open Science approaches such as data sharing and large-scale collaborations are promising for advancing the field, to build a robust and generalizable understanding of early bilingualism.

REFERENCES

- Bail, A., Morini, G., & Newman, R. S. (2015). Look at the gato! Code-switching in speech to toddlers. *Journal of Child Language*, 42(5), 1073–1101.
<https://doi.org/10.1017/S0305000914000695>
- Bosch, L., & Sebastián-Gallés, N. (1997). Native-language recognition abilities in 4-month-old infants from monolingual and bilingual environments. *Cognition*, 65(1), 33–69.
[https://doi.org/10.1016/S0010-0277\(97\)00040-1](https://doi.org/10.1016/S0010-0277(97)00040-1)
- Bosch, L., & Sebastián-Gallés, N. (2001). Early language differentiation in bilingual infants. In J. Cenoz & F. Genesee (Eds.), *Trends in bilingual acquisition* (pp. 71–94). John Benjamins Publishing Company.
- 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(1), 32–48. <https://doi.org/10.1017/S1366728912000120>
- Byers-Heinlein, K. (2014). Languages as categories: Reframing the “one language or two” question in early bilingual development. *Language Learning*, 64(s2), 184–201.
<https://doi.org/10.1111/lang.12055>
- Byers-Heinlein, K. (2015). *Methods for studying infant bilingualism* (J. W. Schwieter, Ed.; pp. 133–154). Cambridge University Press.
- Byers-Heinlein, K. (2018). Speech Perception. In *The Listening Bilingual: Speech Perception, Comprehension, and Bilingualism* (1st ed., pp. 153–175). Wiley.
<https://doi.org/10.1002/9781118835722>

Byers-Heinlein, K., Burns, T. C., & Werker, J. F. (2010). The roots of bilingualism in newborns.

Psychological Science, 21(3), 343–348. <https://doi.org/10.1177/0956797609360758>

Byers-Heinlein, K., Jardak, A., Fourakis, E., & Lew-Williams, C. (2020). *Effects of language mixing on bilingual children's word learning* [Preprint].

<https://doi.org/10.31234/osf.io/298cz>

Byers-Heinlein, K., Morin-Lessard, E., & Lew-Williams, C. (2017). Bilingual infants control their languages as they listen. *Proceedings of the National Academy of Sciences*, 114(34), 9032–9037. <https://doi.org/10.1073/pnas.1703220114>

Byers-Heinlein, K., Schott, E., Gonzalez-Barrero, A. M., Brouillard, M., Dubé, D., Jardak, A., Laoun-Rubenstein, A., Mastroberardino, M., Morin-Lessard, E., Pour Iliaei, S., Salama-Siroishka, N., & Tamayo, M. P. (2019). MAPLE: A Multilingual Approach to Parent Language Estimates. *Bilingualism: Language and Cognition*, 1–7.

<https://doi.org/10.1017/S1366728919000282>

Byers-Heinlein, K., Tsui, A., Bergmann, C., Black, A. K., Brown, A., Carbajal, M. J., Durrant, S., Fennell, C., Fievet, A.-C., Frank, M. C., Gampe, A., Gervain, J., Gonzalez-Gomez, N., Hamlin, K., Havron, N., Hernik, M., Kerr, S., Killam, H., Klassen, K., ... Wermelinger, S. (2020). *A multi-lab study of bilingual infants: Exploring the preference for infant-directed speech* [Preprint]. PsyArXiv. <https://doi.org/10.31234/osf.io/sqh9d>

Byers-Heinlein, K., Tsui, R. K.-Y., Black, A. K., Barr, R., Brown, A., Durrant, S., Gampe, A., Gonzalez-Gomez, N., Hay, J. F., Hernik, M., Jartó, M., Kovacs, A. M., Laoun-Rubenstein, A., Lew-Williams, C., Liszkowski, U., Liu, L., Noble, C., Potter, C. E., Rocha-Hildago, J., ... Wermelinger, S. (2020). *The development of gaze following in monolingual and bilingual infants: A multi-lab study*. 76.

INFANTS IN BILINGUAL ENVIRONMENTS

- Carbajal, M. J., & Peperkamp, S. (2020). Dual language input and the impact of language separation on early lexical development. *Infancy*. <https://doi.org/10.1111/infa.12315>
- Côté, S. L., Gonzalez, A. M., & Byers-Heinlein, K. (2020). *Multilingual toddlers' vocabulary development in two languages: Comparing bilinguals and trilinguals*. <https://psyarxiv.com/hpqez/>
- De Houwer, A. (1990). *The acquisition of two languages from birth*. Cambridge University Press.
- De Houwer, A. (2011). *Language input environments and language development in bilingual acquisition*. 2, 221–240.
- Floccia, C., Delle Luche, C., Lepadatu, I., Chow, J., Ratnage, P., & Plunkett, K. (2020). Translation equivalent and cross-language semantic priming in bilingual toddlers. *Journal of Memory and Language*, 112, 104086. <https://doi.org/10.1016/j.jml.2019.104086>
- Floccia, C., Sambrook, T. D., Luche, C. D., Kwok, R., Goslin, J., White, L., Cattani, A., Sullivan, E., Abbot-Smith, K., Krott, A., Mills, D., Rowland, C., Gervain, J., & Plunkett, K. (2018). Iii: Analyses and results for study 1: Estimating the effect of linguistic distance on vocabulary development. *Monographs of the Society for Research in Child Development*, 83(1), 43–60. <https://doi.org/10.1111/mono.12350>
- Frank, M. C., Braginsky, M., Yurovsky, D., & Marchman, V. A. (2017). Wordbank: An open repository for developmental vocabulary data. *Journal of Child Language*, 44(3), 677–694. <https://doi.org/10.1017/S0305000916000209>
- Genesee, F. (1989). Early bilingual development: One language or two. *Journal of Child Language*, 16(1), 161–179. <https://doi.org/10.1017/S0305000900013490>

- Gonzales, K., Byers-Heinlein, K., & Lotto, A. J. (2019). How bilinguals perceive speech depends on which language they think they're hearing. *Cognition*, 182, 318–330.
<https://doi.org/10.1016/j.cognition.2018.08.021>
- Hoff, E., Core, C., Place, S., Rumiche, R., Señor, M., & Parra, M. (2012). Dual language exposure and early bilingual development. *Journal of Child Language*, 39(1), 1–27.
<https://doi.org/10.1017/S0305000910000759>
- Jardak, A., & Byers-Heinlein, K. (2019). Labels or Concepts? The Development of Semantic Networks in Bilingual Two-Year-Olds. *Child Development*, 90(2), e212–e229.
<https://doi.org/10.1111/cdev.13050>
- Kaushanskaya, M., & Prior, A. (2015). Variability in the effects of bilingualism on cognition: It is not just about cognition, it is also about bilingualism. *Bilingualism: Language and Cognition*, 18(1), 27–28. <https://doi.org/10.1017/S1366728914000510>
- Kremin, L. V., & Byers-Heinlein, K. (2020). *Why not both? Rethinking categorical and continuous approaches to bilingualism*. <https://psyarxiv.com/nkvap>
- Kremin, L. V., Orena, A. J., Polka, L., & Byers-Heinlein, K. (2020). *Code-switching in everyday speech to bilingual infants*.
- Marchman, V. A., Fernald, A., & 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(4), 817–840.
<https://doi.org/10.1017/S0305000909990055>
- Marchman, V. A., Martínez, L. Z., Hurtado, N., Grüter, T., & Fernald, A. (2017). Caregiver talk to young Spanish-English bilinguals: Comparing direct observation and parent-report

- measures of dual-language exposure. *Developmental Science*, 20(1), e12425.
<https://doi.org/10.1111/desc.12425>
- Molnar, M., Gervain, J., & Carreiras, M. (2014). Within-rhythm class native language discrimination abilities of Basque-Spanish monolingual and bilingual infants at 3.5 months of age. *Infancy*, 19(3), 326–337. <https://doi.org/10.1111/infa.12041>
- Morini, G., & Newman, R. S. (2019). Dónde está la ball? Examining the effect of code switching on bilingual children's word recognition. *Journal of Child Language*, 46(6), 1238–1248.
<https://doi.org/10.1017/S0305000919000400>
- Oakes, L. M. (2017). Sample size, statistical power, and false conclusions in infant looking-time research. *Infancy*, 22(4), 436–469. <https://doi.org/10.1111/infa.12186>
- Orena, A. J., Byers-Heinlein, K., & Polka, L. (2020). What do bilingual infants actually hear? Evaluating measures of language input to bilingual-learning 10-month-olds. *Developmental Science*, 23(2), e12901. <https://doi.org/10.1111/desc.12901>
- Place, S., & Hoff, E. (2011). Properties of dual language exposure that influence two-year-olds' bilingual proficiency. *Child Development*, 82(6), 1834–1849.
<https://doi.org/10.1111/j.1467-8624.2011.01660.x>
- Place, S., & Hoff, E. (2016). Effects and noneffects of input in bilingual environments on dual language skills in 2 ½-year-olds. *Bilingualism: Language and Cognition*, 19(5), 1023–1041. <https://doi.org/10.1017/S1366728915000322>
- Potter, C. E., Fourakis, E., Morin-Lessard, E., Byers-Heinlein, K., & Lew-Williams, C. (2019). Bilingual toddlers' comprehension of mixed sentences is asymmetrical across their two languages. *Developmental Science*, 22(4), e12794. <https://doi.org/10.1111/desc.12794>

INFANTS IN BILINGUAL ENVIRONMENTS

- Ramirez, N. F., & Kuhl, P. (2017). Bilingual Baby: Foreign Language Intervention in Madrid's Infant Education Centers. *Mind, Brain, and Education*, 11(3), 133–143.
<https://doi.org/10.1111/mbe.12144>
- Ribot, K. M., Hoff, E., & Burridge, A. (2018). Language Use Contributes to Expressive Language Growth: Evidence From Bilingual Children. *Child Development*, 89(3), 929–940. <https://doi.org/10.1111/cdev.12770>
- Ronjat, J. (1913). *Le développement du langage observé chez un enfant bilingue*. Champion.
- Schott, E., Mastroberardino, M., Fourakis, E., & Lew-Williams, C. (2020). *Fine-tuning language discrimination: Monolingual and bilingual infants' detection of language*.
<https://psyarxiv.com/xkc9b/>
- Singh, L. (2014). One World, Two Languages: Cross-Language Semantic Priming in Bilingual Toddlers. *Child Development*, 85(2), 755–766. <https://doi.org/10.1111/cdev.12133>
- Singh, L., Hui, T. J., Chan, C., & Golinkoff, R. M. (2014). Influences of vowel and tone variation on emergent word knowledge: A cross-linguistic investigation. *Developmental Science*, 17(1), 94–109. <https://doi.org/10.1111/desc.12097>
- Surrain, S., & Luk, G. (2019). Describing bilinguals: A systematic review of labels and descriptions used in the literature between 2005–2015. *Bilingualism: Language and Cognition*, 22(2), 401–415. <https://doi.org/10.1017/S1366728917000682>
- Unsworth, S. (2016). Quantity and quality of language input in bilingual language development. In E. Nicoladis & S. Montanari (Eds.), *Bilingualism across the lifespan: Factors moderating language proficiency*. (pp. 103–121). American Psychological Association.
<https://doi.org/10.1037/14939-007>

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Volterra, V., & Taeschner, T. (1978). The acquisition and development of language by bilingual children. *Journal of Child Language*, 5, 311–326.

<https://doi.org/10.1017/S0305000900007492>

Werker, J. F., & Byers-Heinlein, K. (2008). Bilingualism in infancy: First steps in perception and comprehension. *Trends in Cognitive Sciences*, 12(4), 144–151.

<https://doi.org/10.1016/j.tics.2008.01.008>