Languages as categories:

Reframing the “one language or two” question in early bilingual development

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Abstract

One of the most enduring questions in the field of bilingualism is whether bilingual infants and children initially have “one language system or two”. Research with adults indicates that while bilinguals do not represent their languages in two fully encapsulated language systems, they are able to functionally differentiate their languages. This paper proposes that bilinguals differentiate their languages insofar as they can treat elements of their languages as belonging to different categories. Several lines of research with bilingual adults and children are considered in the context of perceptual and conceptual language categories. The paper ends with a discussion of how language categories might emerge over the course of early bilingual development, and outlines directions for future research.

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Reframing the "one language or two" question in early bilingual development

One of the most enduring questions in the field of early bilingual development is whether children exposed to two languages simultaneously from birth initially have "one language system or two": whether they differentiate their languages (L. Arnberg & Arnberg, 1985; Genesee, 1989; Köppe, 1996; Lanza, 1992; Nicoladis, 1998; Nicoladis & Genesee, 1996; Poulin-Dubois & Goodz, 2001; Vihman, 1985; Volterra & Taeschner, 1978). Similarly, others have asked whether young bilinguals are able to discriminate (L. Arnberg & Arnberg, 1985; Bosch & Sebastián-Gallés, 2001b; Byers-Heinlein, Burns, & Werker, 2010; Genesee, 1989; Köppe, 1996; Lanza, 1992; Nicoladis, 1998; Nicoladis & Genesee, 1996; Poulin-Dubois & Goodz, 2001; Sebastián-Gallés, Albareda-Castellot, Weikum, & Werker, 2012; Vihman, 1985; Volterra & Taeschner, 1978; Weikum et al., 2007), separate (De Houwer, 1990; J. Paradis, 2001a), or construct "distinct files" for each language (Mehler, Dupoux, Nazzi, & Dehaene-Lambertz, 1996). Posed differently, "Are bilingual children initially monolingual?" (Genesee, 2005). A number of early theorists argued that bilinguals begin development with a "fused" or "unitary" language system (Leopold, 1954; Vihman, 1985; Volterra & Taeschner, 1978) that becomes differentiated over the course of development. In contrast, more recent theoretical approaches posit that bilinguals have a differentiated language system from the beginning (Genesee, 1989; Werker & Byers-Heinlein, 2008). Understanding how the two languages become differentiated in bilingual children remains a central question in the field of language acquisition.

Drawing from our current understanding of adult bilingualism, this paper proposes that bilinguals differentiate their languages insofar as they can treat elements from their languages as belonging to different categories. Two types of language categorization are distinguished: perceptual categorization and conceptual categorization (Mandler, 2000; 2003). Perceptual categorization is based on sensitivities to observable differences between languages (e.g., rhythm), and emerges very early in development. Building from perceptual categorization abilities, conceptual categorization is based on more abstract language knowledge, and emerges later in development. This reframing of the "one language or two" debate invites a reconsideration of previous research findings, points to novel empirical directions for studying language differentiation in children, and motivates a discussion of how language categories might develop.

Bilingual Adults: One Language System or Two?

One starting point for understanding language differentiation in children is to ask to what extent bilingual adults have "two language systems". The earliest theories of bilingualism posited that bilingual adults' two languages were independently represented, and could be separately switched on and off (Macnamara, 1967; Penfield & Roberts, 1959). Subsequent models of the bilingual lexicon proposed that words in each language were represented in separate stores, but that words from the two languages accessed a common store of conceptual representations (Kroll & Stewart, 1994).

Although these were reasonable starting hypotheses, decades of research have demonstrated that they do not fully characterize the adult bilingual mind. Studies have

revealed that adults cannot choose to "turn off" one of their languages. Instead bilingual language access is often non-selective, and languages interact at every level (for a recent review see Kroll, Dussias, Bogulski, & Kroff, 2011). In light of these discoveries, it is inaccurate to say that bilingual adults represent their languages within two fully encapsulated language systems (see also J. Paradis, 2001a for related arguments).

Yet, there are still many different current proposals for how bilinguals' languages are represented. For example, Green's Inhibitory Control model (1998) and the Bilingual Interactive Activation Plus model (BIA+; Dijkstra & Van Heuven, 2002) propose that words are represented in a common store with a language tag that tells the system what language a word belongs to.

In contrast, self-organizing connectionist models do not feature explicit language tags or separate language stores (Li, 1998; Li & Farkas, 2002; Shook & Marian, 2013; Zhao & Li, 2010). Instead, words and sounds from different languages cluster in different topographic areas of the representational spaces, and this organization emerges organically from the statistical structure of the input.

Another model, BIMOLA (Bilingual Model of Lexical Access), posits that bilinguals' languages (including words, phonemes, and features) form independent subsystems which are situated within a larger interconnected language system (Grosjean, 1988; 1997). Bilinguals can operate in different language modes (e.g., a monolingual versus a bilingual mode) by modulating whether one or both language systems are activated.

There are similar debates in the field of bilingual sentence processing. Current models vary considerably as to whether the two languages have shared versus separate

syntactic representations, although all models recognize interactivity between the languages (Hartsuiker & Pickering, 2008).

Languages as Categories in Adulthood While there is disagreement about whether bilingual adults *represent* their languages in two separate language systems, what is uncontroversial is that bilingual adults are able to *functionally* separate their languages. Bilingual adults can speak one language or the other at will (Grosjean, 2001). They can treat the sounds, words, and utterances of one language as being different from the sounds, words, and utterances of the other language. Indeed, functional language differentiation is in some way built into all models of adult bilingualism: through separate language systems, language tags, or language clusters. This suggests that language differentiation should be operationally defined in terms of what bilinguals can do with their languages, rather than how they represent them.

Here, a novel behavioral definition for language differentiation is proposed: the ability to treat elements (e.g., sounds, words, and utterances) of different languages as belonging to different categories. Categorization is a topic that has been extensively studied, but rarely considered with respect to bilinguals' two languages. To categorize is defined as to "render discriminably different things equivalent, to group objects and events and people around us into classes, and to respond to them in terms of their class membership rather than their uniqueness," (Bruner, Goodnow, & Austin, 1956), and to "treat a set of things as somehow equivalent: to put them in the same pile, or to call them by the same name, or respond to them in the same way," (Neisser, 1987). Different languages form distinct systems of communication, such that words and

utterances produced by monolingual speakers can be categorized as belonging to one language or another [1]. Bilingual adults respond to languages "in terms of their class membership", for example, by replying in English when addressed in English, in other words producing an utterance that is in the same language category.

Numerous lines of experimental research support the idea that bilingual adults can use their languages as functional categories. For example, interlingual homographs are words with identical spelling across two languages, but different pronunciations and meanings (e.g., "four" which refers to a number in English, and an oven in French). Bilingual adults can read interlingual homophones differently depending on their purported language – French or English (Beauvillain & Grainger, 1987; Dijkstra, Grainger, & Van Heuven, 1999). In other words, bilingual adults can respond to identical visual stimuli differently according to their language category.

Language switching studies also provide a clear demonstration that bilingual adults operate on their languages as categories. In Meuter and Allport's (1999) classic study, bilingual adults were asked to name numbers displayed on a computer screen. The color of the background signaled which language to respond in, for example a blue background for English, and a yellow background for French. Trials were designated either switch or non-switch trials as a function of whether the preceding trial was in a different language (switch) or in the same language (non-switch). Participants responded slower on switch than on non-switch trials. This processing cost for language switching has been replicated across numerous studies of language production (Costa &

[1] Although for very close language varieties, this might not be possible for every word or utterance.

Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006), reading (Grainger & Beauvillain, 1987; Thomas & Allport, 2000), and auditory comprehension (Abutalebi et al., 2007; Proverbio, Leoni, & Zani, 2004). Such studies demonstrate that adults perform poorer when adjacent stimuli come from different language categories than from the same language categories. If words from different languages were completely equivalent to bilingual adults (i.e., they were not from different categories), there would be no basis for a language switching cost.

Other experiments show that adults can use language categories to interpret sublexical information such as speech sounds. Gonzalez and Lotto (2013) had adult participants listen to a continuum of nonsense words whose first sound spanned a range of voice onset time values, from /pafri/ to /bafri/. In one condition, participants were told that the words were Spanish and the /r/ was pronounced in a Spanish manner. In a different condition, participants were told that the words were English and the /r/ was pronounced in an English manner. Bilinguals, but not monolinguals, changed their perception of the initial consonant depending on the condition. They perceived ambiguous sounds in a Spanish manner in the Spanish condition, and in an English manner in an English condition. Thus, identical stimuli were perceived differently depending on whether participants were acting within the category of “English” or “Spanish”. In sum, multiple lines of research demonstrate that bilingual adults use language categories in their comprehension and production of language.

Languages as Categories in Infancy and Childhood

What evidence is there that children can treat elements of their languages as belonging to different categories? Numerous studies addressing the "one language or two" question have tested whether bilingual children can selectively produce the sounds (Poulin-Dubois & Goodz, 2001), words (L. Arnberg & Arnberg, 1985; Genesee, 1989; Genesee & Nicoladis, 2001; Nicoladis & Genesee, 1996) and constructions (De Houwer, 1990; Meisel, 2001; 2008) of each language in contextually-appropriate ways. For example, studies have investigated whether bilingual children tend to use words from a single language within a single utterance, or whether they code switch indiscriminately. These studies have complicated pattern of results which have been discussed at length elsewhere, but most researchers argue that they provide evidence for early differentiation (Genesee, 1989).

While many studies observe children's natural productions, other studies have taken an experimental approach. For example, Paradis (2001b) tested 30-month-old French-English bilinguals on a non-word repetition task. Children showed different patterns of syllable omissions and truncations as a function of the language of testing, suggesting that the purported language of the word influenced children's productions. In another study, Genesee and colleagues (1996) observed bilingual children's interactions with monolingual adults who spoke each of their languages. Although bilingual children did not exclusively produce words in the adult interlocutors' respective languages, they did vary the proportion of words in each language to somewhat match the adults' languages.

Children's successful use of the language that matches the situation has been called "pragmatic differentiation" (Nicoladis, 1998). Pragmatic differentiation constitutes evidence that bilingual children can treat their languages as different categories, as it shows that they can selectively produce utterances from one language category as opposed to the other. However, issues of performance often make it difficult to evaluate children's underlying competence. As Genesee (1989) has pointed out, there may be many reasons why bilingual children mix their languages, including lack of lexical knowledge, norms of code mixing in their communities, and children's language dominance. Younger children are especially difficult to study using these approaches, as they often produce little speech, and their performance is particularly affected by factors unrelated to competence. Thus, a lack of pragmatic differentiation does not necessarily imply that children *cannot* treat elements of their languages as belonging to different categories.

Another frequent approach to investigating early language differentiation has been to assess children's knowledge of translation equivalents (cross-language synonyms). The reasoning is as follows: if bilingual children initially have a unitary language system, then once they have learned a particular word, they will be unmotivated to learn and/or use its translation. In this view, children's lack of translation equivalents would signal a failure to differentiate their languages. Some studies have found that bilingual children know a paucity of translation equivalents (Volterra & Taeschner, 1978), while other studies have found that they know translation equivalents from early in development (De Houwer, Bornstein, & De Coster, 2006;

Holowka, Brosseau-Lapre, & Petitto, 2002; Junker & Stockman, 2002; Pearson, Fernández, & Oller, 1995). However, the interpretation of these studies rests on the assumption that monolingual and bilingual children share the same approaches to word learning. It is well-demonstrated that monolingual children avoid learning two words with the same meaning and expect novel words to have novel meanings (Clark, 1988; Halberda, 2003; Markman & Wachtel, 1988). However, bilinguals do not always use this word learning strategy from the same age as monolinguals (Byers-Heinlein & Werker, 2009; 2013; Houston-Price, Caloghiris, & Raviglione, 2010). Bilingual children's successful learning of translation equivalents could reflect the absence of this word learning strategy, rather than a lack of knowledge that words come from two different language categories.

Other research has investigated infants' capacity to discriminate their languages – a skill foundational to language categorization. For example, one study investigated newborn infants' discrimination of different languages, comparing newborns with monolingual English and bilingual English-Filipino prenatal exposure (Byers-Heinlein et al., 2010). Infants sucked on a pacifier connected to a computer, which played a sentence every time they produced a strong suck. Infants were habituated to sentences from one language (e.g., English) until their sucking rate declined. At test, infants heard either sentences from the habituated language (English), or sentences from the other language (Filipino). Both monolingual and bilingual infants increased their sucking to the novel language at test, showing that they detected the change. These results replicated previous studies with monolingual newborns, showing that even very young

infants are able to discriminate languages that differ rhythmically (Mehler et al., 1988; Nazzi, Bertoncini, & Mehler, 1998). By age 3-5 months, infants from both monolingual and bilingual backgrounds can discriminate between sentences of rhythmically similar languages (Bosch & Sebastián-Gallés, 1997; 2001b; Molnar, Gervain, & Carreiras, 2013; Nazzi, Jusczyk, & Johnson, 2000). They are also sensitive to visual information available on the lips and face that distinguishes sentences of different languages (Sebastián-Gallés et al., 2012; Weikum et al., 2007).

Despite infants' impressive language discrimination skills, it is unclear whether such studies indicate that bilingual infants actually represent language categories. Early language discrimination is often attributed to infants' innate perceptual sensitivities to rhythm and prosody (Nazzi et al., 1998). Theorists in the field of conceptual development have made the distinction between perceptual and conceptual categorization (Mandler, 2000; 2003). Perceptual categorization is based on observable features, whereas conceptual categorization is based more on abstract, non-observable properties. Studies of language discrimination show that young bilingual infants can form perceptual language categories, but they do not necessarily reveal the operation of conceptual language categories (see also Bosch & Sebastián-Gallés, 2001a). A parallel example can be found in grammatical development. Newborn infants can readily discriminate between perceptual features that distinguish function words (e.g., prepositions, pronouns) from content words (Shi, Werker, & Morgan, 1999). However, this is not taken as evidence that newborn infants have a conceptual understanding of how these particular sounds relate to different grammatical categories. Instead, such

perceptual sensitivities might bootstrap later conceptual knowledge. This point will be discussed further in the next section.

A second issue is that most discrimination studies have used full sentences as stimuli, so they do not address infants' categorization of smaller units of language such as words. To date, there have been few studies investigating whether young bilinguals are sensitive to language differences at the word level (but see Conboy & Mills, 2006; Vihman, Thierry, Lum, Keren-Portnoy, & Martin, 2007 for related work). However, in one study, Kuipers and Thierry (2012) tested English monolingual and Welsh-English bilingual children's word-based language discrimination in an event related potential (ERP) study. Children saw a series of pictures that were labeled (e.g., a picture of a duck labeled "duck"). In an oddball paradigm, most trials were presented in one language (e.g., Welsh), but a few trials were presented in the other language (e.g., English). Both monolinguals' and bilinguals' brains detected the change in the stimulus language within 300ms, showing different brain responses to same-language trials versus change trials. However, these results were somewhat different from those of bilingual adults (Kuipers & Thierry, 2010). Adults showed an early brain response similar to what infants had shown, but they also showed a later brain response that is usually associated with semantic integration. The authors concluded that while children might detect the phonetic cues associated with language change, the bilingual adults had also responded according to their metalinguistic knowledge of the two languages. Thus, it is not clear whether the results with bilingual children point to early perceptual categories, or adult-like conceptual categories.

New research approaches are needed for testing whether young bilinguals have conceptual language categories. Studies of bilingual adults provide some inspiration. The adult studies discussed in the previous section manipulated participants' language mode, either with an implicit or an explicit cue. For example, these studies asked participants to read either "English" or "French" words which happened to be interlingual homographs, to name a number in one language or the other as a function of background color, or to categorize a sound when given implicit and explicit cues to a word's language. Research with infants could take a similar approach, by first cueing infants to a particular language, and then testing whether infants can treat identical stimuli differently depending on the cued language category. For example, our lab has compared 20-month-old French-English bilinguals' comprehension of nouns presented in single-language sentence frames ("Find the dog!") to code-switched sentences wherein the carrier phrase cued infants to expect the other language ("*Trouve le* dog!"). Our preliminary results suggest that infants were less accurate to look at the named picture on code-switched sentences than on single-language sentences (Byers-Heinlein, 2013a). This provides evidence for infants' use of languages as categories.

The Emergence of Language Categories

Regularities in the world support the emergence of mental categories (Sloutsky, 2010). Language is a system replete with regularities, and for individuals in bilingual environments, many of these regularities correspond to the languages in the input. English words are likely to be adjacent to other English words. They are composed of English sounds, follow English phonotactic rules, take English morphological endings,

and are heard in sentences with English prosody. Bilingual adults' language categories likely reflect their knowledge of these regularities. It is important to consider both when young bilinguals have knowledge of language categories, as well as how this knowledge might emerge in development.

One way to consider the development of bilingual children's language categories is in the context of the PRIMIR (Processing Rich Information in Multidimensional Interactive Representations) framework of early speech perception and word learning (Curtin & Werker, 2007; Curtin, Byers-Heinlein, & Werker, 2011; Werker & Curtin, 2005). PRIMIR starts from the observation that the speech stream is a rich signal replete with regularities. This information is processed and represented within three spaces: the general perceptual space, the word form space, and the phoneme space. The general perceptual space stores phonetic information (e.g., [b] versus [p]) and indexical information (e.g., male versus female), which over time forms similarity-based clusters that support phonetic and indexical categories. The word form space stores sound-sequence exemplars, which eventually become linked to word meanings. These linkages in turn support the development of the phoneme space, in which abstract phoneme-like categories emerge to summarize across variation that is irrelevant to word meanings. Domain general learning mechanisms support information pick-up, and alter representations within the spaces. Information processing is directed by three dynamic filters: innate perceptual biases, task demands, and infants' developmental level.

Recently, we extended the PRIMIR framework to include bilingual infants (Curtin et al., 2011). Like monolingual infants, bilingual infants bring perceptual sensitivities and powerful learning mechanisms to their rich bilingual input. Perceptual biases and learning mechanisms together detect and organize language information within the three perceptual spaces, and this in turn is proposed to support the formation of language categories. Elements from each language cluster together within the representational spaces due to shared features, which is similar to what has been described in other self-organizing connectionist models of bilingual adults' language comprehension (Shook & Marian, 2013).

As discussed in the previous section, bilingual infants have early-emerging perceptual sensitivities that support language discrimination. Bilingual infants respond to rhythmic differences between languages in both auditory (Bosch & Sebastián-Gallés, 1997; 2001b; Byers-Heinlein et al., 2010; Molnar et al., 2013) and visual (Sebastián-Gallés et al., 2012; Weikum et al., 2007) modalities. Further, they are sensitive to phonetic information (Sundara, Polka, & Molnar, 2008) and phonotactic distinctions that could also support language discrimination (Sebastián-Gallés & Bosch, 2002). It is likely that bilingual infants are also sensitive to other perceptual differences between their languages that have not yet been enumerated (see Kyle Danielson, Seidl, Onishi, Alamian, & Cristià, 2014, for a study of acoustic information available in bilingual infant-directed speech). These perceptual sensitivities could support early perceptual language categories, which would be foundational for the development of conceptual language categories.

Statistical learning mechanisms would also play an important role in infants' development of conceptual language categories, which by definition incorporate abstract knowledge. Numerous studies have suggested that even young infants are sensitive to co-occurrence and distributional patterns of words (Gerken, Wilson, & Lewis, 2005), syllables (Saffran, Aslin, & Newport, 1996), and sounds (Maye, Werker, & Gerken, 2002). For example, it has been proposed that frequent frames (pairs of jointly occurring words with another word intervening) might induce children to categorize the words that occur within those frames (Chemla, Mintz, Bernal, & Christophe, 2009; Mintz, 2003). Given that words from a particular language are likely to co-occur, sensitivity to these statistical regularities might also support bilinguals' categorization of words as belonging to different languages.

In sum, infants can use early-emerging perceptual sensitivities to detect perceptual language categories (i.e., perform language discrimination). Conceptual language categorization requires language knowledge and representations, and would be supported once the languages form clusters in infants' representational spaces. These language clusters would emerge as infants' perceptual sensitivities and learning mechanisms detect, process, and represent regularities in the input that covary with language categories. An important point is that conceptual language categorization might not develop for all aspects of language on the same schedule. For example, language clusters might emerge in the word form space before they emerge in the phoneme space, or vice versa. Further, in PRIMIR, infants' performance on any language task will depend on the nature of the task, infants' developmental level, and the

particular representational spaces being accessed. The same principle will likely hold for language categorization tasks.

In PRIMIR, representational spaces do not act independently, but dynamically inform each other to direct processing. Accordingly, it is important to understand how young bilinguals integrate different sources of information about the nature of their two languages. In one study, Gervain and Werker (2013) showed that bilingual infants can flexibly use prosodic information as a cue for appropriately segmenting the speech stream. Their study tested 7-month-old bilingual infants, who had been exposed from birth to two languages with different characteristic word orders (verb-object and object-verb). Infants listened to a stream of nonsense syllables that could be parsed in two different ways, depending on whether that stream was construed as being from a verb-object language or an object-verb language. When given prosodic cues (pitch and duration) known to correlate with a language's word order, bilingual infants flexibly parsed the speech stream in the way that corresponded with the cue. However, monolingual infants could only parse the stream in a manner consistent with their native language. This demonstrates how bilinguals could detect and apply correlated perceptual cues in interpreting information from different language categories, and bootstrap across different language elements.

Conclusions

Researchers have long sought to answer the question of whether young bilinguals have "one language system or two", and when they differentiate their languages. This paper argues that bilinguals can be said to differentiate their languages

when they can treat elements from their languages as belonging to different categories. This reframing yields several theoretical advances. First, it provides an operational definition for language differentiation, which can be applied to language at multiple levels, from sounds, to words, to whole utterances. Second, it disentangles questions of how bilinguals use language categories from questions of how they represent them. Third, it provides a common way of considering language differentiation across development from infancy to adulthood. Fourth, it links together diverse lines of research with bilingual children and adults, and points to new research directions. Finally, it provides a context for considering how language differentiation might emerge developmentally.

The ultimate answer to the question of when and how bilinguals develop the ability to categorize their languages is almost certain to be complex. This discussion has distinguished perceptual language categorization from conceptual language categorization, but both of these are likely different from explicit metalinguistic awareness that there are two languages. Further, language categories at different levels (e.g., words versus sounds) are likely to emerge at different points in development. Whether this occurs in rapid succession during early infancy or shows a more protracted developmental course is an open question. It is also possible that there will be individual differences as a function of the particular language pair being learned, the absolute and relative amounts of exposure to each language, whether input comes from monolingual or bilingual speakers, and the prevalence of language mixing in the environment (Byers-Heinlein, 2013b), amongst other factors (see also M. Paradis, 2004 for a related

discussion). Research is needed not only to pinpoint when different language categorization abilities emerge, but also how they develop, and to investigate the representations that underlie language categories in both children and adults.

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