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Interpreting phonological memory performance in bilinguals

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The central hypothesis in the Pierce, Genesee, Delcenserie, and Morgan article is that phonological memory is key to explaining the relationship between early language experience (more specifically, less and more optimal ends of the language-experience continuum) and language learning outcomes. One piece of evidence offered is that phonological memory skills are enhanced by bilingualism, with bilingualism representing enriched experience. Here, I propose that data from bilingual children may contradict Pierce et al.'s central hypothesis, rather than support it.

The findings of the so-called bilingual advantages for phonological memory are relatively rare in the literature. A large number of studies documented bilingual *disadvantages* on phonological memory tasks (e.g., Buac, Gross, & Kaushanskaya, 2016; Masoura & Gathercole, 1999; Michas & Henry, 1994; Thorn & Gathercole,

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1999). When advantages are found, they appear to be limited to very specific subsets of bilinguals (i.e., ones who are in the process of gaining proficiency in their second language) and to a very select set of tasks (i.e., those that load more heavily on the central executive rather than the storage component of the working memory system; Kaushanskaya, Gross, & Buac, 2014; Kudo & Swanson, 2014; Yoo & Kaushanskaya, 2012).

The bilingual literature therefore highlights the need to carefully consider the terminology one uses when talking about phonological memory, because conflation of working memory and short-term memory measures (the way Pierce et al. do) is deeply problematic both for theory building (most models/theories of working memory distinguish between the two; Baddeley, 2003; Engle, Tuholski, Laughlin, & Conway, 1999; Kail & Hall, 2001; Kane, Bleckley, Conway, & Engle, 2001), and for interpretation of research findings (the easier storage-only tasks behave differently than the more difficult storage+processing tasks, at least for bilinguals).

However, even if we accept the premise that bilingual experience may enhance phonological memory function, the argument that early experience influences language outcomes through phonological memory still falls short. This is because whatever the influences of bilingualism are on phonological memory, bilingual experiences do *not* appear to enhance children's language outcomes. Bilingual children have repeatedly been found to score below their monolingual peers (e.g., Bialystok, Luk, Peets, & Yang, 2010) or below monolingual norms (e.g., Fernandez, Pearson, Umbel, Oller, & Molinetmolina, 1992; Pearson, Fernandez, & Oller, 1993; Umbel, Pearson, Fernandez, & Oller, 1992) on single-language vocabulary measures in one or both of their languages. Of course, when vocabulary knowledge in both languages is taken into account, bilingual/monolingual differences in vocabulary can disappear (Pearson et al., 1993), but they do not always (Gross & Kaushanskaya, 2014). However, for the Pierce et al. argument to work, it has to be the case that enhancements in phonological memory are associated with enhancements in language, and this is simply not the case for bilinguals (unless one defines enhancements in language as metalinguistic in nature, thus conflating language and executive-function tasks).

Another set of findings in the bilingualism literature, the link between phonological memory performance and language ability (or proficiency), also goes against the hypothesis that phonological memory is at the root of the effects that language experience has upon the language system. Phonological memory tasks by their very nature are nearly always language-specific, and as Pierce et al. point out, bilinguals' proficiency in the target language is consistently associated with performance on such tasks (e.g., Masoura & Gathercole, 1999; Michas & Henry, 1994; Thorn & Gathercole, 1999). However, it cannot be the case that the relationship between phonological memory and language proficiency stems from the effects of phonological memory on language proficiency, at least in sequential bilinguals. Instead, it must be that language knowledge constrains phonological memory performance. This is because in bilinguals who are in the process of acquiring their second language, the phonological memory system is already in place (via native language acquisition). Thus, unless one were to propose formation of two different phonological memory systems each supporting acquisition in bilinguals' two languages, the relationship between second language proficiency and performance on

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phonological memory tasks administered in the second language must stem from the influences of language knowledge upon phonological memory performance (and not vice versa).

Such a conceptualization of the relationship between language knowledge and phonological memory is consistent with theoretical views of working memory other than Baddeley's. For example, Cowan (1988) suggested that working memory involves activation of information in long-term memory, and that selection of specific information within the activated space is accomplished via an attention-based process. However, even Baddeley's model presupposes participation of language knowledge (stored in long-term memory) and attention (through the central executive) in performance on phonological *working* memory tasks. Viewed in this way, data from bilingual children (as well as from children with less optimal language experiences and the corresponding language and phonological memory difficulties) may be interpreted to suggest that experience influences the formation of linguistic representations and attentional mechanisms, and it is the interaction between them that gives rise to performance on phonological memory tasks.

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Beyond typical learning: Variation in language experience as a lens to the developing mind

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Infants are exposed to the language of the environment in which they are born and, in most instances, become native speakers of that language. Although the history of research on language acquisition provides a colorful debate on the specific ways that nature and nurture shape this process (e.g., MacWhinney, 1999; Pinker, 1995), its primary focus has been on typically developing children exposed to a single language from birth. Pierce, Genesee, Delcenserie, and Morgan (2017) turn the table on this discussion to argue that critically important lessons can be learned by shifting the focus from typically developing children to children for whom the trajectory of language learning follows a different course. Some of the variation in language development reflects attributes of child learners themselves, such as whether they are born hearing or deaf and whether they have conditions that disrupt their ability to fully perceive the speech input to which they are exposed. Other variations reflect attributes of the external conditions in which learners develop, including whether they remain in their country of birth or move to a location in which another language is spoken, whether exposure to the native language is continuous or disrupted, and whether they are exposed to a second language (L2) early or late in development. For deaf children, there is also variation in whether their parents or caregivers are themselves deaf or hearing and able to expose them to sign language during infancy. Pierce et al. use the diversity of early language experience as a tool to examine the relation between phonological working memory and language development and to begin to suggest how conditions that may produce costs or benefits in language learning may be related to one another.

The approach taken by Pierce et al. (2017) is ambitious. They exploit a comparison across groups of children whose trajectory of language learning varies widely as a means to identify a feature of the cognitive/linguistic interface that emerges as

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