Pearson, B. Z., Fernandez, S. C., & Oller, D. K. (1993). Lexical development in bilingual infants and toddlers—Comparison to monolingual norms. *Language Learning, 43*, 93–120.

Pierce, L. J., Genesee, F., Delcenserie, A., & Morgan, G. (2017). Variations in phonological working memory: Linking early language experiences and language learning outcomes. *Applied Psycholinguistics, 38*, 1265–1302.

Thorn, A. S. C., & Gathercole, S. E. (1999). Language-specific knowledge and short-term memory in bilingual and non-bilingual children. *Quarterly Journal of Experimental Psychology*, *52A*, 303–324.

Umbel, V. M., Pearson, B. Z., Fernandez, M. C., & Oller, D. K. (1992). Measuring bilingual children's receptive vocabularies. *Child Development, 63*, 1012–1020.

Yoo, J., & Kaushanskaya, M. (2012). Phonological memory in bilinguals and monolinguals. *Memory & Cognition, 40*, 1314–1330.

Margarita Kaushanskaya
University of Wisconsin–Madison

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

doi:10.1017/S0142716417000315

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

central in all cases, the relationship between phonological working memory and language development itself. Although a causal model for relating working memory and language is not readily available, the correlational patterns observed under these different conditions provide an initial basis on which to generate hypotheses that may guide future research. Children who are denied an opportunity to fully acquire the phonology of the native language reveal deficits in phonological working memory that undermine other aspects of language development, including vocabulary and aspects of the morphosyntax. In contrast, bilingual children who acquire and achieve proficiency in two languages from early childhood reveal advantages in working memory relative to their monolingual native language speaking counterparts. Critically, regardless of whether the early stages of language learning are altered relative to the typical trajectory, most children achieve adequate general language performance, suggesting that there may be many different routes to the same end. A fascinating aspect of the Pierce et al. discussion considers how alternative compensatory processes may be engaged, particularly under conditions of early disruption.

Recent studies of L2 learning and bilingualism in young adults converge with the conclusion that the native speaker model is limited in its ability to account for variation in patterns of language learning and in the dynamic state of language processes in mature speakers who are already proficient in all of the languages that they speak (e.g., Emmorey, Geizen, & Gollan, 2016; Kroll, Dussias, Bice, & Perrotti, 2015; Kroll & Navarro-Torres, in press). As Grojean (1989) observed many years ago, proficient bilinguals are not two monolinguals in one. The native language changes in response to learning and using an L2, with a continual flow of cross-language activation that influences not only language processing but also the cognitive resources that are engaged during language use (e.g., Green & Abutalebi, 2013). A persistent question in the research on L2 learners and bilinguals also aligns with the question raised by Pierce et al. (2017) about the direction of causality: are cognitive resources required to enable language learning or do those cognitive resources develop as a consequence of language learning? The evidence on adult L2 learners and bilinguals, like the research on child learners, suggests interactions in both directions. Individual differences in working memory and executive function ability appear to modulate the course of L2 language learning and processing (e.g., Linck, Osthus, Koeth, & Bunting, 2014; Pivneva, Mercier, & Titone, 2013), but there are also consequences of L2 use that come to modify the neural networks that support cognitive control (e.g., Abutalebi & Green, 2016; Bialystok, 2017).

The course of initial language learning in children exposed to two languages from birth illustrates the two sides of variation. From one perspective, and one that historically has been misinterpreted (e.g., Kroll & Dussias, 2016), bilingually exposed children have been thought to be confused by the presence of two languages because their initial learning trajectory differs from that of monolingually exposed children (e.g., Werker & Byers-Heinlein, 2008). However, the evidence suggests that not only do these children succeed in language learning but early exposure to two languages from birth tunes mechanisms for memory flexibility and attentional control (e.g., Brito & Barr, 2012; Pons, Bosch, & Lewkowicz, 2015; Sebastian-Galles, Albareda-Castellot, Weikum, & Werker, 2012) that may later enhance cognition and new language learning. It is not clear how these attentional

and memory mechanisms relate precisely to phonological working memory, but the evidence is compelling that early delays relative to a typical standard do not predict later language and cognitive performance.

A goal of research for both child and adult language learning will be to develop models that isolate the course and consequence of the interactions between cognitive resources and language learning. Critically, it will be important to understand how the effects of age of acquisition constrain or enable these interactions, and whether constraints, when they exist, are attributable to domain-general learning mechanisms or to language learning specifically. The enduring consequences of early exposure, even when interrupted by a shift in language context, as is the case for many international adoptees or deaf children, suggest that the initial tuning of speech or sign opens the networks that enable language learning and perhaps learning more generally across the life span.

There is a curious paradox in the past research that surfaces in the Pierce et al. (2017) review and that may merit additional consideration. Deficits in vocabulary knowledge have been reported for child learners across the varied groups for whom some disruption was present during the first years of life and also for bilinguals for whom the competition between the two languages early in life may create costs in the domain of lexical retrieval. At the same time, studies of adult word learning provide clear evidence that bilinguals are better word learners than monolinguals and that early bilinguals, in particular, may reveal more robust advantages in new learning (e.g., Kaushanskaya & Marian, 2009). How can variation in language experience produce a deficit and a benefit at the same time? Is it all a reflection of phonological working memory? As Pierce et al. note, there may be a range of compensatory mechanisms in place that enable language learning even when the initial trajectory of language development has been altered. If learners miss some or all aspects of early exposure during a hypothesized sensitive period, other mechanisms may provide compensatory support. That support may involve cognitive processes that would not otherwise be primary at the time of learning or later opportunities to reopen the mechanisms at play during the sensitive period. Recent training studies of adult language learners provide evidence for remarkable plasticity, even for older adults (e.g., Bak, Long, Vega-Mendoza, & Sorace, 2016).

An appealing hypothesis is that variation in language exposure may tune the neural networks that enable language regulation and control in specific ways that, depending on both the individual and the context of learning, may have positive consequences when generalized to new learning. Variation in exposure may induce processing costs and deviation to the initial trajectory of language learning, but at least some of those costs may be countered by later benefits. A long history of research on learning and memory on desirable difficulties demonstrates the benefits of learning conditions that tax cognitive resources in ways that enhance understanding and provide opportunities for self-regulation (e.g., Bjork & Bjork, 2014). Variation in learning has itself been identified as a desirable difficulty, producing costs during initial study of novel material but benefits at later test. We know little at this point about how these domain-general cognitive mechanisms are engaged during language learning and use and how they may play a role in training studies that aim to re-create the plasticity available early in life. Acknowledging the possibilities for new learning afforded by differences among individuals and across contexts

of learning provides a much richer framework for understanding language development and its consequences than the dichotomous categories of typical versus atypical. The focus on variation that is the theme in the Pierce et al. (2017) target article would seem to be precisely the right context for conceptualizing the next stage of research. The new methods available to examine language learning and its cognitive and neural underpinnings are likely to realize the promise of this approach.

ACKNOWLEDGMENTS

The writing of this paper was partially supported by NIH Grant HD082796 and NSF Grants BCS-1535124 and OISE-1545900 (to J.F.K.).

REFERENCES

Abutalebi, J., & Green, D. W. (2016). Neuroimaging of language control in bilinguals: Neural adaptation and reserve. *Bilingualism: Language and Cognition, 19*, 689–698.

Bak, T. H., Long, M. R., Vega-Mendoza, M., & Sorace, A. (2016). Novelty, challenge, and practice: The impact of intensive language learning on attentional functions. *PLOS ONE, 11*, e0153485.

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143*, 233.

Bjork, E. L., & Bjork, R. A. (2014). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher & J. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society* (2nd ed., pp. 59–68). New York: Worth.

Brito, N., & Barr, R. (2012). Influence of bilingualism on memory generalization during infancy. *Developmental Science*, *15*, 812–816.

Emmorey, K., Giezen, M. R., & Gollan, T. H. (2016). Psycholinguistic, cognitive, and neural implications of bimodal bilingualism. *Bilingualism: Language and Cognition*, *19*, 223–242.

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*, 515–530.

Grosjean, F. (1989). Neurolinguists, beware! The bilingual is not two monolinguals in one person. *Brain and Language*, *36*, 3–15.

Kaushanskaya, M., & Marian, V. (2009). The bilingual advantage in novel word learning. *Psychonomic Bulletin & Review, 16*, 705–710.

Kroll, J. F., & Dussias, P. E. (2016). *Language and productivity for all Americans: What are the benefits of multilingualism to the personal and professional development of residents of this country?* Cambridge, MA: American Academy of Arts and Sciences.

Kroll, J. F., Dussias, P. E., Bice, K., & Perrotti, L. (2015). Bilingualism, mind, and brain. *Annual Review of Linguistics*, *1*, 377–394.

Kroll, J. F., & Navarro-Torres, C. (in press). Bilingualism. In J. Wixted (Ed.), *The Stevens' handbook of experimental psychology and cognitive neuroscience: Section IV. Language and thought*. Hoboken, NJ: Wiley/Blackwell.

Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin & Review*, *21*, 861–883.

MacWhinney, B. (1999). *The emergence of language*. London: Taylor & Francis.

Pierce, L. J., Genesee, F., Delcenserie, A., & Morgan, G. (2017). Linking early language experiences and language learning outcomes. *Applied Psycholinguistics, 38*, 1265–1302.

Pinker, S. (1995). *The language instinct: The new science of language and mind* (Vol. 7529). London: Penguin.

Pivneva, I., Mercier, J., & Titone, D. (2014). Executive control modulates cross-language lexical activation during L2 reading: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*, 787–796.

Pons, F., Bosch, L., & Lewkowicz, D. J. (2015). Bilingualism modulates infants' selective attention to the mouth of a talking face. *Psychological Science, 26*, 490–498.

Sebastián-Gallés, N., Albareda-Castellot, B., Weikum, W. M., & Werker, J. F. (2012). A bilingual advantage in visual language discrimination in infancy. *Psychological Science*, *23*, 994–999.

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

Judith F. Kroll, Andrea Takahesu Tabori, and Emily Mech
University of California, Riverside

Working memory and language: From phonology to grammar

doi:10.1017/S0142716417000327

Pierce, Genesee, Delcenserie, and Morgan (2017) are right to suggest that working memory is a crucial part of the machinery underlying linguistic development. In this brief commentary, I will move beyond the emergence of phonological representations, on which Pierce et al.'s essay focuses, and consider ways in which working memory shapes the character and acquisition of grammatical phenomena, a topic that has been explored in various ways in the recent literature (e.g., Chater & Christiansen, 2010; Hawkins, 2014; O'Grady, 2005, 2015).

A first illustration of the role of working memory in grammar involves the typology of word order and the question of why verb-initial and verb-medial languages such as English favor prepositions over postpositions, whereas the reverse preference is found in verb-final languages such as Korean.

(1) a. English: **at** school
b. Korean: hakkyo-**eyse** school-at

A promising explanation, developed in detail by Hawkins (2014), is that each language type seeks to reduce the burden on working memory by minimizing the distance between the verb and the pre/postposition with which it is associated.

(2) Maximally economical (and typologically common)
a. Prepositions in a V-initial/medial lg. b. Postpositions in a V-final lg.

stud*y* [***at*** *school*]
V P

[*school* ***at***] ***study***
P V