Journal Club

Editor's Note: These short reviews of recent *JNeurosci* articles, written exclusively by students or postdoctoral fellows, summarize the important findings of the paper and provide additional insight and commentary. If the authors of the highlighted article have written a response to the Journal Club, the response can be found by viewing the Journal Club at www.jneurosci.org. For more information on the format, review process, and purpose of Journal Club articles, please see http://www.jneurosci.org/content/jneurosci-journal-club.

The Early Language Environment and the Neuroanatomical Foundations for Reading

Gabrielle-Ann A. Torre,[1,2] Cameron C. McKay,[1,2] and Anna A. Matejko[1]

[1]Center for the Study of Learning, Department of Pediatrics, Georgetown University Medical Center, Washington, DC 20007, and [2]Interdisciplinary Program in Neuroscience, Georgetown University, Washington, DC 20057

Review of Romeo et al.

The early language environment provides children with an understanding of many important aspects of language, such as grammar, vocabulary, and print concepts (Scarborough, 2001). Knowledge of these language components provides a foundation for nearly all forms of later communication and is especially critical for the acquisition of later academic skills such as literacy (Scarborough, 1990). However, the effects of oral language experience are difficult to disentangle from those of socioeconomic status (SES), as SES is related to the quantity and quality of child–parent verbal interactions (Hoff et al., 2002; Rowe et al., 2005; Huttenlocher et al., 2007). As a result, it is critical to take SES into account when examining the role of early language experience on the developing brain. Yet, previous research has rarely considered these factors together, and the precise role of the early language environment and SES on the neuroanatomical structures supporting language has remained unclear.

Received Nov. 12, 2018; revised Dec. 18, 2018; accepted Dec. 21, 2018.

We thank Dr. Guinevere F. Eden, for thoughtful suggestions and comments.

The authors declare no competing financial interests.

Correspondence should be addressed to Gabrielle-Ann A. Torre at gat35@georgetown.edu.

https://doi.org/10.1523/JNEUROSCI.2895-18.2018

A recent study by Romeo et al. (2018) explored the relationships among early language experience, SES, and brain systems important for both oral and written language. The authors used diffusion tensor imaging to examine how individual differences in children's oral language experience related to fractional anisotropy (FA), a metric of white matter coherence, in the arcuate (AF) and superior longitudinal fasciculi (SLF). These white matter tracts connect left inferior frontal and superior temporal cortices, which are critical for language production and reception, respectively Romeo et al. (2018). Oral language experience was measured by studying home audio recordings of parent–child interactions that captured salient aspects of the language environment of prekindergarten and kindergarten children from a broad SES range. Specifically, Romeo et al. (2018) counted the number of words spoken, the number of child utterances, and the number of conversational turns between the parent and child. Critically, conversational turns reflect contiguous linguistic interactions between an adult and child, which can be thought of as a measure of the quality, rather than the quantity, of oral language experience.

Of the oral language environment measures assessed by Romeo et al. (2018), only the number of adult–child conversational turns was related to FA in the left AF and SLF. Importantly, this effect was significant after controlling for SES, suggesting that the relationship was not due to the effect of SES alone. An analysis examining nodes along the AF and SLF subsequently revealed that the correlation between conversational turns and FA was driven by white matter near the termination of the AF and SLF in the left inferior frontal lobe, which has frequently been found to be involved in both language comprehension and articulation (Friederici, 2012). Romeo et al. (2018) did not observe any other associations between white matter and adult–child conversational turns, suggesting that the relationship was specific to the left AF and SLF. Although SES did not account for the relationship between oral language experience and brain structure, Romeo et al. (2018) found that SES played a role in children's language skills through its effect on adult–child conversational turns and white matter in the AF and SLF. Together, the results of the study by Romeo et al. (2018) suggest that language quality rather than quantity is critical for the development of the left AF and SLF, independent of SES. Yet, SES may still contribute to language development through its effect on the early oral language environment.

Although Romeo et al. (2018) did not investigate reading skills in their sample of children (who were likely preliterate and early readers), the findings have several implications for the development of reading skills, particularly how the early oral language environment may contribute to the neuroanatomical foundations of reading. Skilled reading relies on the fluent integration of word recognition and comprehension; therefore, reading requires effectively co-opting language skills that exist before the acquisition of literacy (Dehaene et al., 2010). One of the strongest predictors of reading ability is phonological awareness, which is an understanding of the sound structures in one's language and the ability to manipulate these sound structures (Wagner et al., 1987; Torgesen et al., 1997). Oral language skills, such as speech sound accuracy and vocabulary, contribute to phonological awareness in children (McDowell et al., 2007), suggesting that oral language is closely related to reading acquisition through its role in the development of phonological awareness. Neuroimaging research has also supported the notion that oral language, phonological awareness, and reading likely rely on some overlapping brain systems. Much like the relationships between the home language environment and white matter microstructures reported by Romeo et al. (2018), FA in the left AF and SLF has been associated with individual differences in phonological awareness (Yeatman et al., 2011; Vandermosten et al., 2012) and reading ability (Ben-Shachar et al., 2007; Thiebaut de Schotten et al., 2014; Vandermosten et al., 2015). These findings support the notion that oral language and reading abilities are strongly interrelated. Early language experience may, therefore, have direct effects on white matter microstructure in the AF and SLF, which could provide a neuroanatomical scaffold for later reading acquisition.

The role of the AF and SLF in reading has also been demonstrated in research examining populations who have a specific disability in learning to read. Developmental dyslexia is characterized by difficulties with accurate and/or fluent word reading along with poor spelling and decoding abilities (Lyon et al., 2003). Even though dyslexia is defined as a reading disability, children with dyslexia have been shown to exhibit oral language deficits as early as 2.5 years, and some researchers have speculated that these early language deficits may alter a child's ability to engage with conversational partners (Scarborough, 1990). Structural differences have been observed in white matter tracts supporting reading and language skills in studies of dyslexia. Specifically, children with dyslexia tend to have lower FA in the left AF (Vandermosten et al., 2012, 2015) and left anterior SLF (Rimrodt et al., 2010) compared with typically developing children. Furthermore, several studies have demonstrated structural differences in the AF in preliterate children with a family history of dyslexia (Vandermosten et al., 2015, 2016; Wang et al., 2017). Even though dyslexia has a strong genetic component and is often familial (Harlaar et al., 2005), it has been speculated that environmental factors, including how much children engage with books and how much parents read themselves, could also affect language and reading skills (Snowling and Melby-Lervåg, 2016). In addition, oral language skills have been shown to be a protective factor in the development of dyslexia (Snowling, 2001). Thus, the findings of Romeo et al. (2018) indicate that atypical brain connectivity in prereaders with a family history of dyslexia may result not only from the genetic aspects of dyslexia, but also from differences in oral language skills (Vandermosten et al., 2016). Future research should examine how adult–child conversation serves as a protective buffer for reading development and white matter microstructure in dyslexia.

The findings by Romeo et al. (2018) underscore the importance of understanding the role of early oral language experiences in the anatomical connections of the brain. Their results show that even before the onset of learning to read, factors in a child's early language environment (namely parent–child conversational turns) shape the white matter tracts that are ultimately used for reading and whose integrity is correlated with reading proficiency. Additionally, their research lends insight into how SES may have indirect effects on the neuroanatomy of language and reading through its influence on the early childhood environment. Individual differences in the white matter pathways underlying oral language and reading are likely influenced by a combination of both genetic factors, such as a family history of language or reading impairments, and environmental factors, such as SES and the quality of the early language and literacy environment. Understanding the precise role of early language environment on brain systems important for reading may ultimately help to explain why children follow different developmental trajectories in reading and could provide neurobiological evidence in favor of specific early interventions.

References

Ben-Shachar M, Dougherty RF, Wandell BA (2007) White matter pathways in reading. Curr Opin Neurobiol 17:258–270. CrossRef Medline

Dehaene S, Pegado F, Braga LW, Ventura P, Nunes Filho G, Jobert A, Dehaene-Lambertz G, Kolinsky R, Morais J, Cohen L (2010) How learning to read changes the cortical networks for vision and language. Science 330:1359–1364. CrossRef Medline

Friederici AD (2012) The cortical language circuit: from auditory perception to sentence comprehension. Trends Cogn Sci 16:262–268. CrossRef Medline

Harlaar N, Dale PS, Plomin R (2005) Telephone testing and teacher assessment of reading skills in 7-year-olds: II. Strong genetic overlap. Reading Writing 18:401–423. CrossRef

Hoff E, Laursen B, Tardif T (2002) Socioeconomic status and parenting. In: Handbook of parenting, Ed 2 (Bornstein MH, ed), pp 231–252. Mahway, NJ: Erlbaum.

Huttenlocher J, Vasilyeva M, Waterfall HR, Vevea JL, Hedges LV (2007) The varieties of speech to young children. Dev Psychol 43:1062–1083. CrossRef Medline

Lyon GR, Shaywitz SE, Shaywitz BA (2003) A definition of dyslexia. Ann Dyslexia 53:1–14. CrossRef

McDowell KD, Lonigan CJ, Goldstein H (2007) Relations among socioeconomic status, age, and predictors of phonological awareness. J Speech Lang Hear Res 50:1079–1092. CrossRef Medline

Rimrodt SL, Peterson DJ, Denckla MB, Kaufmann WE, Cutting LE (2010) White matter microstructural differences linked to left perisylvian language network in children with dyslexia. Cortex 46:739–749. CrossRef Medline

Romeo RR, Segaran J, Leonard JA, Robinson ST, West MR, Mackey AP, Yendiki A, Rowe ML, Gabrieli JDE (2018) Language exposure relates to structural neural connectivity in childhood. J Neurosci 38:7870–7877. CrossRef Medline

Rowe ML, Pan BA, Ayoub C (2005) Predictors of variation in maternal talk to children: a longitudinal study of low-income families. Parenting 5:259–283. CrossRef

Scarborough HS (1990) Very early language deficits in dyslexic children. Child Dev 61:1728–1743. CrossRef Medline

Scarborough HS (2001) Connecting early language and literacy to later reading (dis)abilities: evidence, theory and practice. In: Handbook of early literacy research, Vol 1 (Neuman SB, Dickinson DK, eds), pp 97–110. New York: Guilford.

Snowling MJ (2001) From language to reading and dyslexia. Dyslexia 7:37–46. CrossRef Medline

Snowling MJ, Melby-Lervåg M (2016) Oral language deficits in familial dyslexia: a meta-analysis and review. Psychol Bull 142:498–545. CrossRef Medline

Thiebaut de Schotten M, Cohen L, Amemiya E, Braga LW, Dehaene S (2014) Learning to read improves the structure of the arcuate fasciculus. Cereb Cortex 24:989–995. CrossRef Medline

Torgesen JK, Wagner RK, Rashotte CA (1997) Prevention and remediation of severe reading disabilities: keeping the end in mind. Sci Studies Reading 1:217–234. CrossRef

Vandermosten M, Boets B, Wouters J, Ghesquière P (2012) A qualitative and quantitative review of diffusion tensor imaging studies in reading and dyslexia. Neurosci Biobehav Rev 36:1532–1552. CrossRef Medline

Vandermosten M, Vanderauwera J, Theys C, De Vos A, Vanvooren S, Sunaert S, Wouters J, Ghesquière P (2015) A DTI tractography study in pre-readers at risk for dyslexia. Dev Cogn Neurosci 14:8–15. CrossRef Medline

Vandermosten M, Hoeft F, Norton ES (2016) Integrating MRI brain imaging studies of pre-reading children with current theories of developmental dyslexia: a review and quantitative meta-analysis. Curr Opin Behav Sci 10: 155–161. CrossRef Medline

Wagner RK, Torgesen JK, Bradley L, Bryant P, Crowder B, Mann V, Wagner AK (1987) The nature of phonological processing and its causal role in the acquisition of reading skills. Psychol Bull 101:192–212. CrossRef

Wang Y, Mauer MV, Raney T, Peysakhovich B, Becker BLC, Sliva DD, Gaab N (2017) Development of tract-specific white matter pathways during early reading development in at-risk children and typical controls. Cereb Cortex 27:2469–2485. CrossRef Medline

Yeatman JD, Dougherty RF, Rykhlevskaia E, Sherbondy AJ, Deutsch GK, Wandell BA, Ben-Shachar M (2011) Anatomical properties of the arcuate fasciculus predict phonological and reading skills in children. J Cogn Neurosci 23:3304–3317. CrossRef Medline