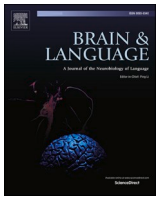
Brain & Language 248 (2024) 105368

Contents lists available at ScienceDirect

Brain and Language

journal homepage: www.elsevier.com/locate/b&l



Short communication

Expanding the emergentist Account:Reply to open peer commentaries

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ARTICLE INFO

Keywords:
Second language acquisition
Emergentism
Critical period
Motivation
Age effects

ABSTRACT

Emergentism provides a framework for understanding how language learning processes vary across developmental age and linguistic levels, as shaped by core mechanisms and constraints from cognition, entrenchment, input, transfer, social support, motivation, and neurology. As our commentators all agree, this landscape is marked by intense variability arising from the complexity. These mechanisms interact in collaborative and competitive ways during actual moments of language use. To better understand these interactions and their effects, we need much richer longitudinal data regarding both input and output during actual contexts of usage. We believe that modern technology can eventually provide this data (Flege & Bohn, 2021) in ways that will allow us to more fully populate an emergent landscape.

1. Emergentism as a framework

We greatly appreciate these seven excellent commentaries. They have provided us with an opportunity to refine and extend our understanding of age effects in second language (L2) learning and to clarify the role of the emergentist approach. As in Biology, Neuroscience, or Physics, emergentism provides a framework or road map within which more detailed theories can be located and integrated. For example, the theory of entrenchment in neural network models can be used to model children's learning of verb argument structure (Ambridge & Blything, 2015) or automaticity in L2 (Tavakoli, 2019). It then links up in detail to the diffusion decision model of lexical activation (Ratcliff et al., 2016) which in turn has consequences for models of competition in speech errors (Nozari & Hepner, 2019). Or we can look at how L2 pedagogical practice can lead to overanalysis in adult learners which in turn leads to delayed learning of morphology (Arnon & Christiansen, 2017; MacWhinney, 2012). Given the complexity of language learning, structure, and usage and the wide variety of social and motivational contexts for learning, it is not surprising that a full account of L2 development across ages must rely on dozens of more specific models (Long, 1993). Emergentism provides the overall framework within which these more detailed models can be configured and coordinated to provide an integrated understanding of the overall course of language learning, structure, and usage.

As an illustration of how this can work, Lambelet and Valian (L&V) provide a particularly insightful way of integrating many of the forces shaping L2 learning. They identify exposure as the core proximal variable fostering L2 learning. This emphasis aligns with observations from MacWhinney (2022) and Long (2022) that learning occurs primarily when learners attend to specific patterns when either listening or speaking. During listening, learners can pick up new patterns from comprehensible input (Krashen, 1994) by attending to the form and function of specific meanings, words, constructions, and pronunciations. During production, learners can track their errors and successes (Swain, 2005). This emphasis on the core role of exposure is in accord with usage-based frequentist analyses (Ellis et al., 2015). What is particularly appealing about L&V's proposal is the way in which it allows us to think of additional cognitive and motivational supports as distal variables that control and modulate the proximal variable of exposure. As L&V note, immigrants may have decreased exposure due to distal factors such as post-traumatic stress, rejection in the new country, the lack of a sense of belonging, stereotype threat, and the need to work in positions that only provide L1 exposure. Alternatively, parents' interest in accelerating their children's cognitive and linguistic development can motivate distal practices such as book reading or word games that increase the quality and quantity of proximal exposure to both L1 and L2. The fact that these distal variables control the proximal variable of exposure does not lessen their importance as major determinants of variation in L2 learning success. Rather, it helps us understand how various constraints and facilitations can come together at different ages to determine learning progress.

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https://doi.org/10.1016/j.bandl.2023.105368
Received 30 November 2023; Accepted 12 December 2023
Available online 22 December 2023

2. Big data

Looking at a very different type of data, Marian suggests that recent advances in the development of AI (artificial intelligence) and large language models (LLMs) can guide our thinking about L2 learning and age effects. The idea is that, if these models can acquire advanced language abilities without rules or modules, we should also expect that humans can learn without rules or pre-configured modules, as suggested by emergentist analyses. What makes such an interpretation of LLMs particularly compelling is the fact that expansions of the training sets for these models have been leading to increasingly powerful and humanlike performance. Current models, such as ChatGPT perform well when asked to "write an essay on civil disobedience", but when asked to complete a simple children's story or a textbook, they can go off into left field, whereas smaller models trained specifically on children's stories perform much better (Eldan & Li, 2023). Demonstrations of this type are in line with the focus on content areas in task-based learning theory (TBLT) (Skehan, 2003), as well as findings regarding lexical fields from child language studies (Gleason & Ely, 1997). MLLMs (multimodal large language models) take this work further into areas such as the guiding of virtual robots to act on objects in virtual scenes (Zhu et al., 2023), operating in a virtual Web arena (S. Zhou et al., 2023), engaging in social negotiation (X. Zhou et al., 2023), and performing massively multilingual speech-to-speech translation (Jia et al., 2022). As these models increase the variety of input types and the parameters they compute, they come closer and closer to achieving human-like output across a wide variety of tasks (Chowdhery et al., 2022). As we become able to add additional neurological, motivational, and social constraints, we will be able to use these models to simulate core aspects of L2 learning. To make maximal use of these opportunities, we will need rich *in vivo* longitudinal data of the type mentioned by L&V and described in Flege and Bohn (2021). This is also the type of Big Data which Kroll and Finger believe we will need to properly assess variability in L2 acquisition and bilingualism.

3. Attrition

We have also benefitted from a line of commentary advanced by Hernandez, Kroll, and Bylund regarding early language attrition. Before age 7, adoptees who arrive to an L2 community without L1 support uniformly lose their ability to use L1 (Pallier et al., 2003). There have been studies showing that during adolescence or early adulthood these adoptees can "relearn" some of the fine-grained phonological contrasts in their L1 (Choi et al., 2017; Oh et al., 2010; Singh et al., 2011), although this effect is not always replicated (Ventureyra et al., 2004). However, it is difficult for these relearning studies to avoid the possibility that the adoptees have a desire to recapture aspects of their former identity and the possibility that this motivation leads them to focus more intensely on learning these contrasts. Other studies partly avoid this criticism by studying brain activation differences in the way in which L2 sounds are processed by adoptees. In the first study in this area, Pallier et al. (2003) observed slightly larger areas of fMRI activation in native L1 speakers than in the adoptees. Normann, Bylund, and Thierry (2022) found that Chinese adoptees outperformed Swedish native speakers in tone perception, as measured by MMN reactions. Similarly, Pierce et al. (2014) found that adoptees and Chinese native speakers, but not French native speakers, used similar areas of the left temporal lobe when listening to contrasting Chinese lexical tones. These neural response results lead us to reformulate and expand our account of early attrition. Rather than thinking of adoptees as undergoing simply radical language loss, we can view them as using their L1 as a springboard for initial learning and consolidation of L2 which preserves traces of its L1 origin. This understanding of the residual effects of a lost L1 fits in well with the emphasis in emergentism on interactions between languages.

4. Updating the critical period Hypothesis?

Bylund raises another issue that we find more problematic. He holds that Lenneberg (1967, 1975; 1969) had never proposed a single-process account for critical period effects. In his 1975 chapter Lenneberg does not address this issue, because it deals with early word learning, not bilingualism. However, he does take up the issue in his 1969 Science article in the section labelled "Critical Age for Language Acquisition." There, he identifies a critical period as terminating during the early teens when "the maturation of the brain marks the end of regulation and locks certain functions into place." Perhaps, Lenneberg thought of this as involving a single maturational switch which then controlled a variety of additional brain mechanisms, such as lateralization, myelination, and synaptic plasticity. In that sense, his single-process account could be viewed as a linked multiple-process account. However, in the intervening 54 years, neuroscience has shown us that these systems retain far more plasticity than Lenneberg had allowed. We know that lateralization operates in different ways across linguistic levels during development (Olulade et al., 2020), that myelin rises and falls with practice (Pliatsikas, 2020) and sleep (de Vivo & Bellesi, 2019), and that synaptic connections remain plastic and changeable throughout life (Quartz & Sejnowski, 1997). We know that Lenneberg's analysis of lateralization relied on work by Basser (1962) which was shown to be problematic (St James-Roberts, 1981). We now have detailed neurochemical models showing how neuronal tissue can become entrenched (Werker & Hensch, 2014) and how entrenchment can be reversed (Zhou et al., 2011). Most crucially, we know that puberty and early adolescence is a time of rapid changes in brain structure and functioning (Luna et al., 2015), rather than a time of final neural consolidation. Lenneberg's views were advanced for his time, but we can now move on to newer understandings of the neural bases of language (Hagoort, 2005; Kemmerer, 2015).

5. Is earlier Better?

Han and Baohan (H&B) argue that our target article does not engage with certain core issues pertinent to the CPH, because we do not differentiate between younger and older learners, first and foreign language acquisition naturalistic learners, and instructed learners native-like and nonnative-like attainment. In fact, these factors are discussed extensively in our target article, but as dimensions of variation, rather than as binary opposites to be differentiated as separate categories. We contend that the factors operative during childhood second language acquisition (SLA) are also at work for adult learning. However, these dimensions vary continuously with age, not according to an early / late learning dichotomy.

H&B urged researchers to investigate how cognitive risk and protective factors interact over time and with advancing age. We wholeheartedly agree. Those authors reminded readers that the cliché of "younger-is-better" does not entail "earlier-is-better" for foreign language instruction. Language learning based on L2-medium instruction actually improves across childhood and adolescence (Swain, 1981). Yun et al. (2023) analyzed WIDA standardized English assessments conducted during the first two years of English medium instruction. The WIDA assesses the four language domains of listening, reading, speaking, and writing. It is a holistic test meant to determine if learners need support for English language learning (ELL). Older ELLs learned English at a faster rate than younger ELLs, especially in the initial periods of learning. The superiority in learning for the older group (whose learning was assessed from age 15–17) increased in magnitude as a function of L1-L2 similarity. One inference is that learning is superior for older learners because they benefited from positive transfer from their L1.

These findings conflict with pre-adolescence being a sensitive period for language acquisition and also conflict with established findings (cited by H&B) that the brain declines in plasticity over childhood. If

teenagers reliably learn faster than younger children, this raises the question (again) of why ultimate attainment is lower when L2 learning begins in mid-adolescence, as identified in graphs such as Figure 6 of Hartshorne et al. (2018). Note that Hartshorne and colleagues explain this decline as due to the learning rate abruptly decreasing at age 17, entailing less time to learn more of the L2 for learners who started L2 learning during the teen years.

One explanation is that Yun et al.'s (2023) WIDA test scores improve faster for teenagers than for younger learners because positive transfer from L1 compensates for declines in plasticity. The faster rate of learning for teenage learners was most apparent in the early years of learning. This is consistent with ultimately attainment being influenced by a broader range of factors than the early stages of L2 learning during immersion in a school setting.

Future work can examine whether learning in private schools using EMI is representative of additional language learning more generally. Consider the special motivational context accompanying attending a private school that employs EMI. Attending private schools with EMI implies a family with financial resources and an expectation that learners' English achievement will facilitate careers in the global economy (Ayçiçeği-Dinn et al., 2017).

6. Terminology

DeHouwer's careful review of our article highlights several points that we need to clarify. Despite some differences in terminology and emphasis, DeHouwer shares with us (and Kroll and Finger) an emphasis on the core fact of variability. Along with Kroll, we take this fact as evidence of the need for an account that deals with competition, levels, timescales and a variety of social/motivational factors (Lambelet and Valian's distal forces).

DeHouwer is concerned that many of our statements reflect an unhelpful focus on ultimate attainment. Such a focus could buttress discriminatory practices in the broader fields of the language sciences and applied linguistics (Dewaele et al., 2021, pp 20-22). We agree that holding up ultimate attainment as the ideal for language learners is unhelpful. We agree that arguing for a particular 'native speaker' standard serves no purpose. We do not devalue adult learners for failing to acquire the more subtle features of their L2.

We agree with many distinctions noted by DeHouwer. For example, foreign and second language are indeed different, but they can also be ends of a continuum of exposure (Lambelet and Valian) and immersion. Second language learners may begin as foreign language learners and they may acquire additional languages through initial study.

How second and foreign language attainment should be viewed in the of bilingualism is important, but this topic is orthogonal to the goals of the target article. Instead, our starting point was that the CPH as an explanatory framework is a relic of mid-20 century theorizing that needs to be replaced with a contemporary emergentist view of multi-causal multi-level learning. However, disavowing the CPH leaves open the inference that, anything goes and that no systematic or strong constraints on learning exist. Some readers might infer that, without maturational constraints on language learning, adult immigrants could learn the language of their new country to the same level of proficiency as a child immigrant.

By way of countering the 'anything goes' alternative, we noted the many ways in which we agree with CPH theorists about the data to be explained. Specifically, we agree that additional language learning for adults typically differs in multiple ways from the outcomes observed for children. We set out the cognitive, social and motivational factors that can explain these differences, without recourse to a solely biologically-based critical period. Adult learners and child learners differ because the age of learning is an organizing variable which sets in motion linked differences in neurological status, cognition, social environment and motivation. These distal forces then constrain exposure and attention to input from the new language and ultimately learning.

We only relied on the distinction between "successful" and "unsuccessful" language learning as a way of organizing a review of the various environments and configurations of L2 learning. We agree with DeHouwer that success is defined by the learner, but that success also depends on motivation, identity, belongingness, and social support. DeHouwer's analysis fills out further examples of how this works. Her emphasis on variability fits in well with an emergentist multi-process account. Importantly, DeHouwer has done a service by showcasing how easy it is for theoretical science to be viewed as promulgating a prescriptive agenda.

7. A tale of two literatures: The causes and consequences of bilingualism

Kroll and Finger (K&F) observe that research on the consequences of bilingualism for cognition wrestles with similar issues to those we highlighted regarding age effects. One much-studied consequence, often called the bilingual advantage, is that using two or more languages facilitates perspective-taking, understanding words' multiple meanings, and possibly some executive function tasks, such as rapid set-shifting (Bialystok, 2017; Greenberg et al., 2013).

Both lines of research are affected by Chomsky's claim (1965) that the human language faculty is domain-specific and under genetically determined maturational control. Domain-specificity conflicts with a bilingual advantage, because language is separate from the rest of cognition, it can't influence cognition. In the mid-20th century, the claims of autonomy of grammar were the context against which many researchers found the critical period hypothesis (CPH) natural and compelling (Cook, 1985). Since then, rapid progress in understanding the flexibility of human learning has made those older proposals less credible. This progress includes the 1980 s neural net (connection) revolution within cognitive science of the 1980 s, as well as contemporary neuroimaging findings, undergirding theoretical frameworks like emergentism (MacWhinney, 2019).

The critics of the cognitive consequences of bilingualism dispute that cognitive consequences exist, pointing to replication failures and confounding factors (Paap & Greenberg, 2013). K&F explain that conflicting findings are not surprising, given the variability in learning situations across cognitive, social and motivational factors. Aggregating across bilinguals, and thus treating them as a homogenous group, obscures the learning experiences that may link bilingualism to cognitive outcomes.

Our target article focused on the long-standing question of how the age of acquisition affects ultimate outcome. As K&F correctly note, age effects are more diverse than just the ultimate outcome. For example, learning additional languages produces consequences for brain structure and function that differ for early and later bilingualism, even for people with similar profiles of proficiency (Navarro-Torres et al., 2021; Li et al., 2014). Regardless of age of acquisition, dealing with the interplay and interactions across multiple languages can create a more tolerant, adaptive language system, with weaker adherence to grammatical and other constraints.

8. Moving forward

Emergentism provides a framework for understanding how language learning processes vary across developmental age and linguistic levels, as shaped by core mechanisms and constraints from cognition, entrenchment, input, transfer, social support, motivation, and neurology. As our commentators all agree, this landscape is marked by intense variability arising from the complexity. These mechanisms interact in collaborative and competitive ways during actual moments of language use. To better understand these interactions and their effects, we need much richer longitudinal data regarding both input and output during actual contexts of usage. We believe that modern technology can eventually provide this data (Flege & Bohn, 2021) in ways that will allow us to more fully populate an emergent landscape.

CRediT authorship contribution statement

Catherine L. Caldwell-Harris: . Brian MacWhinney: Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ambridge, B., & Blything, R. (2015). A connectionist model of the retreat from verb argument structure overgeneralization. *Journal of Child Language, 1–32*. https://doi.org/10.1017/S0305000915000586

Arnon, I., & Christiansen, M. H. (2017). The role of multiword building blocks in explaining L1–L2 differences. *Topics in Cognitive Science, 9*(3), 621–636.

Ayçiçeği-Dinn, A., Şişman-Bal, S., & Caldwell-Harris, C. L. (2017). Does attending an English-language university diminish abilities in the native language? *Data from Turkey. Applied Linguistics, 38*(4), 540–558.

Basser, L. S. (1962). Hemiplegia of early onset and the faculty of speech with special reference to the effects of hemispherectomy. *Brain, 85*, 427–460.

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143*(3), 233.

Choi, J., Broersma, M., & Cutler, A. (2017). Early phonology revealed by international adoptees' birth language retention. *Proceedings of the National Academy of Sciences, 114*(28), 7307–7312.

Chomsky, N. (1965). *Aspects of the theory of syntax*. MIT Press.

Chowdhery, A., Narang, S., Devlin, J., Bosma, M., Mishra, G., Roberts, A., Barham, P., Chung, H. W., Sutton, C., & Gehrmann, S. (2022). Palm: Scaling language modeling with pathways. *arXiv preprint arXiv:2204.02311*.

Cook, V. J. (1985). Chomsky's universal grammar and second language learning. *Applied Linguistics, 6*(1), 2–18.

de Vivo, L., & Bellesi, M. (2019). The role of sleep and wakefulness in myelin plasticity. *Glia, 67*(11), 2142–2152.

Dewaele, J.-M., Bak, T., & Ortega, L. (2021). Why the mythical "native speaker" has mud on its face. In *Changing Face of the" Native Speaker": Perspectives from multilingualism and globalization* (pp. 23–43).

Eldan, R., & Li, Y. (2023). TinyStories: How Small Can Language Models Be and Still Speak Coherent English? *arXiv preprint arXiv:2305.07759*.

Ellis, N., O'Donnell, J. J., & Römer, U. (2015). Usage-based language learning. In B. MacWhinney, & W. O'Grady (Eds.), *The handbook of language emergence* (pp. 163–180). Wiley.

Flege, J. E., & Bohn, O. (2021). The revised speech learning model (SLM-r). In R. Wayland (Ed.), *Second language speech learning: Theoretical and empirical progress*. Cambridge Univerrsity Press.

Gleason, J. B., & Ely, R. (1997). Input and the acquisition of vocabulary: Examining the parental lexicon. In C. Mandell, & A. McCabe (Eds.), *Problem of meaning: Behavioral and cognitive perspectives* (pp. 221–260). Elsevier.

Greenberg, A., Bellana, B., & Bialystok, E. (2013). Perspective-taking ability in bilingual children: Extending advantages in executive control to spatial reasoning. *Cognitive Development, 28*(1), 41–50.

Hagoort, P. (2005). On Broca, brain, and binding: A new framework. *Trends in Cognitive Sciences, 9*(9), 416–423.

Hartshorne, J. K., Tenenbaum, J. B., & Pinker, S. (2018). A critical period for second language acquisition: Evidence from 2/3 million English speakers. *Cognition, 177*, 263–277.

Jia, Y., Ramanovich, M. T., Wang, Q., & Zen, H. (2022). CVSS corpus and massively multilingual speech-to-speech translation. *arXiv preprint arXiv:2201.03713*.

Kemmerer, D. (2015). *The cognitive neuroscience of language*. Psychology Press.

Krashen, S. (1994). The Input Hypothesis and its rivals. In N. C. Ellis (Ed.), *Implicit and explicit learning of languages* (pp. 45–78). Academic.

Lenneberg, E. (1967). *Biological foundations of language*. Wiley.

Lenneberg, E. (1975). The concept of language differentiation. In E. H. Lenneberg, & E. Lenneberg (Eds.), *Foundations of language development: A multidisciplinary approach* (Vol. 1). Academic Press.

Lenneberg, E. H. (1969). On explaining language: The development of language in children can best be understood in the context of developmental biology. *Science, 164*(3880), 635–643.

Li, P., Legault, J., & Litcofsky, K. A. (2014). Neuroplasticity as a function of second language learning: Anatomoical changes in the human brain. *Cortex, 58*, 301–324.

Long, M. H. (1993). Assessment strategies for second language acquisition theories. *Applied Linguistics, 14*(3), 225–249.

Luna, B., Marek, S., Larsen, B., Tervo-Clemmens, B., & Chahal, R. (2015). An integrative model of the maturation of cognitive control. *Annual Review of Neuroscience, 38*, 151–170.

MacWhinney, B. (2012). The logic of the Unified Model. In S. Gass, & A. Mackey (Eds.), *The Routledge Handbook of Second Language Acquisition* (pp. 211–227). Routledge.

MacWhinney, B. (2019). Neuroemergentism: Levels and constraints. *Journal of Neurolinguistics, 49*(232–234), 6329393.

MacWhinney, B. (2022). Synthesis: The psycholinguistics of learning. In *The Routledge handbook of second language acquisition and psycholinguistics* (pp. 361–370). Routledge.

Navarro-Torres, C. A., Beatty-Martínez, A. L., Kroll, J. F., & Green, D. W. (2021). Research on bilingualism as discovery science. *Brain and Language, 222*, Article 105014.

Norrman, G., Bylund, E., & Thierry, G. (2022). Irreversible specialization for speech perception in early international adoptees. *Cerebral Cortex, 32*(17), 3777–3785.

Nozari, N., & Hepner, C. R. (2019). To select or to wait? The importance of criterion setting in debates of competitive lexical selection. *Cognitive Neuropsychology, 36*(5–6), 193–207.

Oh, J. S., Au, T.-K.-F., & Jun, S.-A. (2010). Early childhood language memory in the speech perception of international adoptees. *Journal of Child Language, 37*(05), 1123–1132.

Olulade, O. A., Seydell-Greenwald, A., Chambers, C. E., Turkeltaub, P. E., Dromerick, A. W., Berl, M. M., … Newport, E. L. (2020). The neural basis of language development: Changes in lateralization over age. *Proceedings of the National Academy of Sciences, 117*(38), 23477–23483.

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*(2), 232–258.

Pallier, C., Dehaene, S., Poline, J.-B., LeBihan, D., Argenti, A.-M., Dupoux, E., & Mehler, J. (2003). Brain imaging of language plasticity in adopted adults: Can a second language replace the first? *Cerebral Cortex, 13*(2), 155–161.

Pierce, L. J., Klein, D., Chen, J.-K., Delcenserie, A., & Genesee, F. (2014). Mapping the unconscious maintenance of a lost first language. *Proceedings of the National Academy of Sciences, 111*(48), 17314–17319.

Pliatsikas, C. (2020). Understanding structural plasticity in the bilingual brain: The Dynamic Restructuring Model. *Bilingualism: Language and Cognition, 23*(2), 459–471.

Quartz, S. R., & Sejnowski, T. J. (1997). The neural basis of cognitive development: A constructivist manifesto. *Behavioral and Brain Sciences, 20*(4), 537–556.

Ratcliff, R., Smith, P. L., Brown, S. D., & McKoon, G. (2016). Diffusion decision model: Current issues and history. *Trends in Cognitive Sciences, 20*(4), 260–281.

Singh, L., Liederman, J., Mierzejewski, R., & Barnes, J. (2011). Rapid reacquisition of native phoneme contrasts after disuse: You do not always lose what you do not use. *Developmental Science, 14*(5), 949–959.

Skehan, P. (2003). Task-based instruction. *Language Teaching, 36*(01), 1–14.

St James-Roberts, I. (1981). A reinterpretation of hemispherectomy data without functional plasticity of the brain: I. *Intellectual function. Brain and Language, 13*(1), 31–53.

Swain, M. (1981). Time and timing in bilingual education. *Language Learning, 31*, 1–16.

Swain, M. (2005). The output hypothesis: Theory and research. In E. Hinkel (Ed.), *Handbook of research in second language teaching and learning* (pp. 471–484). Lawrence Erlbaum.

Tavakoli, P. (2019). Automaticity, fluency and second language task performance. *Researching L2 task performance and pedagogy*, 39-52.

Ventureyra, V. A., Pallier, C., & Yoo, H.-Y. (2004). The loss of first language phonetic perception in adopted Koreans. *Journal of Neurolinguistics, 17*(1), 79–91.

Werker, J., & Hensch, T. (2014). Critical periods in speech perception: New directions. *Annual Review of Psychology, 66*, 173–196. https://doi.org/10.1146/annurev-psych-010814-015104

Yun, H., Li, W., & Hartshorne, J. K. (2023, Nov 2-5, 2023). *Why do older chidlren learn second languages faster than younger children?* 48th Annual Meeting of the Boston University Child Language Development Conference, Boston, MA.

Zhou, S., Xu, F. F., Zhu, H., Zhou, X., Lo, R., Sridhar, A., Cheng, X., Bisk, Y., Fried, D., & Alon, U. (2023). Webarena: A realistic web environment for building autonomous agents. *arXiv preprint arXiv:2307.13854*.

Zhou, X., Panizutti, R., de Villers-Sidani, É., Madeira, C., & Merzenich, M. (2011). Natural restoration of critical period plasticity in the juvenile and adult primary auditory cortex. *The Journal of Neuroscience, 31*, 5625–5634.

Zhou, X., Zhu, H., Mathur, L., Zhang, R., Yu, H., Qi, Z., Morency, L.-P., Bisk, Y., Fried, D., & Neubig, G. (2023). SOTOPIA: Interactive Evaluation for Social Intelligence in Language Agents. *arXiv preprint arXiv:2310.11667*.

Zhu, H., Kapoor, R., Min, S. Y., Han, W., Li, J., Geng, K., Neubig, G., Bisk, Y., Kembhavi, A., & Weihs, L. (2023). EXCALIBUR: Encouraging and Evaluating Embodied Exploration. Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition.