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Editorial: Neurobehavioral changes in language learning

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Editorial on the Research Topic
Neurobehavioral changes in language learning

Brain plasticity enables language learning across the life span. Ranging from exposure to bi- or multilingual environment in childhood to rehearsal type of learning later in life, the conditions of language acquisition can vary drastically. Similarly, the neural activation to the same language input or output may change in the course of learning and diverge based on the type of training that takes place. Probing the changing neurobehavioral outcomes will enhance our understanding on the elaborate processes of language learning.

Our aim in this Research Topic is to provide evidence on language learning in concurrent behavioral and brain levels. To this end, we present investigations on (i) the neuronal dynamics induced by learning, (ii) integration of behavioral measures with their neuronal underpinnings, and (iii) the differences in language learning originating from distinct language backgrounds or clinical disorders.

To investigate word-meaning acquisition, Garagnani et al. trained participants to associate a familiar action or object with a novel spoken word-form. The learning was behaviorally confirmed with word-picture matching and recognition tests. First, using an fMRI localizer task, cortical activation to visually presented displays of the objects and actions was determined. When presented again with the new speech items during fMRI, the participants' brain responses showed distinct patterns of activation for objects and actions in the primary visual cortex and fusiform gyrus. Namely, the activation of these areas was significantly larger for novel spoken words associated with objects compared to those associated with actions. Taking an embodied theory approach of grounded semantics, the authors revealed category-specific activation of relevant primary sensory brain areas in novel word learning. As opposed to exclusively measuring brain activation to novel word-forms after training, Shtyrov et al. recorded ERPs to spoken words before and after fast mapping and explicit encoding of word-referent mapping. They evaluated behavioral responses across the training as well as learning-induced changes in ERPs to the novel words. While recognition and semantic matching of newly acquired words were equally successful under fast mapping and explicit encoding conditions, the ERP activity patterns indicated that distinct neural routes underpin the two learning strategies. Namely, while both conditions elicited changes in bilateral fronto-temporo-parietal networks, a more left-lateralised mechanism was observed in fast mapping and a more diverse one in explicit encoding. The above studies suggest that specific semantic links and learning regime govern the neural learning routes for new language.

Studying the development of lexico-semantic brain networks in much younger population, such as infants, poses numerous challenges. In the absence of reliable behavioral measures, EEG provides a means to record infants' brain responses to words in context. Junge et al. review over 30 studies on the N400 component in infants up to 24 mo of age. They report multiple factors accounting for heterogeneity in the results: N400 latency and distribution are critically affected by brain maturation, familiarity of stimuli (highly familiar vs. newly acquired), and language ability level. The review by Junge et al. crucially pinpoints the need for systematic paradigms in longitudinal settings to get comprehensive information of semantic integration in childhood.

Echoing this demand, longitudinal studies by Cui et al. and Louleli et al. address questions of brain maturation and experience-related changes in the language networks. These studies investigate the effect of preliterate skills on later language and reading development. Cui et al. report that higher gains in a visual matching task requiring both speeded visual and implicit phonological processing between ages 6 and 8 predict better reading ability at age 11 in Chinese children. Furthermore, the visual matching gains and reading ability were positively correlated with left fusiform gyrus surface area at 14 yrs, suggesting that learning to map phonology to orthography is associated with structural growth in the fusiform area, which is critically also activated by reading. Louleli et al. measured MEG while children with or without familial risk for dyslexia carried out a morphological judgement task in pre-school and again in first grade. They assessed whether MEG responses for correctly vs. incorrectly derived words would predict reading ability in first grade. They reported the often-found correlations between preliterate cognitive skills, i.e., phonological skills, rapid automatized naming, and verbal short-term memory, with early reading outcomes. However, they did not find correlations with the neural responses of morphological processing and reading ability. These studies indicate that specific, rather than general, language skills and neural changes are related to reading acquisition.

In addition to brain maturation, language environment and developmental deficits have implications on how the brain processes the acquired language. Shinozuka et al. investigated effects of L2 proficiency on brain activation during word translation between distantly related languages Japanese (L1) and English (L2). Translation accuracy was overall poorer in elementary compared to advanced learners. Furthermore, the difference in translation accuracy between highly familiar vs. rare words was greater in elementary learners. Using fNIRS, they found that advanced L2 learners elicited significant activation increase on the left prefrontal and posterior temporal cortex while translating words with low familiarity, whereas translation of highly familiar words did not elicit any activation increase. By contrast, the low-proficient L2 group demonstrated activation increase on the left posterior temporal region, irrespective of word familiarity. Shinozuka et al. concluded that the distinction in activation patterns reflects differences in cognitive load depending on the level of L2 automaticity. Ding et al. observed different hemodynamic response patterns between simultaneous and sequential bilinguals during agent selection from simple and complex L2 sentences. Simultaneous compared to sequential Chinese-English bilingual children showed greater activation in right DLPFC and left IPL. Furthermore, bilingual adults showed greater bilateral DLPFC, medial PFC, and left IPL activation than bilingual children. These differences in brain activation were observed while behavioral performance between the groups did not differ. Rinker et al. further evaluated the effect of developmental language disorder (DLD), reflecting deficient language ability, and bilingualism, reflecting reduced exposure to the L2, on basic auditory processing of L2 speech and non-speech sounds in 4–6-year-old children. They found that, compared to typically developing monolingual children, bilingual children elicited an attenuated T-complex for both vowels and tones. The DLD showed such attenuation only for the vowel. Further group differences were found in response latencies. Indeed, language proficiency, age of acquisition, length of exposure and general language abilities all seem to influence neural processing of L2.

In sum, the studies presented in this Research Topic underline that behavioral measures do not directly inform about the underlying neural processing during language learning– comparable behavioral performance can be the result of distinct neural activation patterns. Moreover, the research introduced here emphasizes the multitude of factors that determine variability in the brain processing during language learning and language processing after acquisition.

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