Gains and losses for language in the aging brain

Language, the main medium for expressing feelings and thoughts and collecting information for skill development, decision-making, or everyday living, plays a pivotal role over the lifespan and is perhaps more important in later decades of life when physical mobility tends to be compromised. To better understand how the language processing system adapts to the challenges of advanced age, our team capitalizes on the fine temporal resolution and multidimensionality of event-related potentials (ERPs) to probe age-related changes during reading. Our research demonstrated that while some aspects of language processing are susceptible to age-related neural decline, different compensatory mechanisms may be available to help offset the impact in order to achieve successful comprehension. Below, I review two age-related differences we found in language processing and discuss these differences in the Discussion.

Meaning ambiguity resolution

One central feature of language is ambiguity. A single spelling or pronunciation is often associated with multiple meanings, with the appropriate interpretation being contingent on factors including meaning frequency, syntactic structure, message-level semantic context, and pragmatic/world knowledge. With a series of studies assessing ERPs for different forms of lexical ambiguity, including ambiguity associated with long-term lexical knowledge (homographs: Lee & Federmeier, 2012) and ambiguity created over context (referential ambiguity: one word associated with multiple referential candidates, Lai & Lee, 2014), we found that young adults routinely recruit top-down resources reflected by sustained anterior negativity to aid difficult meaning selection (Figure 1, left panel). However, these additional resources are lacking in healthy older adults (Figure 1, right panel).

![Homograph ambiguity](image1)

**Homograph ambiguity**

- Ambiguous (e.g., ‘to park’/‘the park’)  
- Unambiguous (e.g., ‘to differ’/‘the origin’)

![Referential ambiguity](image2)

**Referential ambiguity**

- Ambiguous (two-referent)  
- Unambiguous (one-referent)

Figure 1. Grand average event-related potentials (ERPs) for ambiguous (red dashed line) and unambiguous (black solid line) words in younger and older adults for homograph-induced ambiguity (English data from Lee & Federmeier, 2012) and referential ambiguity (Taiwan Mandarin data from Lai & Lee, 2014). Negative values are plotted up.
**Bilateralization of syntactic processing**

While the consequences of left hemisphere (LH) brain injury for language functions are often devastating, homologous right hemisphere (RH) lesions do not tend to compromise language to the same extent. This asymmetry is particularly striking for syntactic functions and has thus led to the impression that syntactic ability is specialized to the LH.

Indeed, in a study assessing the brain responses of young background, the LH showed responses of structural analysis or revision to syntactic errors (indexed by the P600 grammaticality effect), while the RH showed responses that are more likely to be lexical or association-based (as indexed by the N400 effect) (Figure 2, left panel). Strikingly, unlike the left-lateralized structural-based P600 effects observed in young adults, the P600 grammaticality effects were bilaterally available in older right-handers who were similarly without a familial left-handedness background (Chen, Chen, & Lee, 2017). One critical distinction between these processes is that syntactic processing is highly left-lateralized in young adults, whereas processes involved in ambiguity resolution are bilateral. Based on prior imaging findings, ambiguity resolution in young adults involves bilateral networks, including, for referential ambiguity, the medial frontal region, medial and bilateral parietal regions, and right superior frontal region, and, for homograph ambiguity, the bilateral inferior frontal gyrus and left posterior inferior temporal cortex.

![Diagram showing event-related potentials (ERPs) of the N400 and P600 differences between grammatical (in black) and ungrammatical (in red) phrases in young adults (Taiwan Mandarin: Weng & Lee, Submitted; English: Lee & Federmeier, 2015) and healthy older adults (Taiwan Mandarin: Chen et al., 2017).](image)

**Figure 2.** Grand-average event-related potentials (ERPs) of the N400 and P600 differences between grammatical (in black) and ungrammatical (in red) phrases in young adults (Taiwan Mandarin: Weng & Lee, Submitted; English: Lee & Federmeier, 2015) and healthy older adults (Taiwan Mandarin: Chen et al., 2017).

right-handers while critical grammatical or ungrammatical information was initially perceived by the LH or the RH (Lee, 2018; Lee & Federmeier, 2015), we found that although the RH is sensitive to syntactic information, the RH might provide different contributions than the LH. Specifically, for young right-handers without a familial left-handedness 2017) (Figure 2, right panel).

**Discussion**

These two lines of research demonstrated an intriguing contrast—while older adults showed a lack of the frontal negativity effect in the context of ambiguity, they showed increased RH P600 responses to syntactic errors.

It is possible that for processes specialized/lateralized to a hemisphere (e.g., syntactic processing), resources capable of qualitatively similar processes in the contralateral hemisphere that are spared in younger adults can potentially compensate when the brain ages. However, for processes that are less specialized (e.g., ambiguity resolution),...
compensation will need to come from other qualitatively different resources. The compensatory interpretation of the RH P600s is corroborated by data from young adults showing RH P600s when relevant syntactic processes are challenging (e.g., low-performing learners of a second language: Chen et al., 2018; or an artificial grammar: Yen, Tang, Hsu, & Lee, 2018; high-performing learners who learned target syntactic rules with less generalizable input and showed a slow-rising learning trajectory: Yen et al., 2018). It is possible that the bilateral P600 responses observed in older adults during native language processing reflect increased RH activity to compensate for deteriorated LH efficiency or reduced brain specialization in older brains. Indeed, in Chen et al. (2017), greater RH P600 responses in older adults were correlated with less effective LH-on-RH inhibition, suggesting LH deterioration. Note, however, that even with additional RH P600 responses, older adults were still reliably less accurate than their younger counterparts, suggesting that compensatory efforts may not always suffice to restore older adults’ behavioral performance.

References
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