Project number 77

Neural Mechanisms of Language Control: Evidence from Sentential Switching

［1］Research group

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［2］Research setup

Language switching is what proficient bilinguals and second language learners frequently encounter in daily life. Not all groups of bilinguals choose to switch languages within sentences, but all of them have experience in switching languages between sentences (Gullifer, Kroll, & Dussias, 2013). This study discussed the cognitive mechanisms when Japanese learners of English comprehended language switching. We focused on the following two questions:

1. Considering learners' proficiency level in the second language, does language switching benefit language comprehension?
2. Do components of domain-general executive functions, such as response suppression, engage in language comprehension?

Thirty-two Japanese learners of English were invited to the experiment inside the MRI scanner at IDAC. In order to answer the first question, two types of language blocks were prepared: one is a single-language block, including Japanese (L1) only and English (L2) only blocks (i.e., *single trials* in L1 and L2). The other is a mixed-language block. In addition to stat at a certain language (i.e., *staying trials*), forward switching (L1 → L2) and backward switching (L2 → L1) would occur (i.e., *switching trials*; Figure 1A). The reading duration was limited (Japanese: 1500 ms; English: 3000 ms). Participants were required to read sentence pairs and determine the relatedness between two sentences within 3000 ms (Figure 1B). In the brain imaging data analysis, we focused on the second sentence because it is related to possible language switching and information integration between sentences. We focused on the proactive language control through comparing single trials with staying trials, further creating contrast images to examine whether language switching benefited language comprehension in both L1 and L2: *mixing benefits* [single trials > staying trials] and *mixing costs* [staying trials > single trials].

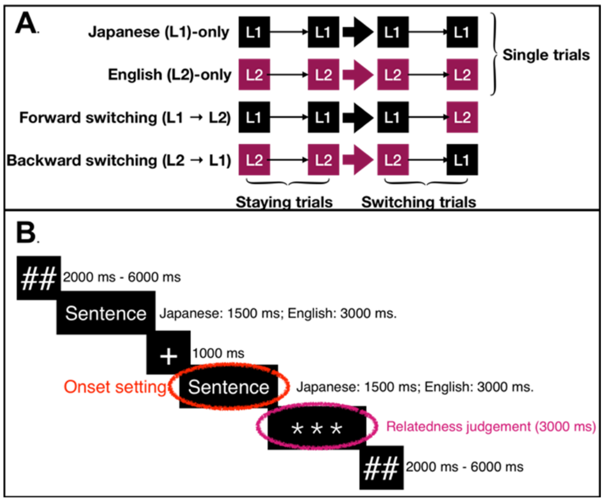

Figure 1. Experimental design and procedure

In order to answer the second question, the antisaccade task was performed outside the MRI scanner (Bialystok et al., 2006). Once participants saw the green eyes, they need to press the response with the same direction as the asterisk. When they saw the red eyes, pressing the opposite direction is required (Figure 2). Determined by the contrast [mean response time of red-eyes blocks > green-eyes blocks], participants' abilities of response suppression was set as a covariate to perform a regression analysis on the brain imaging data, to examine the engagement of response suppression during language comprehension.

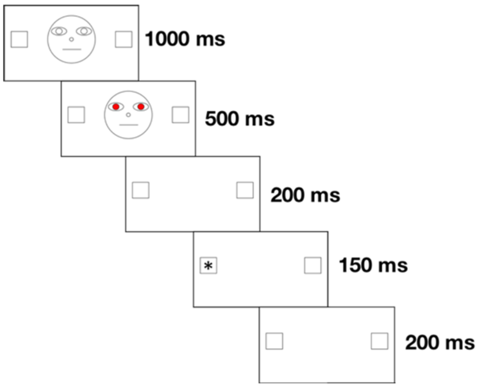

Figure 2. Antisaccade task (Bialystok et al., 2006)

［3］Research outcomes

（3－1）Results

In the brain data analysis, the statistical threshold was set as $p < 0.05$ at cluster-level correction (initial voxel-level height threshold, $p < 0.001$). First, we performed a one-way repeated measures ANOVA on the brain imaging data of Japanese (L1) and English (L2) separately. Mixing costs [staying trial > single trial] were not observed from both Japanese (L1) and English (L2). However, a wide range of brain activations were observed from mixing benefits [single trial > staying trial] in L1 (e.g., left precentral gyrus, left middle temporal gyrus, and right angular gyrus) and L2 (bilateral inferior frontal gyri (IFG) and left supplementary motor area (SMA); Figure 3). Second, learners' abilities of response suppression were positively correlated to the following brain areas in the mixing benefit of English (L2): right SMA, right insula, left orbital part of IFG, and right middle temporal gyrus (Figure 4). In other words, better abilities (i.e., shorter values) in response suppression, lower activations in the aforementioned 4 brain regions when having to focus on English (L2) only.

In sum, the results of this study match the Adaptive Control Hypothesis (Green & Abutalebi, 2013) well. When learners need to focus on only one language, additional cognitive demands are required, such as the response suppression. In other words, language switching may be beneficial to language comprehension. The positive correlation between response suppression and proactive language control in L2 further suggest a possible link between language functions and domain-general cognitive control (DeLuca et al., 2020).

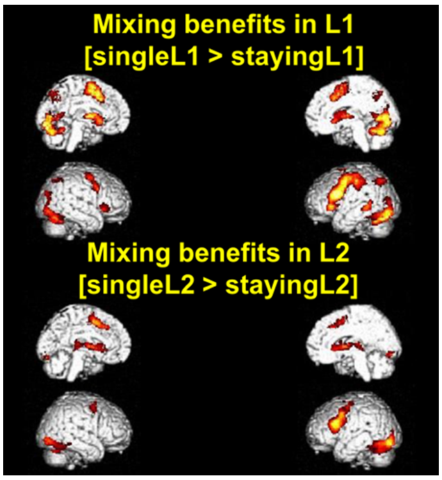

Figure 3. Mixing benefits in L1 and L2

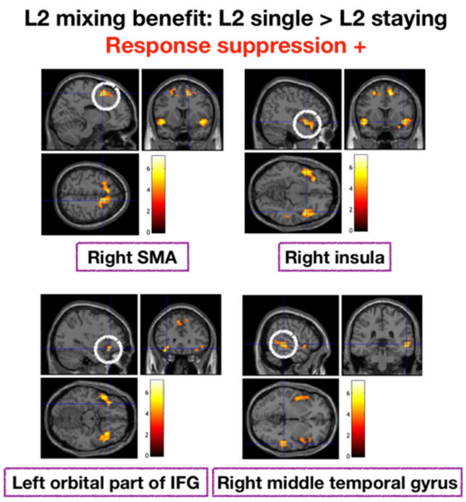

Figure 4. Brain activations by response suppression

（3－2）Future perspectives

Considering the engagement of domain-general cognitive control in the proactive language control (especially L2, see Figure 4), it is worth discussing whether components of domain-general cognitive control modulate the functional dependence between brain regions. In the next step, we will focus on the functional connectivity in the language network and the language control network.

［4］List of Papers

None