Project number 45

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, which switching direction (i.e., L1 → L2 and L2 → L1) can lead to processing cost?
2. Are subcomponents of domain-general executive functions related to language switching comprehension (i.e., working memory, inhibition, and task switching; Miyake et al., 2000)?

Thirty-seven Japanese learners of English were invited to the experiments. In order to answer the first question, we prepared for two types of blocks: one is single block, including Japanese only and English only blocks. The other is mixed block, in addition to stay at a certain language, forward switching (L1 → L2) and backward switching (L2 → L1) would occur (Figure 1). Participants were required to read sentence pairs at their own pace and determine the congruence between two sentences. In the data analysis, we focused on the second sentence because it is related to possible language switching and information integration between sentences.

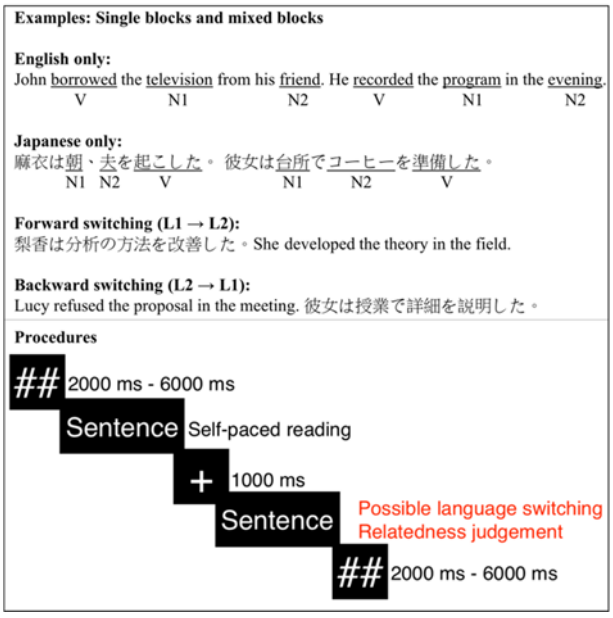

Figure 1. Examples and procedures

In order to answer the second question, we conducted three classical experiments to evaluate participants executive functions: manipulation span for working memory, reversed Stroop task for inhibition, and magnitude-parity switching paradigm for task switching.

［3］Research outcomes

（3－1）Results

Data from nine participants were excluded because their English proficiency level did not pass the threshold of this experiment (matching rate > 70%). We conducted one-way repeated ANOVA on participants' reading time (RT) of L1 (i.e., Japanese) and L2 (i.e., English) separately (Figure 2). In L1, significant difference could not be observed from L1 → L1 (single block), L1 → L1 (mixed block), and L2 → L1 (mixed block; $F(2, 3) = 0.209$, $p = 0.812$). On the other hand, significant difference was observed from L2 ($F(2, 3) = 5.965$, $p < 0.01$). Post-hoc pairwise comparison suggested that participants took more time to read L2 → L2 (single block) and L1 → L2 (mixed block) than L2 → L2 (mixed block). These results suggested the existence of processing cost when comprehending language switching, and switching from L1 to L2 could elicit processing cost, not the opposite direction.

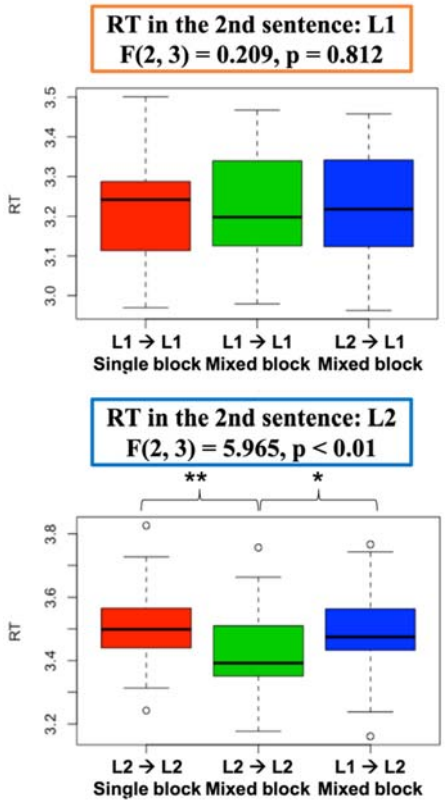

Figure 2. Reaction time in each language

On the other hand, we extracted each participant's RT when comprehending language switching, further conducting correlational analyses to ensure the relationship between language switching and the three components of executive functions (i.e., working memory, inhibition, and task switching). Statistical results indicate that only inhibitory control ability is partially correlated to the RT of backward switching (L2 → L1; $R = 0.36$, $p = 0.073$). In other words, no subcomponent of executive functions is fully involved in language switching comprehension. This result matches previous studies indicating that there are partial, not complete overlaps between language control and executive functions (Calabria, Baus, & Costa, 2019, for a review; cf., Bialystok, Craik, Binns, & Ossher, 2013).

（3－2）Future perspectives

At this moment, I am preparing to submit the results to *Bilingualism: Language and Cognition*, one of the best journals in the field of neurolinguistcis. On the other hand, in order to discuss neural mechanisms of comprehending language switching, the experiment design will be revised and applied to fMRI methodologies. When Japanese learners switch from L1 to L2, anterior cingulate cortex (ACC), which is related to resolve interference between languages, is expected to be activated.

Previous studies indicates that language switching can strengthen the learning outcome in second language (Jamshidi, 2013; Lin, 2013). Considering the principal investigator's experience in Taiwan sign language (Chiu, Lin, Hsieh, Tsai, & Kuo, 2020), it is possible to organize an international group to further discuss language switching between oral and sign languages and contribute the results to language education.

On the other hand, this study can contribute to human-computer interaction (HCI). Through language support tools, language switching becomes possible for non-native speakers when discussing with native speakers in a conference and enhance their participation rate (Chen, Yamashita, & Wang, 2018). However, no design of language support tool pay attention to processing cost at this moment, only providing choices of different languages. This study indicates that processing cost exist when learners switch from L1 to L2. Future design of language support tool should take participants' L1 and L2 into consideration in order to produce appropriate reaction matching humans' cognitive processes.

［4］List of Papers

None