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Interpreting experience enhances early attentional processing, conflict monitoring and interference suppression along the time course of processing

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ABSTRACT

To explore how interpreting experience may modulate young adults' executive functioning, the present study conducted two ERP studies using the Flanker task, and recruited university students of more or less interpreting experience. Experiment 1 revealed that participants of more interpreting experience exhibited larger N1 and N2 amplitudes in both congruent and incongruent conditions, which, according to previous research, are respectively evidence for advantages in early attentional processing and monitoring. As for the response time (RT) data, a smaller interference effect for the group of more interpreting experience was obtained, showing an advantage in inhibition. The P3 results were quite mixed, with the results of the first half P3 time window mainly supporting a monitoring advantage, and the results of the second half mainly supporting an inhibition advantage. Experiment 2 replicated Experiment 1 with two participant groups more closely matched in age and L2 AoA. The pattern of the results was similar to that in Experiment 1, except that the inhibition advantage from the P3 component appeared earlier, and that the inhibition advantage in RT data was only marginally significant. Both experiments have produced results that can be integrated into a coherent whole along the time course of processing, indicating that interpreting experience may enhance early attentional processing, conflict monitoring and interference suppression, with the latter two as parts of inhibitory control.

1. Introduction

Cognitive control, also known as executive functions or executive functioning/control, is an umbrella term containing cognitive processes that are related to the self-regulation and self-control of daily behaviors (Miyake and Friedman, 2012). Such processes include flexibility of thinking, ability to sustain attention, goal maintenance, conflict monitoring, inhibition, interference suppression, switching, (working memory) updating, etc. (Alvarez and Emory, 2006; Chan et al., 2008; Green and Abutalebi, 2013; Salthouse et al., 2003). There is research suggesting that language-specific experiences such as interpreting and public speaking may contribute to the enhancement of cognitive control (Dong and Xie, 2014; Xie and Dong, 2015; Yudes et al., 2011). The rationale behind it is that the exercise of a certain function in the language domain may help enhance its corresponding executive function in the nonlinguistic domain. It seems that this line of research has been stimulated by research on bilingual advantages, which has been a hot topic for the past decade (e.g., Bialystok et al., 2004). It is postulated that bilinguals may be better at cognitive functions such as inhibition (Bialystok et al., 2004; but see Kirk et al., 2014), mental set shifting/switching (e.g., Prior and Macwhinney, 2010; but see Hernández et al., 2013) and monitoring (e.g., Barac and Bialystok, 2012; but see Paap and Greenberg, 2013), probably because bilinguals have to select the right language at the right moment since the two languages are generally non-selectively activated (e.g., Dijkstra and van Heuven, 2002). Since the research on bilingual advantages has become controversial, and the presence or absence of bilingual advantages has become elusive (e.g., Paap et al., 2015; Valian, 2015), it may be helpful to turn our attention to a related question, i.e., what specific language experience enhances which aspect of cognitive control.

Taking the intensity and other unique features of the interpreting task into consideration, we believe that exploring how interpreting experience enhances which aspect of cognitive control will probably offer some help in the study of the mind and brain. Interpreting is a complex and cognitively demanding language task that requires the coordination of several processes under strong time pressure, and thus control over the whole process of interpreting (De Groot and Christoffels, 2006). The two languages are simultaneously activated in interpreting (e.g., Dong and Lin, 2013), certainly more activated

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than when a bilingual is in a monolingual mode. Interpreters have to switch swiftly between languages, inhibiting the interference of the language not wanted at that instant, and updating contents in the working memory system. The functions of switching/shifting, inhibitory control, and updating in the language domain are thus exercised, which may help improve their corresponding functions in the non-linguistic domain. What's more, interpreters have to keep alert to the task at the moment, comprehending the coming information and/or producing the target language (in simultaneous or consecutive interpreting). Attentional control is therefore an essential skill in interpreting (Cowan, 2000; De Groot and Christoffels, 2006; Timarová et al., 2014), and the exercise of such a skill may contribute to a nonlinguistic advantage. Interpreting experience, therefore, may produce domain-general advantages in the executive functions of inhibition, switching/shifting, updating and attentional processing.

There have been a few empirical studies on interpreter advantages in executive functions. Three of the studies (Dong and Liu, 2016; Dong and Xie, 2014; Yudes et al., 2011) suggest that interpreting experience enhances switching ability (as measured in the Wisconsin Cart Sorting Test, or as indexed by the switch costs in a color-shape task), but not inhibition (as measured respectively in the Simon, Flanker and Stroop tasks). Babcock and Vallesi (2015) and Becker et al. (2016), however, found an interpreter advantage in monitoring ability (indexed by mixing costs in a color-shape task), but not in switching ability (indexed by switch costs in the color-shape task). Woumans et al. (2015) found that interpreters outperformed unbalanced bilinguals in the Simon and ANT (a more complex form of Flanker) tasks (i.e., higher accuracy in both tasks and smaller error congruency effect in the ANT), but the interpreters did not outperform balanced bilinguals, suggesting that the interpreter advantage in inhibitory control and attentional processing cannot be uniquely ascribed to interpreting experience. Morales et al. (2015a, 2015b) reported higher updating skills from simultaneous interpreters than from general bilinguals and a modulating effect of interpreting experience on the interaction between attentional networks in the ANT, suggesting an interpreter advantage in updating and in attentional processing. To sum up, it seems that in the few existing studies, there was always a certain cognitive control advantage for professional interpreters or students with more interpreting experience. But the results were not necessarily consistent.

Among the three functions of inhibition, switching and updating (Miyake and Friedman, 2012), there seems to be more research on bilingual advantages in inhibition, and the results were quite mixed (Dong and Li, 2015). The situation is more or less the same for research on interpreter advantages, as can be seen in the few studies described above. Tasks such as the Flanker, the Simon, the Stroop and the ANT are assumed to be typical tests of inhibition; and the word "inhibition" may include quite different processes, especially when tested by different tasks. Timarová et al. (2014), for example, conducted a series of experiments to explore the relationship between simultaneous interpreting experience and executive control ability. Two of the tasks were related to inhibitory control. One was the Flanker task, and it revealed that the interference effect, defined as the ratio of incongruent RT to neutral RT, was negatively correlated to interpreting experience. The other was the antisaccade task, but no such correlation was found. The question of an interpreter advantage in inhibitory control is therefore not so straightforward.

To summarize, more research is needed for the role of interpreting experience in the enhancement of cognitive control. Among all the components of cognitive control, we are more interested in inhibition, which seems the most explored component in the literature. And among all the tasks related to inhibition, the Flanker, together with its more complex form of the ANT, seems the most frequently used task (in studies such as Dong and Xie, 2014; Morales et al., 2015a, 2015b; Timarová et al., 2014; Woumans et al., 2015). With the Flanker task, *an advantage in inhibition* means stronger ability to inhibit the interference from surrounding flankers. Statistically speaking, this advantage is generally reflected in the significant interaction between participant groups and congruency conditions (congruent: ‘> > > > >’, neutral: ‘< > < > > < > < >’, incongruent: ‘> > < > >’). When that interaction is not significant, there is a possibility that the main effect of participant groups is significant, which means that one group, faster in both congruent and incongruent conditions, is more efficient at going back and forth between mixed trials that require conflict resolution (e.g., Hilchey and Klein, 2011). The group that is faster at the task is said to possess *an advantage in monitoring*. In the present study, we intended to use the Flanker task and record participants' electrophysiological responses with the ERP technique.

The ERP technique, with its high temporal resolution, may offer further insights. Previous research indicates that the components of N2, P3 and N1 are related to cognitive control, although the exact processes reflected by these components are still being determined. Specifically, N2 is a typical negative-going component related to the inhibition process (see Folstein and van Petten, 2008, for a review). This component has been analyzed in Flanker tasks to explore inhibitory control (Blackburn, 2013; Johnstone et al., 2009; Kousaie and Phillips, 2012). The Flanker task in Blackburn (2013), for example, revealed a group-congruency interaction in the N2 component. Further analysis showed that only non-switchers (those who do not code-switch between languages during conversation) exhibited larger N2 amplitudes for the incongruent condition than the congruent condition. This congruency effect was not significant for switchers or monolinguals. The results indicate that the non-switchers, with larger N2 effect, exhibited superior inhibitory control due to their frequent suppression of the other language. In the present study, similar to behavioral data, if the group-congruency interaction is significant, we may claim that the group showing larger N2 amplitudes in the incongruent condition possesses better inhibition ability (with no group difference in the congruent condition). If the interaction is not significant but the main effect of group was significant, N2 reflects conflict monitoring, with the advantageous group exhibiting larger N2 amplitudes in both congruent and incongruent conditions.

P3 is a positive-going component related to inhibition and attentional resources (see Polich, 2007, for a review). According to Polich (2007), P3 can be a reflection of inhibition, and the amount of attentional resources allocated to the inhibition process is negatively related to the P3 amplitude. For example, in Kousaie and Phillips (2012), the Stroop task exhibited smaller P3 amplitudes for the incongruent condition than the congruent and neutral conditions, suggesting that *smaller P3 amplitudes meant more attentional resources allocated to the incongruent condition* (since it generally requires more resources to make a decision and respond in the incongruent condition than in the two other conditions). Statistical analysis and its interpretations for P3 are the same as those for N2.

N1 is an ERP component related to early attentional processing (Beste et al., 2008). Beste et al. (2008) found that patients with Huntington's disease and presymptomatic Huntington's disease exhibited reduced N1 amplitudes than their healthy controls when performing the Flanker task, indicating deficient attentional processes. Based on participants' performance in a Flanker task, Johnstone et al. (2009) further suggested that N1 was sensitive to the presence of flankers and was a reflection of automatic attention oriented to the flankers. In short, N1 is considered an index of early attentional processing (especially in a task containing flankers), with larger N1 amplitudes signifying better attentional processing.

The present study was intended to explore the modulation effect of interpreting experience on interpreters' abilities of inhibitory control and early attentional processing, with the employment of the ERP technique. To achieve this goal, groups of university students with different amount of interpreting training were recruited to perform a Flanker task, and the ERP components of N1, N2 and P3, together with RT, were recorded and analyzed. It was hypothesized that participants