

Hemispheric lateralization of executive control and handedness: A P300 event related potential study

Ion N. Beratis^{1,2}, Andreas Rabavilas², Eleni D. Nanou³, Chrissanthi Hountala³, Argiro E. Maganioti³, Christos N. Capsalis³, George N. Papadimitriou¹, Charalabos Papageorgiou^{1,2}

¹Eginition University Hospital, 1st Department of Psychiatry, Medical School, National University of Athens, Greece

²University Mental Health Research Institute (UMHRI), Athens, Greece

³Department of Electrical Engineering, Division of Information Transmission Systems & Material Technology, National Technical University of Athens, Greece

Background

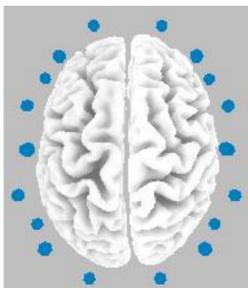
- The P300 component of the event related potentials (ERPs) is considered as an index of information processing and has been extensively used for the exploration of various cognitive processes, such as executive control (Adrover-Roig & Barcelo, 2010; Kamijo & Takeda, 2010)
- Executive control is an umbrella term for higher order cognitive functions such as selecting strategies, inhibiting prepotent responses, updating working memory representations, shifting between tasks or mental sets and monitoring performance (Fossati et al., 2002; Miyake et al., 2000)
- Evidence indicates that right- and left-handers elicit differential P300 activation patterns when performing cognitive tasks of various modalities (Alexander & Polich, 1997; Hoffman & Polich, 1999)
- A general trend that is observed by applying various methodologies is that right-handers elicit asymmetrical hemispheric activation patterns, in contrast to left-handers that show a more symmetrical hemispheric activation pattern (Beratis et al., 2009; Hund-Georgiadis et al., 2002)

Objective

- The present study aims at investigating the hemispheric lateralization patterns of the P300 ERP in right- and left-handers, while performing the initiation and the inhibition condition of the Hayling Sentence Completion task that is considered as a measure of executive control. To our knowledge this is the first investigation of a link between handedness and the P300 ERP activation patterns elicited during the process of executive control operations.

Method

- A total of 60 individuals were analyzed in the study, 30 (16 males) right-handed and 30 (15 males) left-handed. The mean Edinburgh Handedness Inventory (EHI) score in the left-handers was -82.1 ± 26.2 (-18 to -100), and in right-handers 99.1 ± 3.9 (79-100).
- In the initiation condition of the Hayling test, participants were instructed to complete auditory-presented sentences with a word clearly suggested by the context. In the inhibition condition, participants were instructed to produce a word that made no sense in the context of an auditory-presented sentence from which the last word was missing.



- EEG activity was recorded from 20 scalp Ag/AgCl electrodes based on the International 10-20 system of Electroencephalography (Jasper, 1958)
- The ten pairs of counterpart electrodes were Fp1-Fp2, F7-F8, F3-F4, FC5-FC6, C3-C4, T3-T4, CP5-CP6, P3-P4, T5-T6, O1-O2.

Sequence of events in experimental trials

Auditory sentence presentation	3-5 sec
EEG recording	500 ms
Warning stimulus*	100 ms
ERP recording*+	1 sec
Warning stimulus repetition	100 ms
Response onset	Within 5 sec
Period between response completion and onset of next sentence presentation	4-9 sec

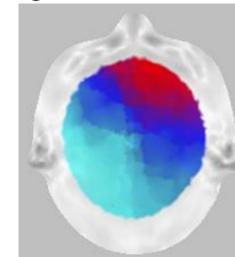
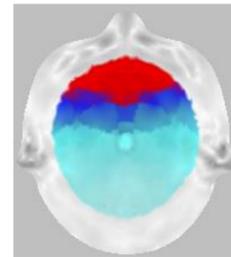
*Simultaneous onset of warning stimulus and of ERP recording

+Peak amplitudes were measured relatively to the mean amplitude of the 100 ms pre-stimulus baseline period; latency measurements were computed relatively to warning stimulus onset (P300 ERP window 220-500 msec)

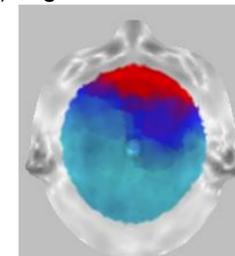
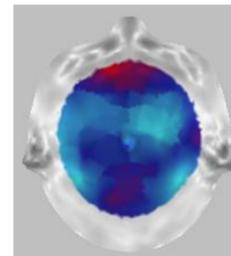
Results

- A mixed between-within subjects analysis of variance revealed significant amplitude differences in 7 out of the 10 pairs of counterpart electrodes in the right-handers during the initiation condition [Pillai's Trace = 0.19, $F(1,58) = 13.41$, $p \leq .001$]. In the inhibition condition no significant differences were observed between counterpart electrodes in the right-handed group.
- In the left-handed group no significant differences were observed between counterpart electrodes in either of the two Hayling conditions

(I) Left-handers Initiation (II) Right-handers Initiation



(III) Left-handers Inhibition (IV) Right-handers Inhibition



LORETA images of the activation patterns in the P300 ERP window in:

(I) initiation condition in left-handed group;

(II) initiation condition in right-handed group;

(III) inhibition condition in left-handed group;

(IV) inhibition condition in right-handed group.

Conclusions

- The findings reveal a symmetrical P300 brain activation pattern in left-handers and an asymmetrical one in right-handers, especially in the initiation condition.
- Handedness may have an impact on the interhemispheric lateralisation patterns of executive control operations, as reflected by the P300 ERP. This is in agreement with findings that indicate behavioral alterations between right- and left-handers in executive control procedures (Beratis et al., 2010; O'Boyle et al., 1995)

•Beratis, I. N., Rabavilas, A., Nanou, E. D., Hountala, C., Maganioti, A. E., Capsalis, C. N.,... Papageorgiou, C. (2009). Effect of initiation-inhibition and handedness on the patterns of the P50 event-related potential component: a low resolution electromagnetic tomography study. *Behavioral and Brain Functions: BBF*, 5, 51.

• Beratis, I. N., Rabavilas, A., Papadimitriou, G. N., & Papageorgiou, C. (2010). Effect of handedness on the Stroop Colour Word task. *Laterality*, 15, 597-609.

• Kamijo, K. & Takeda, Y. (2010). Regular physical activity improves executive function during task switching in young adults. *International Journal of Psychophysiology*, 75, 304-311.

• Adrover-Roig, D. & Barcelo F. (2010). Individual differences in aging and cognitive control modulate the neural indexes of context updating and maintenance during task switching. *Cortex*, 46, 434-450.