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► **To cite this version:**

Gaëlle Leroux, Olivier Houdé, Bernard Mazoyer, Nathalie M Tzourio-Mazoyer, Stephanie Dubal, et al.. Inhibition of number-length interference in a Piaget-like task in adults: an event-related potential study. OHBM, Jun 2005, Toronto, Canada. 2005. hal-02165033

HAL Id: hal-02165033

<https://hal.science/hal-02165033v1>

Submitted on 25 Jun 2019

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Inhibition of number-length interference in a Piaget-like task in adults: an event-related potential study



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RATIONALE

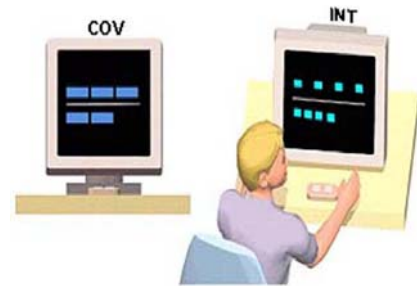
The aim of this ERP study was to explore to observe in young adult brains the electrophysiological markers of a particular childhood developmental stage.

The psychologist Jean Piaget studied numerical cognition with children. One of his famous tasks consisted in showing two rows containing the same number of objects but of different lengths and asking the children **whether the two rows have the same number of objects**¹. Before 7/8 year-old, they fail in this number conservation task and reply that there were more objects in the longer row. It was proposed by Houdé that to succeed in this cognitive task, the subjects **have to inhibit a strong cognitive and perceptual bias or misleading strategy**², **namely the visuospatial length-equals-number strategy**. We hypothesize that **perhaps adults' brains never fully outgrow such biases of early childhood**³.

METHODS

Subjects and tasks

10 right-handed subjects participated in the study. **They had to judge the numerical equivalence of two rows displayed on a computer screen**, either in a Piaget-like task with number/length interference (INT) or in a control task where the number and the length covaried (COV). They were instructed to respond by pressing the "same-number" button or "not-the-same-number" button.



Event-Related Potentials (ERPs)

Scalp voltages with a cap of **64 electrodes distributed according to the 10-20 system** and simultaneous electro-oculograms were recorded (linked-earlobe referenced). **For each condition, 100 epochs were recorded** with an ISI of 2,100 msec (400 msec pre-stimulus). Data were **corrected for eye movements** using independent component analyses⁴ and trial-based manual rejections. Average ERPs were band-pass filtered (0.6 Hz - 30 Hz) with a 200 msec pre-stimulus baseline. Finally, we identified components whose amplitude and latency were individually measured for all electrodes. For each component's amplitude and latency (N1, N2, P3_{early} and P3_{late}), ANOVA with two within-subjects variables: condition (COV, INT) and electrodes sites was computed.

RESULTS and DISCUSSION

Behavioral data

We found significant **longer RTs** ($P < 0.001$) **in INT condition** (785 ± 83 msec) **than in COV condition** (555 ± 103 msec), which we believe to be a classical marker of an interference effect. The **subjects committed few errors** (less than 5% in each condition), which was expected as it was known that this child-psychology task is succeeded as early as 7/8 year-old⁵.

Event-Related Potentials (ERPs)

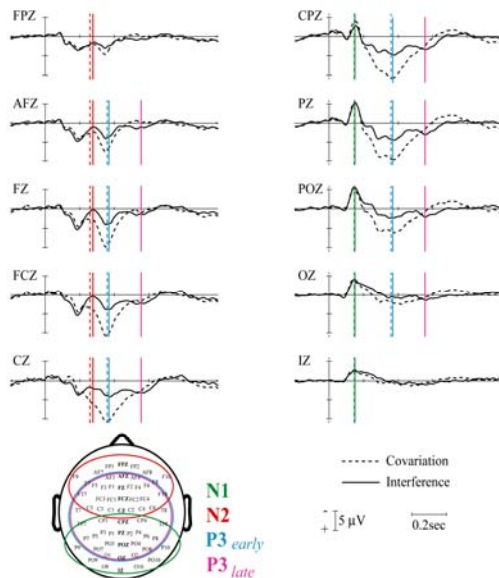


Fig. 1. Grand average ERP waveforms at midline electrodes for both conditions (COV and INT). For each condition and component (N1, N2, P3_{early}, and P3_{late}), the latencies were plotted at their maxima. Electrode sets are displayed on a schematic head (nose is up).

The first difference in ERP was observed for the N2 component over the fronto-central area, of which the amplitude was significantly larger in INT than in COV. Consistently with our previous work⁶, we interpreted **this N2 as an increase of the energetic cost in information processing when the heuristic "length equals number" strategy had to be inhibited**.

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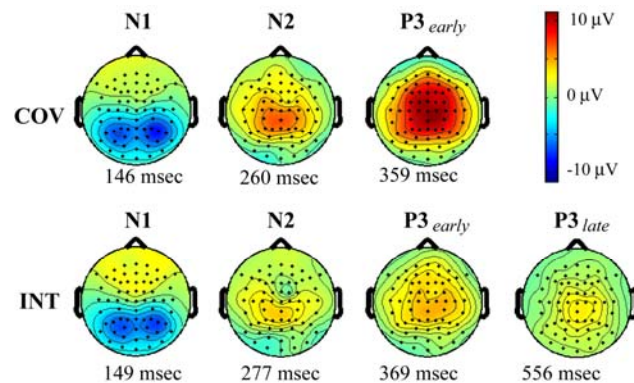


Fig. 2. Grand average topographic maps of COV and INT voltages, at N1, N2, and P3 maxima.

The **P3_{early}** component over the centro-parietal areas was significantly larger in COV than in INT. This **is consistent with Go/NoGo data** showing a larger P3 during the Go condition than during the NoGo condition (inhibition condition)⁷.

Finally, an additional component over the centro-parietal area, called **P3_{late}**, was only observed in INT. During three-stimulus paradigms (target, nontarget, and standard)⁸, this component **was related to nontarget stimuli** (inhibition condition).

Another view would be to consider that this **P3_{late}** bear some resemblance to the so-called P6 component, which was reported to be related to rule violation in a numerical task⁹. Coherently, **during INT, subjects had to manage the number/length interference as a perceptual violation of the "length equals number" rule**.

CONCLUSION

Our ERP data fit very well with our behavioral data (RTs and error rates) showing that INT was a task that required a specific cognitive inhibition by adults. They also fit well with cognitive developmental neuroscience studies showing that the acquisition of a fully coordinated and controlled set of executive functions (namely, response inhibition) occurs relatively late in brain development^{10, 11, 12}.

ACKNOWLEDGEMENTS

We would like to thank Guy Percey for his help in the subjects' recruitment. We are also grateful to Antoine Ducorps and Denis Schwartz for their technical assistance in the ERP acquisition. This work was supported by the ACI "Neurosciences intégratives et computationnelles" from the French Ministry of Research.