ERP and behavioral evidence for interaction/cascade between central (linguistic) and peripheral (motor) processes during word handwriting

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Mélanie Jucla[1], Samuel Planton[1,2], Jean-François Démonet[2,3] & Christiane Soum[1]

[1]E.A Octogone. Laboratoire Jacques-Lordat, E.A 4156, Université Toulouse II Le Mirail, Toulouse, France

[2] Inserm; Imagerie cérébrale et handicaps neurologiques UMR 825; F-31059 Toulouse, France.

[3] Centre Leenaards de la Mémoire, CHUV Département des neurosciences cliniques, Lausanne, Switzerland

Contact : melanie.jucla@univ-tlse2.fr

Background

Models of handwritten language production make a distinction between central (access to semantic, orthographic and phonological information) and peripheral (allographic and gesture planning) processes (see van Galen, 1991; Rapp, 2002). Though, this is still a matter of debate whether these central and peripheral modules are processed in a cascaded or in a serial way (Delattre, Barry & Bonin, 2006; Damian & Stadthagen-Gonzalez, 2009). In the same view, another question still debated is "do central and peripheral processes 'interact' in handwritten word production compared to oral naming"?

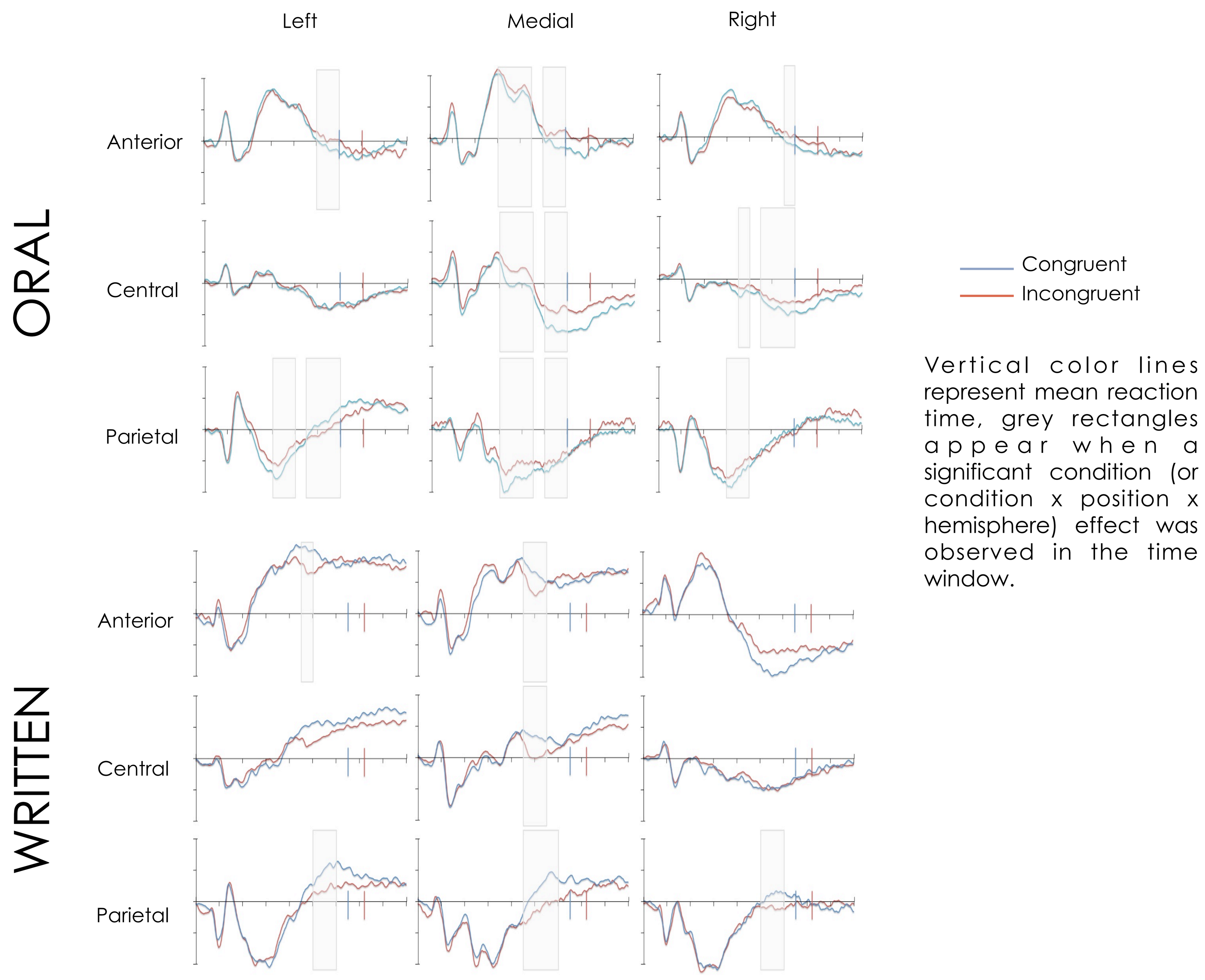
ERP data

POPULATION : 16 French adults (mean age = 25 years old)

- THE STROOP TASK
  - Word Processing
  - Color Processing
- Response modality
  - Oral response
  - Written response
- Stimuli
  - Color words (blue - red - green) printed either in a congruent or incongruent color
  - *36 stim/condition*

Data ACQUISITION & ANALYSIS

- RT recording
  - Oral response : Microphone
  - Written response : Wacom digitizing tablet
- EEG recording
  - 64 electrodes cap
  - NuAmpsTM amplifier (500 Hz)
- Acquisition software : Neuroscan®
- Analysis software = SPM EEG
- HP and LP filters [0.1 – 30 Hz], mean reference
- Mean Amplitude detection: in 50 ms windows in the 300-600 ms interval



Vertical color lines represent mean reaction time, grey rectangles appear when a significant condition (or condition x position x hemisphere) effect was observed in the time window.

Figure 1 : ERPs acquired in the a) oral and (b) written color Stroop task. Waveforms were obtained from linear derivation of:

	Left	Medial	Right
Frontal	F1, F3, F5, FC1, FC3, FC5	Fz, FCz	F2, F4, F6, FC2, FC4, FC6
Central	C1, C3, C5, CP1, CP3, CP5	Cz, CPz	C2, C4, C6, CP2, CP4, CP6
Posterior	P1, P3, P5, PO3, PO7, O1	Pz, POz	P2, P4, P6, PO4, PO8, O2

RESULTS and DISCUSSION

We obtained typical 'N400' interference effect in the Stroop task mainly at medial sites in the oral modality. We put forward a different scalp topography in the written modality (Perret & Laganaro, 2012) with an interference effect that only starts around 450 ms. Lateralization is partly due to motor response and thus could partially explain the late interference effect. This effect could account for the specificity of hand-written language production supporting the view that peripheral processing start before lexical and orthographic selection ends and might impact the 'conflict resolution' → **In favor of interaction between central and peripheral processes**

Regularity and length effects

TASK : **Written spelling under dictation of isolated words**

POPULATION : 26 (exp. 1) and 27 (exp. 2) French adults

Data ACQUISITION & ANALYSIS

Written response registered on a Wacom digitizing tablet (via Matlab)

Variables measured : Errors, writing latencies and duration, relative writing speed

STATISTICS: Linear mixed models (subjects and items as random effects). Length x regularity x position effects

Experiment 1

STIMULI : 64 monomorphemic nouns, varying on length (short -1 syll.- vs. long -3 syll.-) and regularity paired on frequency(Lexique.org). Irregularity at the beginning or at the end

RESULTS:

- Regularity effect

Latencies ↗ (Fig. 2) and speed ↘ for words irregular at the beginning

- Length effect *(controlled for stimulus length)*

Latencies ↗ and speed ↗ for short words

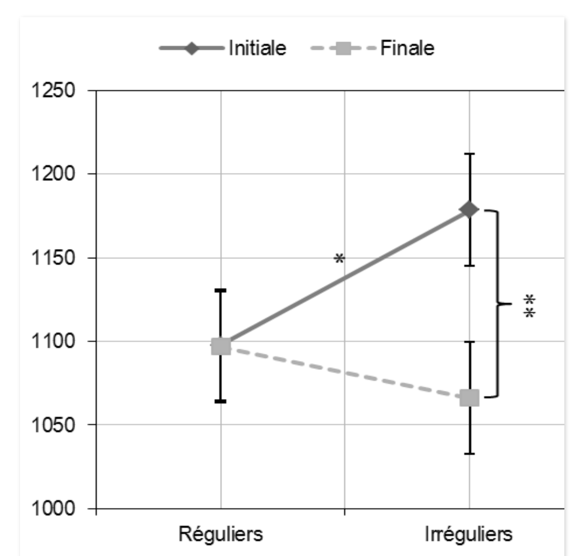


Figure 2 : Latencies are longer for words irregular at the beginning

Experiment 2

Stimuli : 180, monomorphemic nouns of 1, 2 et 3 syllables. Consistency manipulated on the first and last segment (→ 4 conditions, in/consistent at the beginning and/or at the end)

RESULTS:

- Consistency effect

Latencies ↗ (Fig. 3) for words inconsistent at the beginning

Speed ↘ for words inconsistent at the end

- Length effect *(controlled for stimulus length)*

Latencies ↗ for one syllable words

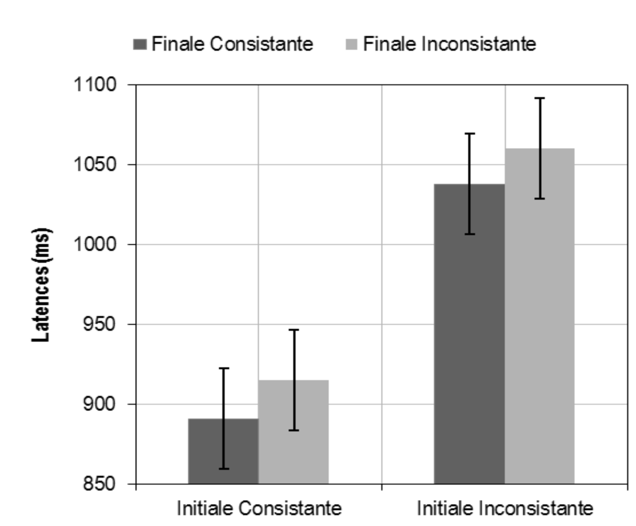


Figure 3 : Latencies are longer for words inconsistent at the beginning

Further analysis on writing speed (Fig. 4) : In long words inconsistent at the end, speed ↘ at the beginning of word writing

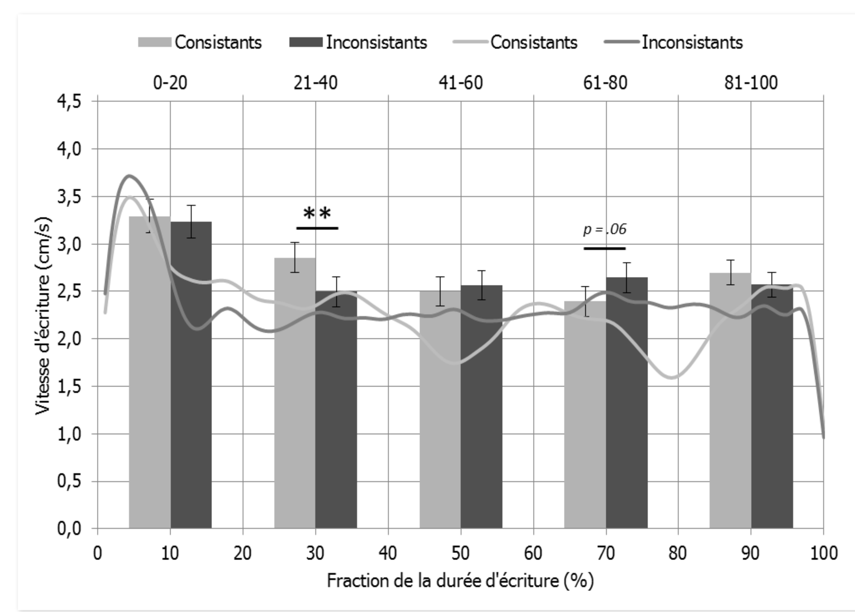


Figure 4 : Relative writing speed during word writing for long consistent and inconsistent words

DISCUSSION

Effects on latencies (no effect of final inconsistencies, of the increased number of letters) contradicts a purely serial conception. Inconsistencies at the end of long words seem to reduce writing execution speed during the production of the first syllable.

→ In favor of a parallel/cascaded view of central and peripheral processes during writing

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