Modality switch effects emerge early and increase throughout conceptual processing: Evidence from ERPs

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Data online

Engagement of sensory and motor brain regions during word processing is broadly documented. Outstanding questions:

Functional or epiphenomenal role **?** Directly **compatible with symbolic processing ?**

BACKGROUND: Reaction time (e.g., **Conceptual Modality Switch / CMS** [1]), fMRI (e.g., seeing colour, reading color words engage same cortex [2]), ERPs (e.g., **CMS** [3, 4]), causality-oriented TMS (e.g., hand-related verbs engage premotor cortex [5]).

Word onset || ~150 ms ~170 ms ~250 ms ~400 ms … ~1 s.
(Ref. [6]) Lexical | Semantic | Working memory | Response-related | Mental imagery | Episodic memory

CMS design: [1] Property-concept verification in each trial. Covert manipulation across trials: conceptual modality switches.

Result: Even if CMS is orthogonal to task, switching conceptual modalities incurs costs in **Event-Related Potentials** and RTs.

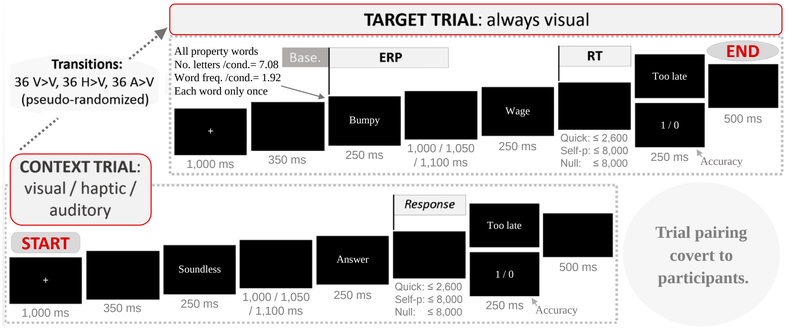
Previous studies time-locked ERPs to last word in target trials (adjective). Ref. [3]: An iron is hot || Ref. [4]: Candles flicker

CURRENT GOALS: **Probe time course of CMS effect and test interplay of symbolic and embodied processing.**

Time-lock ERPs to *first* word in target trials, adjective (CMS not testable in RTs). Quick & Slow groups. Major & minor switch.

Advantages: Measuring CMS without lag and removing the confound of the relationship between each concept and property.

Hypotheses [7, 8, 9]: Larger CMS effect for auditory-to-visual switch, in Slow group, later in time, and in primary visual cortex. Quick group relatively miss haptic-to-visual switch. Quick group CMS in language cortex, Slow group CMS in perceptual cortex.



Stimuli norming: [10] *N*=42 rated auditory, haptic, visual experience of property & concept words. α = .75; λ_6 = .79

Pretest: *N* = 19. Response accuracy = 63%, SD = 48 pp.

Participants: One ptp. w/ errors > 50% and another with too noisy ERPs were removed. Original groups (see left) hardly differed in RTs, so were re-split into **Quick group** (*n* = 23, *M* = 568 ms) and **Slow group** (*n* = 23, *M* = 937 ms). CMS effect was very similar with original groups.

Response accuracy: **Quick g.:** *M* = 63%, *SD* = 48 pp.
Slow g.: *M* = 64%, *SD* = 48 pp.

Stat tests: Linear Mixed Effects models via Likelihood.

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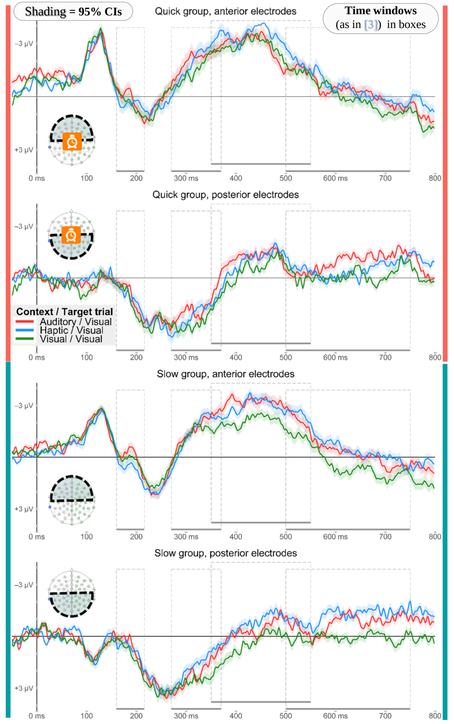
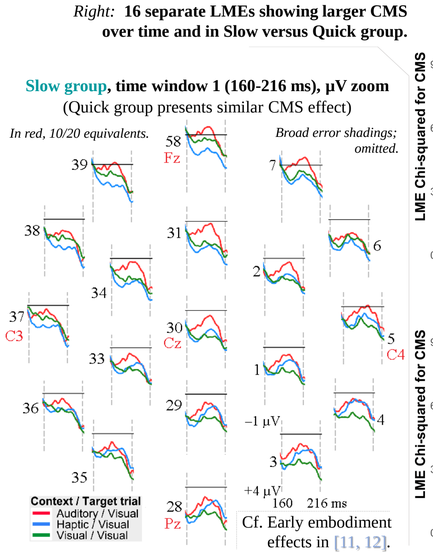
[1] Pecher, Zeelenberg & Barsalou (2003) *Psychological Science;* [2] Simmons et al. (2007) *Neuropsychologia;* [3] Hald et al. (2011) *Frontiers in Psychology;* [4] Collins et al. (2011) *Frontiers in Psychology;* [5] Willems et al. (2011) *Psychological Science;* [6] Hauk (2016) *Psychonomic Bulletin & Review;* [7] Louwerse & Connell (2011) *Cognitive Science;* [8] Louwerse & Hutchinson (2012) *Frontiers in Psychology;* [9] Barsalou et al. (2008) In De Vega, Glenberg & Graesser. Oxford U Press; [10] Bernabeu, Willems & Louwerse (in prep.) Data at figshare.com; [11] Amsel, Urbach & Kutas (2014) *Neuroimage;* [12] Van Dam et al. (2014) *Topics in Cognitive Science;* [13] Hauk et al. (2012) *Neuroimage;* [14] Lupyan (2017) *Frontiers in Psychology.*

RESULTS & CONCLUSIONS

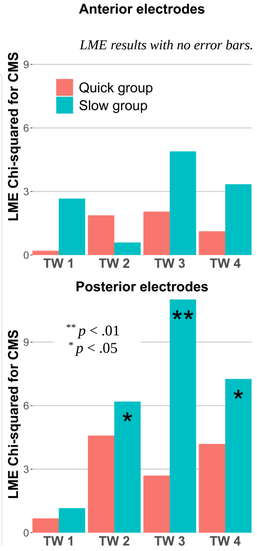


Relative deflection for conceptual modality switches, similar for both switch types (general switch contrast *t* = 2.26; switches contrast *t* = –0.01). CMS most notable in **Slow group**, N400 window, and posterior electrodes.

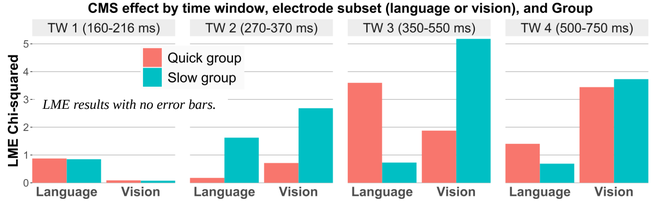
Right: **16 separate LMEs showing larger CMS over time and in Slow versus Quick group.**



Cf. Early embodiment effects in [11, 12].



Interaction CMS x Group x Language/Vision area significant (*) in time windows 3 (N400) and 4 (LPC).



Electrodes' 10/20 equivalents: Language = TP7, T7, ~T7, FT7. Vision = O1, PO3, O2, PO4.

LME SUMMARY ***p* < .001; **p* < .01; *p* < .05

Time window	Factors	Effect: χ^2
1) 160–216 ms	CMS	1.40
	CMS x Ant/Pos Area	48.59***
	CMS x Ant/Pos Area x Group	23.63**
2) 270–370 ms	CMS	6.40*
	CMS x Ant/Pos Area	10.89**
	CMS x Ant/Pos Area x Group	4.13***
3) 350–550 ms	CMS	9.47**
4) 500–750 ms	CMS	7.58*

Degree of symbolic and embodied processing subject to contextual factors such as time resources [7, 8, 9]. More research on word processing stages is advised [6, 13, 14].