Hemispheric asymmetries in processing semantic relationships during reading

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Introduction

To make sense of language (at the timescales required), individuals must rapidly use and integrate many sources of information. The two cerebral hemispheres are believed to have important, though somewhat different, roles during these processes: the left hemisphere (LH) has been linked to (pre-)activating narrow meanings while the right hemisphere (RH) has been linked to more flexible, and weaker but broader, activation of multiple meanings.[1-3] An often-overlooked source of variability in language processing is the information available to individuals: people vary in what they know, and this has rapid consequences for neural processing of language in real time.[4-6] Here, we combine event-related brain potentials (ERP) with word-by-word reading and lateralized visual presentation to ask:

How does variability in knowledge influence language processing across the two cerebral hemispheres in real time?

N400 amplitudes reflect fine-grained sensitivity to a word's meaning in context[7], including not only its predictability but also its relationship with a predictable word[8] and/or contextual descriptions of events.[9] The extent to which N400 amplitudes are sensitive to these relationships depends on an individual's degree of knowledge about the sentence content.[6]

Sirius Black was sentenced to prison.
*He spent time in { **Azkaban** / **dementors** / **diadem** }.*

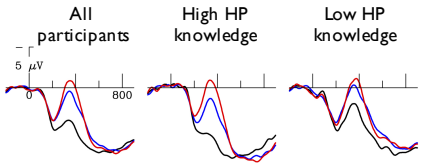


Figure adapted from Ref. 6

When words were contextually **supported** N400 amplitude was reduced; **unsupported** words elicited a larger N400; and unsupported but **related** words elicited an intermediate-amplitude N400, suggesting their meaning was facilitated by the context. These effects were modulated by each individual's degree of content knowledge.

ERP studies using lateralized presentation show that both hemispheres quickly make use of context, though somewhat differently: LH is more sensitive to categorical relationships with predicted words[10] and RH more sensitive to event relationships[11]. Here, we examined hemispheric asymmetries in processing similar (though fictional) types of relationships as a function of individuals' degree of knowledge of the narrative world of Harry Potter. We asked whether hemispheric asymmetries in use of context and semantic relationships might be modulated by degree of domain knowledge.

Refs. [1] Beeman et al., 1994. *JOCN*. [2] Federmeier, 2007. *Psychophys*. [3] Federmeier & Benjamin. *PBR*. [4] Troyer & Kutas, 2018. *LCN*. [5] Troyer, Urbach, & Kutas, 2019. *JEP:LMC*. [6] Troyer & Kutas, 2020. *JML*. [7] Kutas & Federmeier, 2000. *TICS*. [8] Federmeier & Kutas, 1999. *JML*. [9] Metusalem et al., 2012. *JML*. [10] Federmeier & Kutas, 1999. *Cog Brain Res*. [11] Metusalem et al., 2016. *Neuropsychologia*.

Experiment (N=48)

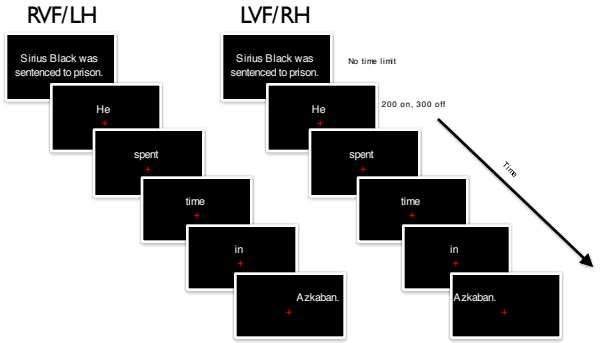
Sentence materials

Control (80 items)
We had been watching the blue jay for days.
*The bird laid her eggs in the **nest**.* SUPPORTED
yard. UNSUPPORTED

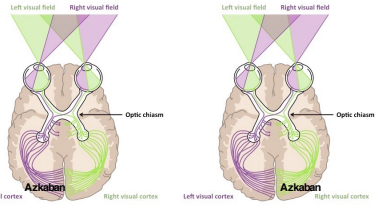
Harry Potter (HP; 156 items)
Sybill Trelawney is a Hogwarts professor.
*She teaches **Divination**.* SUPPORTED
Transfiguration. CATEGORY-RELATED
basilisk. UNRELATED

Sirius Black was sentenced to prison.
*He spent time in **Azkaban**.* SUPPORTED
dementors. EVENT-RELATED
diadem. UNRELATED

EEG reading experiment with lateralized visual presentation

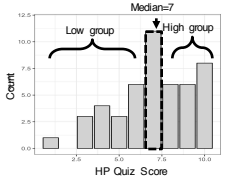


Words presented to the right visual field (RVF) initially are processed by the LH; words presented to the left visual field (LVF) initially are processed by the RH.



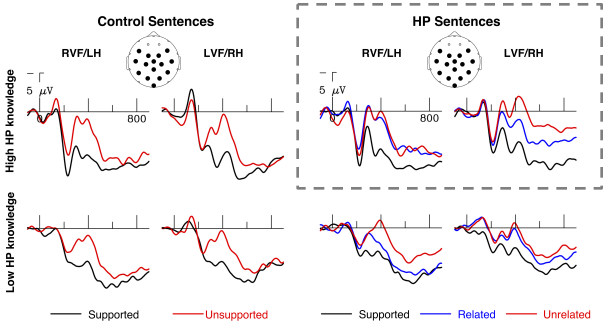
Knowledge and offline measures

HP knowledge was estimated using a 10-question trivia quiz; additional measures included self-reported experience with HP, print exposure, and general knowledge.



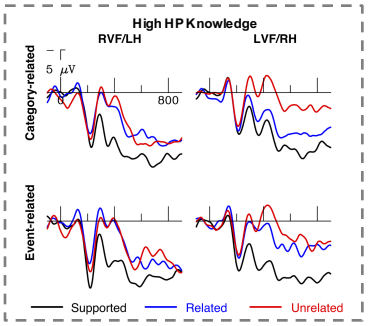
Results

Across participants, both hemispheres were sensitive to contextual support



ERPs revealed N400 effects of contextual support (Supported < Unrelated) across sentences, hemispheres, and participants; HP-related-anomaly effects (Related < Unrelated) were limited to within the RH (LVF) for high-knowledge participants (dashed box).

Within HP "experts," only the RH showed sensitivity to related anomalies, with subtle differences based on type



We analyzed the category-related (N_{items}=78) and event-related (N_{items}=78) item subsets separately. Results from LH were the same for each subtype (Supported < Related / Unrelated). Within the RH: Category-related words were processed similarly to supported words, both eliciting reduced N400 amplitude compared to unrelated words. N400 amplitude to event-related words did not differ statistically (p=.14) from unrelated words, amplitudes for both being larger than for related words.

Conclusions. As expected, both hemispheres made rapid use of contextual (including fictional) information. For the first time, we show that the size of the effect depended on individuals' degree of knowledge. Only HP "experts" showed (RH-only) sensitivity to related anomalies, with slightly different profiles dependent on the type of relation. We speculate that knowledge might influence how individuals optimize different hemispheric "specialties," with LH being involved in semantic verification of facts while RH remains available for flexible recruitment of semantically related content.

Acknowledgements. We would like to acknowledge and thank Sean Coulson, Ken McRae, and members of the Kutas lab for their input and feedback on this work.