The Left Hemisphere Knows More about Verbs (in most People)

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Introduction

Hemispheric Asymmetry in Language

Left hemisphere (LH) "dominance" for language has been the most salient feature of the neural basis of human language since the discovery of Broca's area. Since then, however, it has become clear that both hemispheres contribute to language. Federmeier and colleagues [1,2] have argued that one important difference between the hemispheres lies in their ability to make predictions based on the input so far. On their view, the LH actively predicts what will come next while the right hemisphere (RH) processes words more passively, and they have shown that the LH predicts semantic features of upcoming words in a way the RH does not. The present study combines hemi-field visual presentation with EEG recording to explore the following questions about brain asymmetry:

1. Do both hemispheres make use of probabilistic information about the kinds of sentence structures verbs are most likely to appear in (verb bias)?
2. Do both hemispheres make similar use of cues to syntactic structure provided by function words?

Individual Variation

Individual differences in working memory and inhibitory control have been found to predict aspects of online language processing [3,4], as have differences in family history of handedness [5,6]. This study incorporates individual difference measurements and finds that they are related to hemispheric differences.

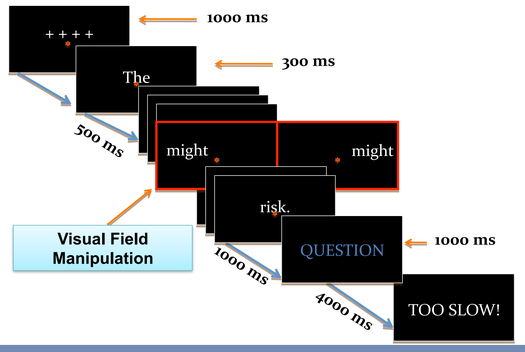
Participants and Stimuli

46 right-handed English native speakers (mean age 20).

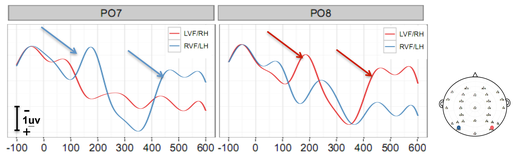
Materials

Verb Bias	Direct Object Bias Verbs (DO) (10 verbs, 80 items)	Sentential Complement Bias Verbs (SC) (10 verbs, 80 items)
Unambiguous	*The young lawyer accepted that the position might put his career at risk.*	*The shifty salesman admitted that the deception would lead to clients returning the merchandise.*
Ambiguous	*The young lawyer accepted the position might put his career at risk.*	*The shifty salesman admitted the deception would lead to clients returning the merchandise.*

Stimulus Presentation Procedure



EEG Recording and Hemi-field Paradigm



N1/P2 and Selection Negativity

Lateralized words elicit a larger N1/P2 complex & larger negativity around 400 msec at contralateral posterior sites, showing that initial processing is done in contralateral hemisphere.

Individual Difference Measures

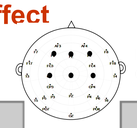
Familial Left Handedness
- Survey of participants' family history of left-handedness

Working memory measures [7]: Average scores of 3 tasks
- Loaded reading span
- Digit span
- Alpha span

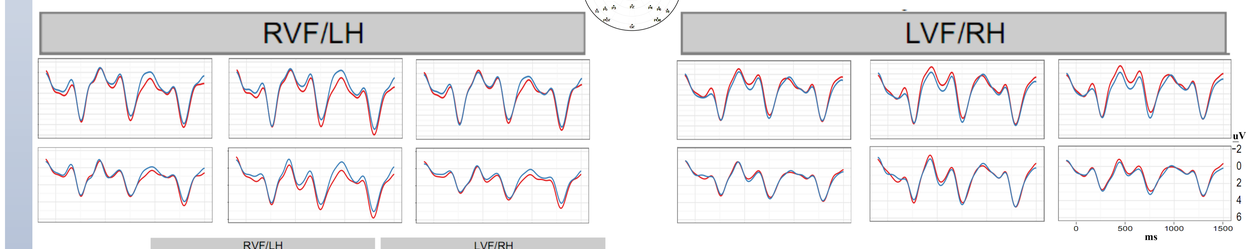
Inhibitory control measures [8]: Accuracy scores
- Lateralized version of Stroop task:1/3 of the stimuli were presented to RVF/LH, another 1/3 were presented to LVF/RH, and the rest were presented centrally.

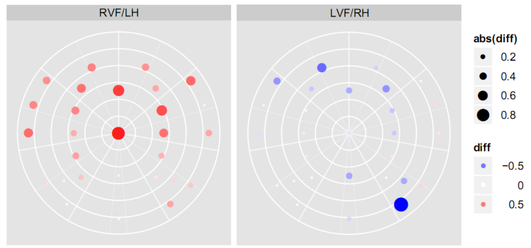
Hemispheric Asymmetry in Verb Bias Effect

DO: *accepted (that) the position **might**…*
SC: *admitted (that) the deception **would**…*



ERP waveforms are time-locked at the onset of the disambiguating auxiliary verbs (e.g. *might* and *would*).



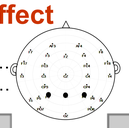


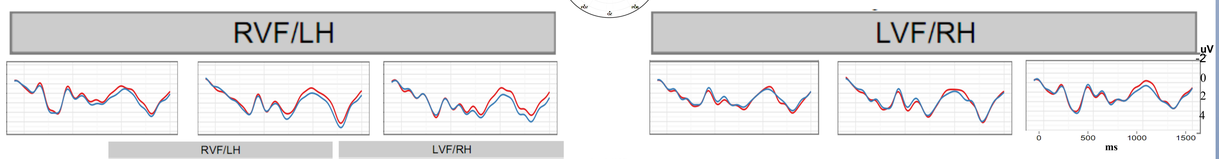
ERP difference (DO-SC) averaged over 500-1300 ms (Red: DO more positive, Blue: DO more negative; Size of dots = Size of bias effect)

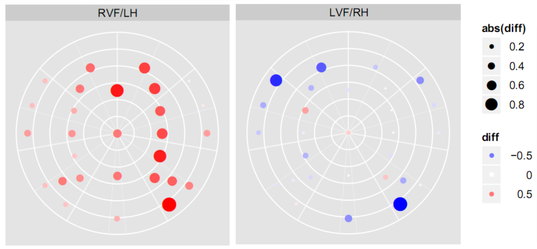
Larger positivity at central frontal channels for disambiguating words following DO-bias verbs **only with RVF/LH presentation**.

Hemispheric Asymmetry in Ambiguity Effect

Unambiguous: *accepted / admitted (that) …**might/would**…*
Ambiguous: *accepted / admitted … **might/would**…*



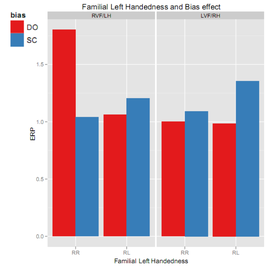




ERP difference (Ambig-Unambig) averaged over 500-1300 ms (Red: Ambig more positive, Blue: Ambig more negative; Size of dots = Size of ambiguity effect)

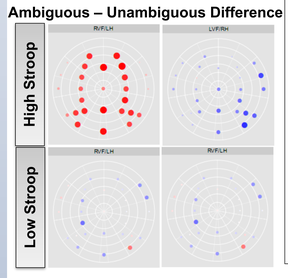
Larger positivity at posterior channels (marginal at frontal channels) elicited by the disambiguating words in sentences without the earlier function word cue *that* **only with RVF/LH presentation**.

Influence of Individual Differences



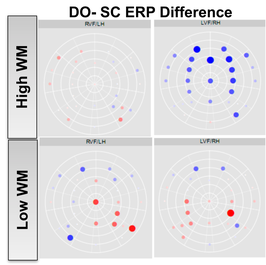
The LH knows more than the RH about Verb Bias only in those with no left-handed relatives

In people with left-handed relatives (RL), ERPs did not distinguish DO- & SC-Bias verbs with presentation to either hemisphere, while in those with no left-handed relatives (RR), ERPs were more positive for DO-Bias Verbs with RVF/LH presentation.



The LH uses a function word cue (*that*) only in people with high inhibitory control.

Only people with high Stroop scores show decreased positivity with LH presentation in sentences with a disambiguating function word, suggesting they are more able to take advantage of the cue.



Working memory score modulates the RH response to Verb Bias.

For people with high working memory (WM) span scores, the disambiguating word elicited a larger frontal negativity at 150-700 ms following DO-Bias Verbs only with LVF/RH presentation, which may indicate more need for selection at that point, perhaps because the RH of those with High WM is maintaining more options.

Conclusions

- The LH is better than the RH at using both Verb Bias and function words to disambiguate temporary structural ambiguity in sentences.
- Exceptions include people with left-handed family members and those who perform poorly in the Stroop task.
- A frontal negativity thought to reflect selection among options is more pronounced with LVF/RH presentation in those with High WM, suggesting that their RH maintains more options for longer.

References

1. Coulson, Federmeier, van Petten and Kutas, 2005
2. Wlotko and Federmeier, 2008
3. Caplan and Waters, 1999
4. Novick et al., 2005
5. Townsend et al., 2001
6. Lee and Federmeier, 2010
7. Waters and Caplan, 2003
8. Weekes and Zaidel, 1996

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