Finding the Right Word: Hemispheric Asymmetries in the Use of Sentence Context Information

Wlotko and Federmeier 2007

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Background

- earlier: language processing thought of as an example of hemispheric asymmetry
  - damage in the LH → language deficits
  - damage in the RH → more subtle problems

- now: language processing is bilateral, but the hemispheres may contribute differently
Problem

- many experiments have tested how each hemisphere processes individual words

BUT

What about their role in normal discourse and sentence processing?
The Right Hemisphere

- experimental evidence on the role of the RH in language processing has been divided
View A: RH Contributes to Discourse Understanding

- studies of RH damaged patients show problems in higher level processing including:
  - understanding the main idea of discourse (Gardner, Brownell, Wapner & Michelow, 1983)
  - forming some types of inferences (Brownwell & Martino, 1998)
  - comprehending non-literal language (Winner & Gardner, 1977)
  - appreciating jokes (Brownell, Michel, Powelson & Garder, 1983)
- neuroimaging shows RH involvement in similar high-level language process (Bottini et al, 1994; Coulson & Williams, 2005)
View B: RH at Word Level

- behavioural data suggest RH processing is driven entirely or primarily by word-level relationships (lexical associative) and thus partially or wholly insensitive to message-level information (propositional information)
So which one is it?

- this discrepancy → a quest for more electrophysiological evidence for better understanding of RH's role in language processing
A Previous Experiment

- Federmeier, Wlotko, De Ochoa-Dewald, Kutas (2007) used the stimuli in this experiment but presented them centrally

- found: N400 responses graded by cloze probability
The Visual Field Paradigm

**method**: stimuli presented to the left or right VF, so that stimulus apprehension takes place in the contralateral hemisphere and biases later stages of processing toward this hemisphere

**advantages**: decades of studies, which have found “robust and highly replicable hemispheric processing asymmetries, attesting to the effectiveness of this procedure”
The Experiment

Goal: “... further assess when and how each hemisphere makes use of message-level information provided by a sentence context.”

By investigating:

- the effect of constraint and expectancy on P2
- the effect of constraint and expectancy on N400
- hemispheric differences in the above two
The Theory

- LH may “use context info to predict (process conceptual and maybe perceptual features) of upcoming words”

- RH may “adopt a more integrative approach, in which fit of a word to its context is assessed in a bottom up, post hoc fashion”
The Theory

If this is the case:

- only LH should react to an unexpected item since it is predicting an expected completion and must revise its prediction

- RH should react to both SC and WC unexpected endings similarly, because “their bottom-up (lack of) fit to the context, as indexed by cloze probability, is the same”
Participants

- 32 right-handed native English speakers
- no exposure to other languages before age 5
- 16 female, 16 male
- university students
Stimuli

- 282 sentence frames
- half strongly constraining
- half weakly constraining
- each associated with its most expected and an unexpected but plausible ending (as determined by cloze probabilities)
Stimuli

- critical words = endings

- **four** conditions:

  1) SC-EE
  2) WC-EE
  3) SC-UE
  4) WC-UE
Determining Cloze Probabilities

- 368 sentence frames into four lists of 92
- 3 lists done by 18 participants and 1 by 19

- Participants read each sentence frame and were asked to write “what they would generally expect to find completing the sentence fragment” plus 2 other, plausible completions

- Cloze probabilities were computed for these
Selecting the Database

- 141 SC sentence frames (best completion: cloze value of 67% or more)
- 141 WC sentence frames (best completion: cloze value of 42% or less)

- matched for length (~10 words per sentence)
- controlled for word frequency
- controlled for word length
- ratings for concreteness, imagability, familiarity
Unexpected Endings

- unexpected, but plausible, endings created and paired with an SC and a WC

- these were taken from a different semantic category than the expected word, to avoid feature overlap

- lexical properties of endings controlled, mean association strength between the word and both expected words and other words in the sentence calculated
Unexpected Endings

Question: The authors claim a near 0% cloze probability for their unexpected endings. Is this justified given the measures they've taken?

Answer: We would need more details of the exact measures and calculations conducted to know for sure.

Possible improvements: a more systematic selection of items, some testing to confirm that the item really is unexpected, more details and examples concerning the selection process
Stimuli

- stimuli divided into four lists
- each participant saw each sentence frame and corresponding critical word only once

- half of the frames from each constraint completed by expected ending, half by unexpected ending
- half of the expected and half of the unexpected endings presented in the RVF and LVF
Method

- dimly lit room, 100cm in front of a 21” CRT computer monitor
- warning sign (several pluses in screen's centre) before each trial
- word-by-word in centre of screen, with a fixation point underneath
- final word, presented with its inner edge two degrees to the left or right of fixation
Method

- each word presented for 200 ms
- interstimulus interval: 300 ms
- 3 second pause between trials
- participants asked to maintain central fixation during lateral presentation
He +
bought
+

her
pearl
+

necklace
+


for
+

her
+

collection. +
Method: Recognition Test

- instructed to read for comprehension and informed they would be asked questions after
  
- 240 words per participant
- 80 unexpected endings from the stimuli
- 80 expected from the stimuli
- 78 unseen (expected, seen by others)
- half from LVF, half from: SC, WC
- half from RVF, half from: SC, WC
- every participant saw every unexpected word
Behavioural (Post-test) Results

- on average: participants correctly recognized 40.5 out of 160 experimental words (25.3%)
- false alarmed to 7 of 78 (9%)

- ANOVA: 2 levels of VF, 2 levels of constraint, levels of expectancy

- unexpected items in both sentence frames remembered equally well for RVF and LVF
- but WC-EE was better remembered than SC-EE
Behavioural (Post-test) Results

- items presented to the RVF better remembered (27% vs 23.4% for LVF)

- unexpected endings remembered equally well across sentence types (SC and WC)

- for RVF, unexpected endings were remembered better than expected endings

- for LVF, unexpected items were remembered less well than expected items
Behavioural (Post-test) Results

Recognition Test Performance

Figure 1.
Post-test recognition performance, displayed as proportion of items recognized from each experimental condition.
Collecting ERP Data

- ERPs computed from 100 ms before the onset of the critical word to 920 ms after
- 100 ms pre-stimulus baseline subtracted
- averages of artifact-free ERPs were calculated for each type of critical word
P2

- P2: response to higher order visual and attentional stimuli (Luck & Hillyard, 1994)

- P2 affected by constraint manipulation only with RVF/lh presentation in a previous experiment (Federmeier, Mai, & Kutas (2005))

- this study: P2 was sensitive to constraint - words in an SC frame elicited larger P2s than in a WC frame for the RVF/lh only
Figure 3.
P2 constraint effect (collapsed over expectancy) shown at the Right Medial Frontal Channel for RVF/lh and LVF/rh presentation.
The Claim

- this appears to be consistent with the LH/predictive and RH/integrative view, because only LH uses context information to predict upcoming words
Some Problems

- P2 is in early stages of research

- seems to be elicited in response to a wide variety of cognitive tasks, more research is needed before drawing conclusions

- for example: P2 is linked to memory (Evans & Federmeier, 2007; Lafebvre et al., 2005) – participants may be remembering a similar sentence in the past, having seen the word before – the link from this to prediction is tenuous
N400 Results: RVF/lh vs LVF/rh

- ANOVA – two VFS, two levels of expectancy (EE, UE), 26 levels of electrode

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N400 Results

Right Visual Field/Left Hemisphere

Left Visual Field/Right Hemisphere

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SC−EE

WC−EE

SC−UE

WC−UE

5 μV
Authors' Conclusions

- N400 responses to SC-EE were smaller than WC-UE in both VFs → both LH and RH use message-level information to assess basic fit of a word to message-level meaning

- SC-UE elicited a stronger N400 than SC-EE in both VFs → does not support the notion of RH as insensitive to message-level information

- pattern of responses reveals differences in how the both hemispheres use context information
Authors' Conclusions

- for LH, the evidence in this study cannot, alone, distinguish between prediction and other forms of processing, but is consistent with evidence that does suggest this

- facilitation for RH occurred mostly when context information provided strong support for the coming word – consistent with integration but not proof in and of itself

- P2 emerged only during RVF/lh presentation → consistent with hypothesis that LH, and not RH uses context information to predict words
Final Comments

- evidence gives support for processing differences between the hemispheres

- fits a prediction/integration view but does not, in and of itself, confirm anything

- different approaches to processing from both hemispheres may increase efficiency and are thus psychologically plausible, but how the mechanisms differ remains unclear

- more research on P2 needed
Suggestions

- more systematic selection of unexpected words, or at least more detail about the process
- correct recognition for behavioural tests seems low (about 25%) - may be good to increase this if possible
- more research needed on the P2 before it can be convincing evidence for prediction vs integration
- revision, or explanation, of the term “message-level”
- a table containing the N400 information would have been helpful

Recommended direction of research:
- more research on LH and RH in discourse comparable to real life conversation
- more research on P2
References


