Dynamic Modularity in Interhemispheric Interaction

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Introduction

- Hemispheric specialization is a powerful design principle for brains, ranging from the avian neural clumping design to the human layer design. In humans, it provides:
  - Complementary information processing styles in the two hemispheres
  - Efficient parallel independent processing
  - Powerful interactive effects where one hemisphere reinforces the other
  - An effective platform for monitoring and control of one hemisphere by the other

We will illustrate these modes using lateralized lexical decision and letter matching.

Mode 1: Degrees of Hemispheric Independence

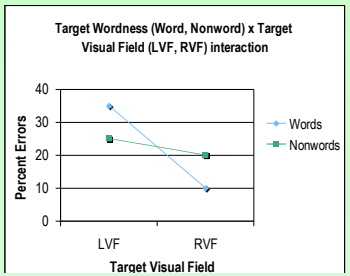
- Task: Lateralized lexical decision. Participants have to indicate by a unimanual button press whether a pronounceable target letter string is an English word or not.
- Lateralized lexical decision correlates with reading competence in each hemisphere (Weems & Zaidel, 2004).
- Hemispheric reading competence is greater than actual hemispheric performance during normal reading.

Lexical decision of lateralized targets (underlined) with lateralized distractors in the opposite visual field.

cipe + your

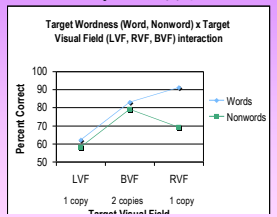
- Hemispheric specialization for lexical decision can vary from complete independence ("direct access") (Iacoboni & Zaidel, 1996) to limited sharing of specialized resources ("interhemispheric interaction"), and to exclusive specialization in one hemisphere ("callosal relay") (Zaidel, Clarke, & Suyenobu, 1990) as the processing load increases (Zaidel et al., 1988).
- Direct access is determined by the input visual field rather than by the responding hand (Weems & Zaidel, 2005).
- Direct access can be increased by distractors in the visual field opposite the target (Fernandino, Iacoboni, & Zaidel, 2007).

Lateralized lexical decision task



Mode 2: Redundant Target Effects

- Multiple copies of targets in the lateralized lexical decision task show a "horse race" pattern, dominated by the left hemisphere (Zaidel & Rayman, 1994).



Wordness x Visual Field interaction in a redundant target lexical decision experiment with cues and *go no-go* responses. This graph combines data from a word detection task and from a nonword detection task.

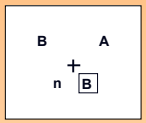
- This is in contrast to hyper redundant target effects in simple reaction time, which violates and exceeds the "horse race inequality" (Iacoboni & Zaidel, 2003).

Mode 3: Parallel Processing; The Bilateral Distribution Advantage (BDA)

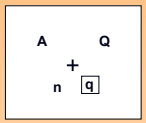
- Matching letter shapes is faster within than between the visual fields.
- Matching letter names is faster between than within the visual fields (the BDA) (Copeland & Zaidel, 1996, 1997).
- By contrast, comparing faces either head-on or in profile is better within than between the visual fields.
- The BDA requires that the following three conditions co-occur:
  1. Each hemisphere can perform the task
  2. Parallel processing makes up for callosal relay
  3. There is a callosum channel for transferring the comparison code directly

Matching (same, different) letter shapes versus letter names

Bilateral - LVF, "Same" Trial Shape Task

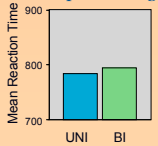


Unilateral - RVF, "Same" Trial Name Task

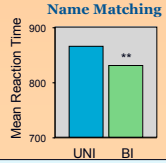


Letter matching within and between the visual fields

Shape Matching



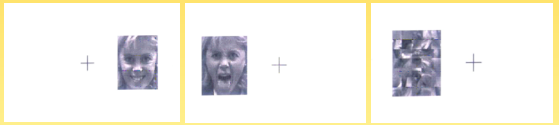
Name Matching



Mode 4: Error Monitoring

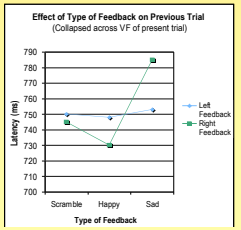
- Sensitivity to error feedback results in slowing down and increasing accuracy following negative feedback due to an error.
- We observed:
  - The left hemisphere is specialized for lexical decision, but
  - The right hemisphere is specialized for implicitly monitoring errors in lexical decision (Iacoboni et al., 1997).
  - And the right hemisphere is also specialized for processing explicit error feedback (Kaplan & Zaidel, 2001).

Explicit Error Monitoring Feedback

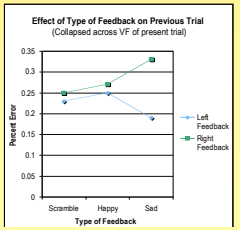


Explicit Error Monitoring Results

Latency



Accuracy



Conclusions

- Interhemispheric interaction increases the complexity of cognitive operations possible in each hemisphere alone.
- The hemispheres can shift across modes of interhemispheric interaction dynamically as a function of task demands.

References

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