Spatial perception and hemispheric lateralization – a factor analysis approach

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Spatial relations

- Spatial relations within and between objects (Kosslyn, 1987)
  - Categorical vs. Coordinate

- Hemispheric lateralization
  - Categorical – left hemisphere (LH)
  - Coordinate – right hemisphere (RH)
Dot-bar task

- Visual half-field task

<table>
<thead>
<tr>
<th>Categorical</th>
<th>Coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above</td>
<td>Not within 2.5 cm</td>
</tr>
<tr>
<td>Below</td>
<td>Within 2.5 cm</td>
</tr>
<tr>
<td></td>
<td>Not within 2.5 cm</td>
</tr>
</tbody>
</table>
Dot-bar results

- Findings
  - Coordinate RH advantage is often found
  - Categorical LH advantage is less often found
  - Coordinate mostly more difficult than categorical
  - Results depend on specific stimulus features
  - Perceptual vs. working memory tasks
Experiment 1

- Interval length variation is suggested to be of importance:
  - Categorical bias – stronger over time
    - Postma et al. (2006)
      - dot – circle task, 500 ms/2000 ms/5000 ms
  - Coordinate – immediate decay

- Congruency with functional properties
  (Kosslyn, 1987)
Stimuli

- 4 categories
- 4 coordinates

van der Ham et al., 2007
Trialsequence

- S1
  - 750 ms
  - +
  - 500 ms
  - S1
    - 150 ms, central
    - 0/1500/4500 ms
    - +
    - 500 ms
    - S2
      - 150 ms, lateral
      - 2000 ms
- Visual field * retention interval
- Instruction * visual field * retention interval
  - At 500 ms: instruction * visual field
- Within instruction: main effect retention interval
  - Cat. 500 ms/2000 ms < 5000 ms
  - Coo. 500 ms < 2000 ms / 5000 ms
Discussion

- Visual field * instruction effect found in 500 ms
  - Main effect in categorical instruction

- Decay over time
  - Coordinate: quick decay
  - Categorical: decay later in time

- How does this outcome relate to the dot-bar paradigm?
Experiment 2: Task battery

- Hemispheric lateralization found in many tasks in different domains
  - spatial perception

- Bringing such tasks together is of importance
  - Speculation on (evolutionary) origin of the hemispheric differences and (causal) relations between them
  - Interpretation of individual differences

- For spatial tasks this has not been done thoroughly
Three spatial perception tasks

- Spatial frequency identification
  High frequency → LH
  low frequency → RH (e.g. Sergent, 1983)

- Local – global processing
  Local features → LH
  Global features → RH (e.g. Van Kleeck, 1989)
- Dot-bar task
  - Categorical $\rightarrow$ LH
  - Coordinate $\rightarrow$ RH (Hellige & Michimata, 1989)

- Additional task: a version of cross-dot design
  - Interval of 500 ms
  - Adapted stimuli
  - Match-to-sample working memory

- Enables comparison between two cat – coo tasks
Combining the tasks

- Theory: Double filtering of frequency model (Ivry & Robertson, 1997)

- Practice: Experiments based on combining features of two of these three paradigms
  - Cat-coo blurred with different frequencies (Okubo & Michimata, 2002, 2004)
  - Local – global with different frequencies (e.g. Badcock, 1990)
Method

- 47 subjects (20 male)
- 4 tasks
  - 3 perceptual (frequency, local-global, cat-coo)
    150 ms stimulus presentation (3° from centre)
  - 1 match-to-sample working memory (cat-coo)
    150 ms stimulus 1 central, and 150 ms stimulus 2 lateral (3° from centre)
- RT was used for analysis
Lateralization index in performance

- \((RVF-LVF)/(RVF+LVF)\)
  - Value between -1 (LVF-RH largest) and 1 (RVF-LH largest)
  - RT:
## Factor analysis

- **3 factors, 80.24% of the variance explained:**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Subtasks</th>
<th>Factor loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Categorical mts LVF</td>
<td>+0.77</td>
</tr>
<tr>
<td></td>
<td>Categorical mts RVF</td>
<td>+0.73</td>
</tr>
<tr>
<td></td>
<td>Coordinate mts LVF</td>
<td>+0.84</td>
</tr>
<tr>
<td></td>
<td>Coordinate mts RVF</td>
<td>+0.89</td>
</tr>
<tr>
<td></td>
<td>Local LVF</td>
<td>+1.00</td>
</tr>
<tr>
<td></td>
<td>Local RVF</td>
<td>+0.98</td>
</tr>
<tr>
<td>2</td>
<td>High spatial frequency LVF</td>
<td>-0.98</td>
</tr>
<tr>
<td></td>
<td>High spatial frequency RVF</td>
<td>-0.99</td>
</tr>
<tr>
<td></td>
<td>Low spatial frequency LVF</td>
<td>-1.03</td>
</tr>
<tr>
<td></td>
<td>Low spatial frequency RVF</td>
<td>-1.14</td>
</tr>
<tr>
<td></td>
<td>Global LVF</td>
<td>-0.52</td>
</tr>
<tr>
<td></td>
<td>Global RVF</td>
<td>-0.55</td>
</tr>
<tr>
<td>3</td>
<td>Categorical p LVF</td>
<td>-0.81</td>
</tr>
<tr>
<td></td>
<td>Categorical p RVF</td>
<td>-0.79</td>
</tr>
<tr>
<td></td>
<td>Coordinate p LVF</td>
<td>-1.04</td>
</tr>
<tr>
<td></td>
<td>Coordinate p RVF</td>
<td>-1.05</td>
</tr>
</tbody>
</table>
Factor analysis 2

- Only tasks showing hypothesized lateralization effect:

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Categorical mts LVF</td>
<td>+0.87</td>
</tr>
<tr>
<td></td>
<td>Categorical mts RVF</td>
<td>+0.86</td>
</tr>
<tr>
<td></td>
<td>Coordinate mts LVF</td>
<td>+0.82</td>
</tr>
<tr>
<td></td>
<td>Coordinate mts RVF</td>
<td>+0.82</td>
</tr>
<tr>
<td></td>
<td>Local LVF</td>
<td>+0.81</td>
</tr>
<tr>
<td></td>
<td>Local RVF</td>
<td>+0.82</td>
</tr>
<tr>
<td></td>
<td>Global LVF</td>
<td>+0.83</td>
</tr>
<tr>
<td></td>
<td>Global RVF</td>
<td>+0.78</td>
</tr>
</tbody>
</table>
Discussion

- For all tasks 3 factors were found
  - Related to task complexity or level of processing
  - Categorical-coordinate perception is separate

- Comparing the two cat – coo tasks
  - the new cross-dot task reflects the hypothesized lateralization effect, the dot-bar task clearly does not
  - Careful consideration when using such cat-coo tasks in further experiments, a working memory design appears to be more appropriate than a perceptual design
Categorical-coordinate WM and local-global load on a single factor

- Stronger relationship between the two than with spatial frequency has been proposed before (Vauclair et al., 2006)
- This suggests a link between the two, unaffected by frequency
Discussion points

- Current theoretical claims seem insufficient to explain these results
- Other factors might underly these patterns
  - Suggestions?
Thank you for your attention.

Questions?