The physiology of coloured hearing:
A PET activation study of colour-word synaesthesia

Brain, 1995

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Presented by Lisa Brockie

Overview
1. What is synaesthesia?
2. Study
   - Hypotheses
   - Methods
   - Results
   - Discussion
   - Conclusions
3. Critical Analysis
4. Q&A

What is synaesthesia?

- Greek: syn = union
  - aisthesis = sensation

- Stimulation of one sense causes perceptual experience in another
- e.g., “seeing music” or “tasting colours”
- High degree of consistency

What is synaesthesia?

How many letter b’s were there?
Purpose of Study

1. Examine the neural basis of colour-word synaesthesia.
2. Understand cross-modal perception – experiences that combine input from different senses that is processed in anatomically separate brain regions.
3. Understand the physiology of visual perception without visual stimulus.

Hypotheses

- In synaesthetes:
  - Hearing words might activate brain areas responsible for colour perception (e.g., the fusiform gyrus)
  - Simultaneous activation of auditory verbal cortex and associative visual area(s) responsible for conjoint representation of colours & letter shapes (e.g., inferior temporal region)

Subjects

<table>
<thead>
<tr>
<th>Synaesthetes</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 females</td>
<td>6 females</td>
</tr>
<tr>
<td>5 right-handed, 1 left-handed</td>
<td>5 right-handed, 1 left-handed</td>
</tr>
<tr>
<td>Mean age 45 ± 7 years</td>
<td>Mean age 40 ± 8 years</td>
</tr>
<tr>
<td>Colour-word synaesthesia ONLY (no similar visual perception for other auditory stimuli like music)</td>
<td>Never experienced synaesthesia</td>
</tr>
<tr>
<td>Colour perception linked to colour of first letter (5) or first vowel (1)</td>
<td></td>
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Subject Task

- Subjects blindfolded
- Auditory stimuli delivered through earphones
- Listen passively to each stimulus (don’t name the colour)
- Tap left index finger for every tone heard
- Interval between stimuli varied from .5 to 1.5 s

Control task:

- Single word stimulus

Control task:

- Pure tone stimulus (tone lasted .5 s)

All subjects:

- 12 consecutive scans
- 6 for each task

Results

<table>
<thead>
<tr>
<th>Synaesthetes</th>
<th>Control Group</th>
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<tbody>
<tr>
<td>Perceived colour with word stimuli but not tones</td>
<td>Did not perceive colour with any stimuli</td>
</tr>
<tr>
<td>Activation in language areas with word stimuli but not tones</td>
<td>Activation in language areas with word stimuli but not tones</td>
</tr>
<tr>
<td>Additional activation in some areas</td>
<td></td>
</tr>
<tr>
<td>Deactivations in other areas</td>
<td></td>
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</tbody>
</table>
Results

- Activation in Synaesthetes vs. Controls (same word stimuli)
  - R middle & inferior frontal gyrus
  - R insula (temporal)
  - R superior temporal gyrus
  - L posterior inferior temporal (PIT) cortex
  - Bilat. parieto-occipital junctions

- Inhibition in Synaesthetes vs. Controls (same word stimuli)
  - L insula (temporal)
  - L lingual gyrus (occipital)
  - ...and NO activation in V1 or V2!

Discussion

PIT cortex - activated
- Colour-selective neurons
- Colour discrimination
- Complex colour perception
- Linking colour to shape

Parieto-occipital junctions - activated
- Colour discrimination
- Not entirely understood

Discussion

Extravisual Areas – activated
- Right hemisphere: frontal lobe, insula, superior temporal gyrus
- Right-hemisphere dominance for colour perception

Discussion

Deactivations
- Left hemisphere: lingual gyrus, insula
- Not fully understood

Conclusions

In Synaesthetes:
- Interaction between brain areas responsible for language and higher vision
  - Activity in higher visual areas without direct visual stimulation – suggests unusual connectivity between visual and language areas
    - More likely to occur at anatomical borders
Critical Analysis

- Elegant experimental design (able to study activation of visual areas with only auditory stimuli)
- Use of PET is limiting – with such a small pool of synaesthetic subjects, repeated scans may be desirable
- Numerous possibilities for investigation with other types of synaesthesia