

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

Brain, 1995

E. Paulesu, J. Harrison, S. Baron-Cohen, J.D.G. Watson,
L. Goldstein, J. Heather, R.S.J. Frackowiak, and C.D. Frith

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?

dddddddddddddddddd
ddd bdddddddddddbdd
dddddddbdddbddddd
ddb ddddb d d d d d d d d
d d d d d d d d d d d d d d
d d d d d b d d d d d d b d d
d b d d d d d d d d d d d d d
d d d d d d d d d d b d d d d d

What is synaesthesia?

How many letter b's were there?

What is synaesthesia?

dddddddddddddddddd
ddd**b**dddddddddd**b**ddd
dddddd**b**ddd**b**ddddddd
ddd**b**dddddd**b**dddddddddd
d d d d d d d d d d d d d d
d d d d d d **b** d d d d d d d d **b** d d
d **b** d d d d d d d d d d d d d d d d
d d d d d d d d d d d **b** d d d d d d

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

Synaesthetes

- 6 females
- 5 right-handed, 1 left-handed
- Mean age 45 ± 7 years
- Colour-word synaesthesia ONLY (no similar visual perception for other auditory stimuli like music)
- Colour perception linked to colour of first letter (5) or first vowel (1)

Control Group

- 6 females
- 5 right-handed, 1 left-handed
- Mean age 40 ± 6 years
- Never experienced synaesthesia

Apple Art Cat Same
See Change

Subjects

All subjects

- Neurologically normal (confirmed by MRI scans)
- No history of neurological or psychiatric disease
- Not taking any psychoactive drugs
- Tested for general intelligence
- Tested for genuineness of synaesthesia
 - 2 tests, 1-10 months apart (mean 6 months)
 - No warning prior to second test
 - Describe colours associated with >100 words
 - Results compared for consistency

Tasks

- 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

Experimental task:

- Single word stimulus

Control task:

- Pure tone stimulus (tone lasted .5 s)

All subjects:

- 12 consecutive scans
 - 6 for each task

Results

Synaesthetes

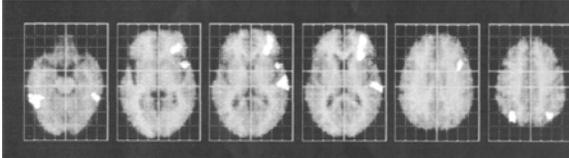
- Perceived colour with word stimuli but not tones
- Activation in language areas with word stimuli but not tones
- Additional activation in some areas
- Deactivations in other areas

Control Group

- Did not perceive colour with any stimuli
- Activation in language areas with word stimuli but not tones

Results

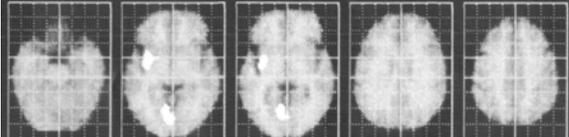
- Activation in Synaesthetes vs. Controls (same word stimuli)
 - R middle & inferior frontal gyrus
 - R insula (temporal)
 - R superior temporal gyrus
 - L posterior inferior temporal (PIT) cortex
 - Bilat. parieto-occipital junctions



Results

- Inhibition in Synaesthetes vs. Controls (same word stimuli)
 - L insula (temporal)
 - L lingual gyrus (occipital)

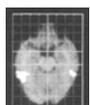
...and NO activation in V1 or V2!



Discussion

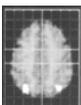
PIT cortex - activated

- Colour-selective neurons
- Colour discrimination
- Complex colour perception
- Linking colour to shape



Parieto-occipital junctions - activated

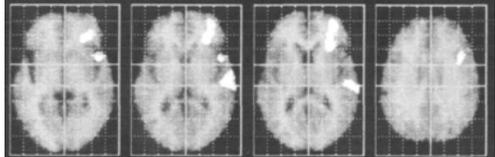
- Colour discrimination
- Not entirely understood



Discussion

Extravisual Areas – activated

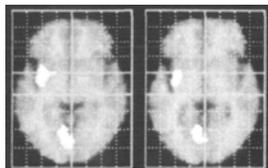
- Right hemisphere: frontal lobe, insula, superior temporal gyrus
- Right-hemisphere dominance for colour perception



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

Questions?