Balint’s syndrome

Psychic paralysis of gaze

1. Ocular Apraxia
   - Paucity of eye movements. Inability to voluntarily shift gaze to foveate objects of interest despite unrestricted eye rotation and intact visual fields.
   - Involvement, particularly with the right hand only, “there is no movement despite normal visual fields.”

2. Spatial disorder of attention
   - Fails to notice things “lying to either side of the object”. The attention of the patient is always directed [30-40°] to the right-hand side of space, when he is asked to direct his attention to another object other having fixed his gaze. He tends to the right-hand rather than the left-hand side.

3. Simultanagnosia
   - The patient’s “field of view was restricted so that he could attend to only one object at a time, irrespective of the size of the object or the number of objects in the field of view.”

4. Functional field of view is not fixed in Balint’s patients

Understanding Simultanagnosia: Theoretical Frameworks

- Deficit in spatial attention
  - Spatial attention is required for feature integration. Impairment leads to feature integration errors, e.g., the illusory conjunction illusion.

- Disengage failure
  - Once attention has been engaged by one object, it cannot be easily disengaged.

- Object competition accounts
  - Visual information from different objects competes for processing resources, e.g., the illusory conjunction illusion.

- Restricted functional visual field
  - Impaired processing of peripheral visual stimuli.

Structure of the talk

- Do Balint’s patients really only ‘see’ a single object?
  - Patients may be aware of multiple objects but are limited in their ability to consciously identify more than one object at a time.

  - Information that fails to reach awareness may nevertheless be processed to identification.

  - Simultanagnosia may extend beyond the visual modality.
Case: JJ

- 65 year old right handed male with history of recurrent cerebral haemorrhages involving both cerebral hemispheres over six years.
- Complains of difficulty seeing objects in peripheral vision. Frequently bumps into objects - "I can see them but it is as if I can’t".
- Misreaches when performing everyday tasks e.g., cutting bread.
- Gaze paralysis - Eye movements are full, but spontaneous eye movements show a paucity of saccades. Like Balint’s patient, JJ tends to always look to the right (20°) of midline.
- Optic ataxia - When fixating JJ misreaches by greater than 5 cm when pointing. Like Balint’s patient, JJ shows impairment largely with his right hand when pointing to extrafoveal targets in left or right hemispace.
- Simultanagnosia - when describing a complex scene, naming objects from an array of overlaid line objects, or naming letter pairs.

How does JJ respond when presented with multiple objects?

- Consistently reports only one of a pair of objects e.g., line drawings or pairs of coloured letters.
- Note, he shows no bias for which item is reported from a pair. No evidence of neglect.
- However, shows evidence of top-down control. If asked to report identity of the "red" thing will be 100% correct.

Staircase procedure used to detect JJ’s thresholds for:

1. Single black masked letter ≈ 150 ms
2. Single coloured letter (report colour & identity) ≈ 150 ms
3. Two coloured letters (report both colours) ≈ 385 ms
4. Two coloured letters (report both identities) ≈ 367 ms
5. Two coloured letters (report identity & colour of both) ≈ 2500 ms

JJ is impaired in binding multiple visual features into multiple objects.

Is JJ unaware of the presence of multiple objects?:

Identifying coloured letters
- Naming a single letter (e.g., blue ‘t’): Staircase procedure revealed 150ms presentation required for 75% correct performance.
- Naming 2 letters (e.g., a blue ‘t’ and a red ‘a’) requires presentation durations of 650ms or greater to achieve 75% accuracy.

Judging number of coloured letters presented
- 2AFC procedure: JJ required to verbally report whether one or two of the coloured letter items had been presented on each trial.
  - 100ms presentation durations 68% correct
  - 1000ms presentation durations 94% correct
- JJ is not unaware that two objects have been presented. His impairment is in simultaneously identify each object.

Illusory conjunctions: Target present/absent judgements

Target defined at start of block, e.g., “blue letter ‘u’”. Press right if present, left if absent. 6 conditions randomly intermixed within in a block.

Single item
- Target present
- Nontarget
- Target feature
- Target colour
- Target item

Two items present
- Target present
- Nontarget
- Target feature
- Target colour
- Target item
- Conjunction

Visual search

Is JJ’s simultanagnosia simply associated with a deficit in feature integration?

"...detection of a feature in a display should remain possible because binding would not be necessary. Even binding to a location would be unnecessary to know whether a particular feature was present..." - L.C. Robertson Nature Reviews (2003)

Evidence from ‘pop-out’ search. Study carried out by Dominic Mort.
JJ doesn’t show evidence of ‘pop-out’. He appears to search such displays serially. Note, on all of these trials JJ correctly detected the presence of the target stimulus and made almost no false positives on ‘target absent’ trials.

Disengage deficit or Object competition?

Name coloured letters i.e., “a red ‘a’ and a blue ‘t’”

Onset-timing manipulations

Name coloured letters i.e., “a red ‘a’ and a blue ‘t’”

Predictions

Disengage deficit: performance worst in sequential condition or overlapping conditions. Object competition: performance worst in simultaneous condition and best in sequential condition.

Onset-timing manipulations

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Total correct / 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential</td>
<td>20</td>
</tr>
<tr>
<td>Overlapping</td>
<td>24</td>
</tr>
<tr>
<td>Simultaneous</td>
<td>13</td>
</tr>
</tbody>
</table>

\( \chi^2 (1 \text{ df}) = 6.22; p < 0.05 \)

Simultaneous gave poorest performance despite longer inter-stimulus for both letters.
Letter stream: name T1 (white), report presence/absence T2 (X)

Perception of local and global level features using ‘Navon’ figures

3AFC: Large displays (5-7 deg.)
Is it a ‘u’, an ‘n’, or an ‘o’?

1. Effects of local item proximity: 2AFC respond ‘L’, or ‘T’

2 Effects of mixed local items: report items at local or global level

RT performance on complex figures (5-7 degrees)
Task: Manual response to local level information (is it a ‘u’ or an ‘n’?)
Global level can be congruent or incongruent with respect to local level.

EEG recording
128-channel geodesic sensor net coupled to high input impedance amplifier; EEG recorded continuously and digitised at 250Hz.
Data were segmented into 1-second epochs, average reference transformed, low-pass filtered (45Hz) and baseline corrected (100ms before stimulus onset):

ERP study

Summary: Navon data

- JJ's performance on global level information was always extremely poor.
- However, his identification of large non-compound letters and local features was excellent.
- On brief (200ms) presentations, JJ can never report the identity of the global letter. However, the RT and ERP data indicate that incongruent global information affects processing at the local level. Specifically:

  - When information at a global and local level were incongruent:
    - JJ's RTs were significantly slower.
    - Differences in VEPs (P100 and N400) for incongruent vs. congruent trials over left occipito-temporal cortex.
    - Frontal ERPs (N200) are amplified on incongruent trials (this ERP component associated with conflict detection).

  JJ shows evidence of implicit processing of global information.

Perception of subjective ‘Kanizsa’ figures

Summary: Navon data

- JJ's performance on global level information was always extremely poor.
- However, his identification of large non-compound letters and local features was excellent.
- On brief (200ms) presentations, JJ can never report the identity of the global letter. However, the RT and ERP data indicate that incongruent global information affects processing at the local level. Specifically:

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    - Frontal ERPs (N200) are amplified on incongruent trials (this ERP component associated with conflict detection).

  JJ shows evidence of implicit processing of global information.

Experimental blocks included randomly intermixed trials of 1000ms and 2000ms durations.

<table>
<thead>
<tr>
<th>Duration</th>
<th>1000ms</th>
<th>2000ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean RT</td>
<td>970ms</td>
<td>1071ms</td>
</tr>
<tr>
<td>Max RT</td>
<td>1646ms</td>
<td>1807ms</td>
</tr>
<tr>
<td>Errors</td>
<td>4/72</td>
<td>2/72</td>
</tr>
</tbody>
</table>

Accuracy rates in each stimulus condition, with 1000ms stimulus duration:

- Real figures: 4/4, 4/4, 3/4, 0/4, 0/4, 0/4
- No central figure: 4/4

Incongruent compared to each stimulus condition, with 1000ms stimulus duration:

- Real figures: 4/4, 4/4, 3/4, 0/4, 0/4, 0/4
- Subjective figures: 4/4, 4/4, 3/4, 0/4, 0/4, 0/4
- No central figure: 4/4
Current work: Can simultanagnosia exist in non-visual domains?

Haptic perception Task

1. Rotate a test bar with one hand (e.g. left) so that it was parallel or mirror-symmetrical to a reference bar, which was either left with the other hand or seen as a 2D image projected on to a felt surface directly above the bar itself.

Task Conditions

- Unperturbed Vision
- Proprioception Alone
- Visual image shows actual orientation of the reference bar.
- Subject is blindfolded, and feels the orientation of the reference bar.
- Visual image is 5° clockwise of the orientation of the reference bar.

Results from 4 individual control subjects

- 1st session:
  - Target present/absent (button press) for subjective judgements
  - Target present/absent (collapsed over 1st session)

- 2nd session:
  - Target present/absent (collapsed over 2nd session)

Regression Analysis For All Control Subjects and JJ - Right Test Hand

<table>
<thead>
<tr>
<th>Task Conditions</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unperturbed Vision</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Proprioception Alone</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Vision Alone</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Proprioception and Vision</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>No square</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Right Test Hand</td>
<td>m  = 35.8</td>
<td>s  = 2.03</td>
<td>r  = 0.82</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

Kanizsa stimuli - verbal descriptions

1. What colour?
   - "Grey"
   - "White"

2. Any other shapes?
   - "A plain one"

3. What colour?
   - "Three quarters of a circle"
   - "White"

4. How many?
   - "Five"
   - "Six segments"

5. Do you see any larger black one?
   - "Yes"

6. How many of these?
   - "Five"

7. Any black shapes?
   - "Triangles"
   - "Five"

8. How many white shapes?
   - "Five"

9. Are they arranged in a orderly way?
   - "Yes"
   - "Virtually four …"

10. What do you see this time?
    - "A circle cut in quarters"
    - "A grey pyramid"

11. Anything else?
    - "Little men with their mouths open"
    - "A circle cut in quarters"

12. Could that be a triangle?
    - "Yes"
    - "A grey pyramid"

13. Anything else?
    - "Virtually four …"
    - "A grey pyramid"

14. Do they form any kind of pattern?
    - "Yes"
    - "Yes"

15. What colour?
    - "All white"

16. How many of these?
    - "Five"

17. What do you see this time?
    - "A grey pyramid"

18. Anything else?
    - "A grey pyramid"

19. Do they form any kind of pattern?
    - "Yes"

20. What colour?
    - "All white"

21. How many of these?
    - "Five"

22. What do you see this time?
    - "Little men with their mouths open"

23. Anything else?
    - "A grey pyramid"

24. Do they form any kind of pattern?
    - "Yes"

25. What colour?
    - "All white"

26. How many of these?
    - "Five"

27. What do you see this time?
    - "Little men with their mouths open"

28. Anything else?
    - "A grey pyramid"

29. Do they form any kind of pattern?
    - "Yes"

30. What colour?
    - "All white"

31. How many of these?
    - "Five"

32. What do you see this time?
    - "Little men with their mouths open"

33. Anything else?
    - "A grey pyramid"

34. Do they form any kind of pattern?
    - "Yes"

35. What colour?
    - "All white"

36. How many of these?
    - "Five"

37. What do you see this time?
    - "Little men with their mouths open"

38. Anything else?
    - "A grey pyramid"

39. Do they form any kind of pattern?
    - "Yes"
### Regression Analysis for JJ and Controls in all Conditions - Right Test Hand

<table>
<thead>
<tr>
<th>Subject</th>
<th>Condition</th>
<th>Task Shape</th>
<th>Slope</th>
<th>r</th>
<th>r²</th>
<th>t</th>
<th>p-value</th>
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<tbody>
<tr>
<td>JJ</td>
<td>PP</td>
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<td>0.73</td>
<td>0.96</td>
<td>39.63</td>
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<td>PP</td>
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<td>0.97</td>
<td>45.69</td>
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<tr>
<td>JJ</td>
<td>PP</td>
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<td>0.86</td>
<td>0.98</td>
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<td>p &lt; 0.001</td>
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<tr>
<td>JJ</td>
<td>PP</td>
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<td>0.84</td>
<td>0.97</td>
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<td>p &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>JJ</td>
<td>PP</td>
<td></td>
<td>0.83</td>
<td>0.97</td>
<td>48.33</td>
<td>p &lt; 0.001</td>
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</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>0.85</td>
<td>0.98</td>
<td>53.54</td>
<td>p &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>0.15</td>
<td>0.15</td>
<td>0.56</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>0.05</td>
<td>0.10</td>
<td>0.39</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>-0.18</td>
<td>-0.27</td>
<td>-1.06</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>-0.37</td>
<td>-0.24</td>
<td>-0.90</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>PP</td>
<td></td>
<td>0.03</td>
<td>0.10</td>
<td>0.37</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

**Summary**

- Balint's patients may be aware of multiple objects but are limited in their ability to consciously identify more than one object at a time.
- Information that fails to reach awareness can be processed to identification.
- Simultanagnosia is not simply an impairment in feature ‘binding’ - impairment can be observed on tasks that do not require feature binding. The effect of the condition appears to be 'competition' between objects.
- Simultanagnosia may extend beyond the visual modality.

**Collaborators**

- Masud Husain
- Georgina Jackson
- Dominic Mort
- Roger Newport
- Sally Pears
- Chris Rorden
- Rachel Swainson

Funded by grants from Wellcome Trust and BBSRC

**Small displays (1-2 degrees)**

- **Small displays: simple filled**
  - RCT randomized 4 times present

- **Small displays: compound**
  - Local: 'made up of sort of little dots'
  - Global: 100% correct
  - BUT estimated 4 items present

- **Small displays, compound, including non-meaningful global level**
  - Global: 100% correct (e.g. "u", "just little dots, can't tell their shape")

**Dots task - perception of location of dot within a central grey box**

- Subject has to give a verbal judgement as to the position of a dot within a central grey box displayed centrally on the screen. Dots are presented until after a few trials JJ was able to describe the display with 100% accuracy. (These displays are 3 degrees (22').
- Within each trial, the dot could be presented singly, or with a distractor dot, then either with or without a bar to the distractor dot. Participants were then presented with a new set of displays, each of which had a single dot.
- There were six possible locations within each of the horizontally and vertically divided box.

**Results for single dots only (collapsed over colour of dot):**

- **Vertical blocks**: 50% (7/14)
- **Horizontal blocks**: 60% (9/15)
ABSOLUTE SPATIAL JUDGEMENTS
Total correct: 60% (vertical: 63%, horizontal: 58%)

<table>
<thead>
<tr>
<th>Display condition</th>
<th>Relevant direction for judgement</th>
<th>Correct trials</th>
<th>Percentage correct *</th>
</tr>
</thead>
<tbody>
<tr>
<td>single dot</td>
<td>vertical</td>
<td>7/14</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>9/15</td>
<td>60%</td>
</tr>
<tr>
<td>dot with separate distractor dot</td>
<td>vertical</td>
<td>12/14</td>
<td>86%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>6/15</td>
<td>40%</td>
</tr>
<tr>
<td>dot joined to distractor dot</td>
<td>vertical</td>
<td>7/13</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>11/15</td>
<td>73%</td>
</tr>
</tbody>
</table>

* Excludes early trial with possible confusion over instructions.

RELATIVE SPATIAL JUDGEMENTS
Total correct: 59% (vertical: 58%, horizontal: 60%)

<table>
<thead>
<tr>
<th>Display condition</th>
<th>Relevant direction for judgement</th>
<th>Correct trials</th>
<th>Percentage correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>sequential separate dots</td>
<td>vertical</td>
<td>8/20</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>11/20</td>
<td>55%</td>
</tr>
<tr>
<td>simultaneous separate dots</td>
<td>vertical</td>
<td>16/20</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>14/20</td>
<td>70%</td>
</tr>
<tr>
<td>simultaneous joined dots</td>
<td>vertical</td>
<td>11/20</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td>11/20</td>
<td>55%</td>
</tr>
</tbody>
</table>

2AFC Target detection - 2
JJ SimLetters task: November 20

Onset-timing manipulations
Number of trials with perfect report:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number of trials with perfect report</th>
<th>Percentage of trials with perfect report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200ms gap</td>
<td>9/34</td>
<td>9%</td>
</tr>
<tr>
<td>No gap</td>
<td>12/34</td>
<td>16%</td>
</tr>
<tr>
<td>Overlapping</td>
<td>17/36</td>
<td>23%</td>
</tr>
<tr>
<td>Sequential</td>
<td>12/32</td>
<td>19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number of trials with perfect report</th>
<th>Percentage of trials with perfect report</th>
</tr>
</thead>
<tbody>
<tr>
<td>200ms</td>
<td>15/20</td>
<td>25%</td>
</tr>
<tr>
<td>1600ms</td>
<td>14/20</td>
<td>23%</td>
</tr>
<tr>
<td>200ms</td>
<td>10/20</td>
<td>16%</td>
</tr>
</tbody>
</table>

Name both colours & letters: e.g. "white a and black t"