Impairments of 3D visual perception in posterior cortical atrophy: functional and anatomical characterization

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Introduction

• Posterior cortical atrophy (PCA) is a rare focal cortical syndrome that is most often caused by Alzheimer’s disease
• Subjects become incapacitated because of the progressive visual dysfunction
• We applied modern visual neuroscience techniques in an attempt to analyze 3D shape perception in PCA
Binocular cues: ocular disparity
Monocular cues: shading – motion - texture
Research question

1. Is 3D shape perception affected in posterior cortical atrophy?
2. Does this differ depending on the cue defining 3D shape?
3. Which structural or functional alterations underly 3D shape perceptual deficit?
Participants

• 12 patients with posterior cortical atrophy

• Patient controls: 9 patients with clinically probable Lewy Body Dementia

• 30 age-matched healthy controls in the behavioral and volumetric studies

• 18 age-matched healthy controls in the task-related fMRI experiment
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<th>1</th>
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<tbody>
<tr>
<td>Age</td>
<td>68</td>
<td>67</td>
<td>56</td>
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<td>52</td>
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<tr>
<td>Sex</td>
<td>F</td>
<td>M</td>
<td>M</td>
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<td>F</td>
<td>M</td>
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<tr>
<td>Disease duration (yrs)</td>
<td>1.5</td>
<td>2</td>
<td>1</td>
<td>1.5</td>
<td>1.5</td>
<td>2</td>
<td>1</td>
<td>0.75</td>
<td>0.5</td>
<td>0.5</td>
<td>2</td>
<td>3.75</td>
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<tr>
<td>MMSE (/30)</td>
<td>27</td>
<td>28</td>
<td>22</td>
<td>26</td>
<td>19</td>
<td>24</td>
<td>19</td>
<td>21</td>
<td>20</td>
<td>17</td>
<td>26</td>
<td>22</td>
</tr>
<tr>
<td>Aβ biomarker</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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A. 3D shape

B. Orientation discrimination

C. Simultaneous same-different task
Outcome measures

- 3D shape perception: Distance from the peak for each of the cues
- Orientation discrimination: clockwise vs counterclockwise compared to 45 deg
- Elementary feature extraction: same-different judgment
- Adaptive procedure (QUEST)
MRI

- Volumetric MRI, analysed using SPM8
  - Performance on the 3D tasks as covariate of interest
  - whole brain search volume at a corrected cluster level
    \( P<0.05 \) with voxel-level at \( P<0.001 \)

- Functional MRI:
  - Passive viewing, 5 blocked conditions
  - 3D shape from shading and 3D shape from motion
  - 2D control conditions
  - Georgieva et al., *Cerebral Cortex*, 18, 2416-2438, 2008
3D shape-from texture

3D Shape from Texture
Orientation from Texture
Same-Different Texture
3D shape-from-shading

3D SHAPE
FROM SHADING

ORIENTATION
FROM SHADING

SAME-DIFFERENT
SHADING
fMRI

3D from shading minus controls

left ITG

right ITG

<table>
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<tr>
<th>% signal change ± s.e.m.</th>
<th>healthy controls</th>
<th>PCA patients</th>
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<tbody>
<tr>
<td>3D shading</td>
<td>0.55 ± 0.02</td>
<td>0.22 ± 0.02</td>
</tr>
<tr>
<td>2D pixel-scrambled</td>
<td>0.34 ± 0.03</td>
<td>0.13 ± 0.02</td>
</tr>
<tr>
<td>2D shaded blobs</td>
<td>0.18 ± 0.01</td>
<td>0.06 ± 0.01</td>
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Conclusion

• 3D shape perception is affected in PCA for all monocular cues with relative preservation of binocular disparity as a cue

• Inferior temporal volume loss is associated with a deficit in 3D shape-from-shading, superior parietal volume loss with deficit in 3D shape-from-texture

• The findings are in agreement with neurophysiological models of 3D shape perception