Examining Neural Correlates of Metacognitive Deficits in Individuals Aging with Traumatic Brain Injury

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Traumatic Brain Injury (TBI)

• “Alteration in brain function, or other evidence of brain pathology, caused by an external force” (Menon et al., 2010)

• Involves pathophysiological, cognitive, and socioemotional changes (Bigler, 2001; Rabinowitz & Levin, 2014)

• Cognitive impairments are commonly persistent and chronic (Tang & Lobel, 2009)

• Cognitive outcomes are heterogeneous (Whitnall et al., 2006)
Aging and TBI

• Normal aging exacerbates neuropathological processes occurring following TBI (Moretti et al., 2012)

  • Weakened vasculature and white matter from aging --> more susceptible to injury (Gardner et al., 2018; Liu et al., 2017; Ikonomovic et al., 2017)

  • Increases the likelihood of complications, such as hematoma (Goleburn & Golden, 2001), and neurodegenerative processes after injury (Dams-O’Conner et al., 2013; Fleminger et al., 2003; Gardner et al., 2018; Jafari et al., 2013)

• Aging + TBI = increased deficits

  • Cognitive impairment above and beyond normal aging decline (Millis et al., 2001)

  • Outcome worse when TBI sustained later in life and at longer time post injury (Senath-Raja et al., 2010)
Metacognition

• Metacognition = ability to reflect on one’s own cognitive processes (Flavell, 1979)

• Disrupted in normal aging, pathological aging, and TBI populations (Bertrand et al., 2018; Rosen et al., 2014; Thomas, Lee, & Balota, 2013)

• Linked to executive functioning and frontal brain regions (Bivona et al., 2008; Roebers, 2017)
  • Both normal aging and TBI linked to damage/degeneration of frontal regions (Dempster, 1992; Hillary, Moelter, Schatz, & Schute, 2001; Moscovitch & Winocur, 1992; Stuss & Gow, 1992; West, 1996)
(Morales, Lau, & Fleming, 2018; DeMartino et al., 2013; Fleming et al., 2010; McCurdy et al., 2013; Sinanaj et al., 2015)
Previous Study

Integrates other networks and functions (Sridharan et al., 2008)

“Self-referential” thoughts (Raichle et al., 2001)
Previous Findings

• Significant interaction between head injury status (TBI or HC) and internetwork connectivity between the anterior DMN and salience network on metacognitive accuracy

• Significant interaction between head injury status and the posterior region of the DMN and salience network on metacognitive accuracy

Grossner et al., 2019
Development of Current Study

• Previous results from sample of individuals sustaining TBI who are 32-36 years of age and 4 years post head injury

• How might the aging process impact this relationship in a sample of individuals 55 years of age or older who are 10 years post brain injury?
Goals of Current Study

1. Demonstrate metacognitive deficit in a sample of older individuals with TBI compared to a healthy control sample.

2. In a subsample with neuroimaging data, determine the relationship between neural networks and metacognition in older individuals aging with TBI.

3. Examine the impact of age on this relationship.
Establishing Metacognitive Deficit
## Participants

### Sample 1
- 102 TBI
- 28 HC

<table>
<thead>
<tr>
<th></th>
<th>Age M (SD)</th>
<th>Gender</th>
<th>Education M (SD)</th>
<th>Race</th>
<th>Ethnicity</th>
<th>TPI (years) M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBI</td>
<td>64.02 (8.07)</td>
<td>70 M, 32 F</td>
<td>13.99 (2.44)*</td>
<td>79 W, 23 B</td>
<td>5 Hispanic, 76 non-Hispanic, 19 not reported</td>
<td>9.60 (6.90)</td>
</tr>
<tr>
<td>HC</td>
<td>64.00 (7.90)</td>
<td>12 M, 16 F</td>
<td>15.64 (2.82)*</td>
<td>21 W, 7 B</td>
<td>28 non-Hispanic</td>
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Measuring Metacognition

Modified Matrix Reasoning (WAIS-III) task with retrospective confidence judgments

Calculate AUROC using task accuracy and confidence judgments

• Sensitive and bias-free measure of metacognition

I am ____ of my choice.

(a) Completely certain
(b) Certain
(c) Somewhat certain
(d) Somewhat uncertain
(e) Uncertain
(f) Completely uncertain
Results

• TBI group performed significant worse on metacognitive task than healthy control (HC) group, $t(128) = -2.56, p = 0.012, d = 0.55$.

  • TBI M(SD) = 0.64(0.10)
  • HC M(SD) = 0.70(0.09)

• Older individuals with TBI exhibited poorer metacognitive performance than age-matched healthy control individuals
Examining Neural Networks
Participants

Sample 2

- 34 TBI
- 17 HC

<table>
<thead>
<tr>
<th></th>
<th>Age M (SD)</th>
<th>Gender</th>
<th>Education M (SD)</th>
<th>Race</th>
<th>Ethnicity</th>
<th>TPI (years) M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBI</td>
<td>63.74 (7.59)</td>
<td>21 M, 13 F</td>
<td>14.09 (2.79)</td>
<td>27 W, 7 B</td>
<td>0 Hispanic, 13 non-Hispanic, 4 not reported</td>
<td>10.24 (7.95)</td>
</tr>
<tr>
<td>HC</td>
<td>63.12 (7.62)</td>
<td>12 M, 7 F</td>
<td>14.59 (2.50)</td>
<td>12 W, 5 B</td>
<td>1 Hispanic, 27 non-Hispanic, 6 not reported</td>
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Procedure

- Using resting state functional connectivity

- Examines functional connections between regions of the brain while at rest (Gusnard & Raichle, 2001)

<table>
<thead>
<tr>
<th>Attention network</th>
<th>Anterior DMN</th>
<th>Salience network</th>
<th>Residual</th>
<th>Frontoparietal network</th>
<th>Posterior DMN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle temporal</td>
<td>Middle frontal</td>
<td>Insular cortex</td>
<td>Sensory-motor</td>
<td>Precentral gyrus</td>
<td>Posterior cingulate</td>
</tr>
<tr>
<td>Lateral occipital</td>
<td>Superior frontal</td>
<td>Anterior cingulate</td>
<td>Auditory</td>
<td>Superior parietal</td>
<td>Precuneus</td>
</tr>
<tr>
<td>Ventral frontal</td>
<td></td>
<td>Visual</td>
<td>Visual</td>
<td>Lateral prefrontal</td>
<td>Temporal pole</td>
</tr>
</tbody>
</table>

Note. DMN = default mode network.

Regions derived from Power’s 264 functionally-defined atlas (Power et al., 2011)
Results

• Significant interaction between head injury status and aDMN to pDMN on metacognitive accuracy
  • $R^2 = 0.16$, $p = 0.030$
Results

• Significant interaction between head injury status and aDMN to pDMN connectivity on metacognitive accuracy when controlling for age
  • $R^2 = 0.17$, $p = 0.014$

• But age is not a significant predictor, $p = 0.878$
Discussion

• Connectivity *within* portions of the DMN was associated with metacognitive ability in older population with TBI

• Prior study demonstrated connectivity *between* portions of DMN and salience network association with metacognition in younger population with TBI

• In older population, connectivity remains within network, rather than relying on additional networks to modulate neural activity and cognition

• Relationship not influenced by age
Implications

• Metacognitive deficit demonstrated in this population
  • Specific recommendations for treatment and rehabilitation

• Association of DMN with metacognition
  • Location of brain damage could be an important predictor of metacognitive deficit
Thank You

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