ME, MY BRAIN AND I: BUILDING A HEALTHY BRAIN FOR TODAY AND TOMORROW

COGNITIVE RESERVE: THE BRAIN’S SHIELD

SEMINAR IN NEUROSCIENCE
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DID YOU KNOW...

• Alzheimer’s disease is the 6th leading cause of death in the United States (Alzheimer’s Association)
  • 1 in 3 older adults dies with a form of dementia (Alzheimer’s Association)

• "The prevalence of dementia will triple by 2050 if interventions are not found." (Tucker et al., 2011)

• 25% of people who undergo autopsies will exhibit Alzheimer's Disease in their brain, but are behaviorally intact while alive (Scarmneas and Stern, 2003)
OUR OBJECTIVES

• What is cognitive reserve?
  • What does it look like in the brain?

• Why do we want to build more reserve?
  • What can reserve postpone or prevent?

• How do we build our cognitive reserve?
  • What is cognitive training?
WHAT IS COGNITIVE RESERVE?

• A hypothesized defense system against changes in the physical brain
• Cognitive reserve repairs and protects the brain from damage, diseases that attack the brain and the nervous system, and natural functional decline
COGNITIVE RESERVE THEORY

• **Passive Model** - Brain Reserve Capacity (BRC)
  - BRC – everyone has an unique BRC threshold and when it is surpassed, the individual may exhibit symptoms of cognitive decline

• **Active Model** - Compensation and Cognitive Reserve
  - Compensation - uses networks and areas of the brain not used as often in response to damage
  - Cognitive Reserve - uses networks and areas of the brain more efficiently

• According to Yaakov Stern (2002), cognitive reserve is a combination of the two models
INDICATORS OF COGNITIVE RESERVE

• Level of IQ (typically verbal)
• Years of education
• Occupational complexity
• More recently: *lifetime* activities (Bosch et al., 2009)
DECLINE SHOWN THROUGH ASSESSMENT

• In a study by Bosch et al. (2009)
  • Total of 45 participants
  • Conditions
    • 15 normal older adults
    • 15 with mild cognitive impairment
    • 15 with mild Alzheimer’s disease

• Assessments
  • Verbal IQ
  • Education-Occupation Survey
  • Lifetime activities questionnaire

• Composite CR – total CR score compiled from each assessment
<table>
<thead>
<tr>
<th></th>
<th>CTR (n = 15)</th>
<th>α-MCI (n = 15)</th>
<th>Mild AD (n = 15)</th>
<th>F/χ²</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.20 (5.75)</td>
<td>74.63 (6.85)</td>
<td>75.27 (5.66)</td>
<td>1.04</td>
<td>n.s.</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>5/10</td>
<td>6/9</td>
<td>7/8</td>
<td>.587</td>
<td>n.s.</td>
</tr>
<tr>
<td>MMSE</td>
<td>27.67 (1.49)</td>
<td>25.50 (2.03)</td>
<td>21.40 (3.06)</td>
<td>29.08</td>
<td>&lt;.05*</td>
</tr>
<tr>
<td>Composite CR</td>
<td>.27 (1.17)</td>
<td>.10 (1.01)</td>
<td>−.38 (.68)</td>
<td>1.86</td>
<td>n.s.</td>
</tr>
<tr>
<td>Vocabulary WAIS-III</td>
<td>37.87 (11.48)</td>
<td>34.69 (8.86)</td>
<td>34 (9.04)</td>
<td>.66</td>
<td>n.s.</td>
</tr>
<tr>
<td>Education–occupation</td>
<td>3.53 (2.13)</td>
<td>3.81 (2.85)</td>
<td>2.60 (1.40)</td>
<td>1.24</td>
<td>n.s.</td>
</tr>
<tr>
<td>CR questionnaire</td>
<td>8.27 (3.88)</td>
<td>7.56 (3.95)</td>
<td>5.53 (2.50)</td>
<td>2.45</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Values for age, MMSE and composite CR scores are given in means (SDs). *Schefe post hoc: CTR > MCI; CTR > AD; MCI > AD. CTR = controls.
PHYSICAL COGNITIVE RESERVE IN THE BRAIN

• Brain Volume correlates to Composite CR score
  • Control – Brain Volume increased as CR score increased
  • MCI – Brain volume decreased as CR score decreased
  • Mild AD – Brain volume decreased as CR score decreased

(Sole-Padulles et al., 2009)
COGNITIVE RESERVE AS ACTIVITY IN THE BRAIN

• Brain response correlates with Composite CR Scores
  • Control – CR Scores increased as Brain Response decreased
  • Mild AD – CR scores increased as Brain Response increased

• Key Points
  • A healthy brain with cognitive reserve uses less resources due to compensation
  • A brain with mild dementia with cognitive reserves will use the brain more efficiently despite the damage (Sole-Padulles et al., 2009)
IMAGING OF COGNITIVE RESERVE

(Sole-Padulles et al., 2009)
HOW DOES COGNITIVE RESERVE CHANGE THE PHYSICAL BRAIN?

- **Neuroplasticity** – physical changes in the brain due to several variables (behavior, environment, emotions, etc.)
  - **Neurogenesis** - growth and development of neurons, or brain cells
  - **Synaptogenesis** - forming alternate pathways in the brain
- Improves cognitive function as one ages
- Exerts biological influences to slow down physical brain changes due to aging (Raymond and Jagust, 2013)
WHY IS COGNITIVE RESERVE IMPORTANT?

• Aids in the decrease of symptoms associated with:
  • Alzheimer's Disease
  • Schizophrenia
  • Multiple Sclerosis
  • Traumatic Brain Injury
  • HIV (Tucker et al., 2011)
  • Parkinson's Disease (Koerts et al., 2012)
GHAFFAR ET AL., 2012

- 72 patients (mean age of 65) with Multiple Sclerosis

- Assessments
  - Cognitive reserve variables
    - IQ during lifetime
    - Occupational attainment
    - Neurological assessment
  - Brain volume
    - Brain images from a 3T MRI scanner

(http://www.my-ms.org)
### Table 1. Demographic and disease variables.

<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th>Low</th>
<th>High</th>
<th>Statistic</th>
<th>p</th>
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<tbody>
<tr>
<td></td>
<td>n = 72</td>
<td>n = 32</td>
<td>n = 40</td>
<td></td>
<td></td>
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<tr>
<td>Age, y(^a)</td>
<td>43.0 ± 9.7</td>
<td>41.1 ± 8.5</td>
<td>44.6 ± 10.5</td>
<td>t,df = 1.534,70</td>
<td>0.130</td>
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<tr>
<td>Female, n (%)</td>
<td>b</td>
<td>46 (63.9)</td>
<td>21 (65.6)</td>
<td>25 (62.5)</td>
<td>0.784</td>
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<tr>
<td>Education, y(^c)</td>
<td></td>
<td>16.0 (13.0–17.0)</td>
<td>13.0 (12.0–15.0)</td>
<td>16.0 (16.0–18.0)</td>
<td>U = 1116.0</td>
</tr>
<tr>
<td>Disease course, n (%)(^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>59 (81.9)</td>
<td>24 (75.0)</td>
<td>35 (87.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>9 (12.5)</td>
<td>6 (18.8)</td>
<td>3 (7.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>4 (5.6)</td>
<td>2 (6.3)</td>
<td>2 (5.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease duration, y(^c)</td>
<td></td>
<td>6.5 (2.8–10.1)</td>
<td>6.0 (2.5–9.0)</td>
<td>7.0 (3.0–11.0)</td>
<td>U = 690.0</td>
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<tr>
<td>Age at diagnosis, y(^a)</td>
<td></td>
<td>35.0 ± 9.3</td>
<td>33.8 ± 8.8</td>
<td>36.6 ± 9.6</td>
<td>t,df = −1.218,67</td>
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<tr>
<td>DMD n (%)(^b)</td>
<td></td>
<td>39 (54.2)</td>
<td>12 (37.5)</td>
<td>27 (67.5)</td>
<td>χ² = 6.445</td>
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<td>EDSS(^c)</td>
<td>4.0 (3.0–6.0)</td>
<td>4.0 (3.1–6.0)</td>
<td>3.5 (2.5–6.0)</td>
<td>U = 526.5</td>
<td>0.195</td>
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<td>9HPT(^c)</td>
<td>21.0 (18.0–25.0)</td>
<td>23.0 (18.2–25.5)</td>
<td>20.0 (17.9–24.3)</td>
<td>U = 505.5</td>
<td>0.171</td>
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<td>TWT(^c)</td>
<td>4.4 (4.0–6.9)</td>
<td>4.8 (4.1–7.6)</td>
<td>4.1 (3.4–6.3)</td>
<td>U = 420.0</td>
<td>0.132</td>
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<tr>
<td>BDH-II(^c)</td>
<td>12.0 (5.0–23.0)</td>
<td>14.5 (6.8–27.8)</td>
<td>12.0 (3.5–19.5)</td>
<td>U = 479.5</td>
<td>0.340</td>
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<tr>
<td>VIQ(^c)</td>
<td>116.4 (112.2–119.4)</td>
<td>112.7 (111.4–118.3)</td>
<td>117.8 (114.4–120.3)</td>
<td>U = 422.0</td>
<td>0.013*</td>
</tr>
<tr>
<td>Employed n (%)(^b)</td>
<td></td>
<td>51 (70.8)</td>
<td>20 (62.5)</td>
<td>31 (77.5)</td>
<td>χ² = 1.936</td>
</tr>
</tbody>
</table>

(Ghaffar et al., 2012)
NOTABLE FINDINGS

• 44.4% of MS patients were classified with low occupational attainment (OA)

• 55.6% were classified with high OA
  • Greater IQ
  • More years of education

• Frequency of cognitive impairment did not differ between two groups
  • Those with low OA performed worse on cognitive assessments than those with high OA (Ghaffar et al., 2012)
48 patients (mean age of about 58) with Parkinson's disease

Assessments

- Cognitive Reserve Variable
  - IQ during lifetime
  - Level of education
    - Ranged from only elementary to university degrees
- Symptoms of cognitive depression

Disease characteristics
- Severity of symptoms
- Duration of disease and age of onset

Neuropsychological measures
- Executive functions
- Psycho-motor speed
• Severity of motor symptoms was a significant predictor of both executive functioning and psychomotor speed
  • Not associated with memory
  • High IQ patients accounted for less impairment in these areas

• PD patients with a high IQ show better memory performance than those with a low IQ (Koerts et al., 2012)
HOW DO WE BUILD OUR COGNITIVE RESERVE?

• Cognitive training (Willis et al., 2006)
• Increase in *lifetime* activities (Bosch et al., 2009)
• Decrease in habituation
• Decrease in negative emotions (Freret et al., 2012)
WHAT IS COGNITIVE TRAINING?
• An activity aiming to improve a specific cognitive ability

• In a study by Willis et al. (2006):
  • 2832 participants with a mean age of 73.6
  • Ten sessions of initial training
    • Memory (mnemonic strategies)
    • Reasoning (pattern finding; guessing)
    • Speed of Processing (visual divided attention)
  • Four sessions of booster training
  • Assessed at years 1, 2, 3, and 5

(Willis et al., 2006)
ACCORDING TO WILLIS ET AL. (2006)

• Results
  • Cognitive improvement sustained after 5 years in all groups
  • Functional improvement sustained after 5 years in reasoning
  • Decline after 2 years without training
  • Severe decline after 3 to 5 years without training

• Key point
  • Continuous brain training can improve our everyday functions
OTHER WAYS OF IMPROVEMENT

• *Lifetime activities* (Bosch et al., 2009)
  - Leisure/cognitively stimulating
    - reading
    - listening to music
    - playing chess
  - Physical
    - sports
    - going to the gym
    - walking
  - Social/community
    - associations
    - volunteering
FURTHER EVIDENCE

• According Freret et al. (2012)
  • 45 female transgenic mice
  • Conditions
    • Adult standard condition (3 mon); young adult
    • Aged standard condition (20 mon); older adult without CR
    • Aged enriched condition (20 mon); older adult with CR
ANXIETY LEVEL

• Elevated plus maze

• Aged-EC showed less anxiety
  • Entered open arms more frequently
  • Remained on open arms longer

• Translates into the mouse being happier when trying something new
  (Freret et al., 2012)
ACTIVATION IN THE HIPPOCAMPUS

- Hippocampus is in charge of memory consolidation and learning
  - Stays alive after removal
  - Can observe functionality with electrical stimulation
- Adult-SC and Aged-EC showed increased functionality
  - More able to learn new things (Freret et al., 2012)
SPATIAL LEARNING ABILITY

• Morris water maze

• More time spent in the water means less learning capability

• Adult-SC and Aged-EC showed enhanced spatial learning
  • Reflected in their increased hippocampal activation (Freret et al., 2012)
KEY POINTS

• An enriched environment is a must
  • Surround yourself with stimulating things
  • Switch it up now and then to avoid routines

• Choose things that make you happy
  • Be comfortable with what you do
FINAL THOUGHTS

• Cognitive reserve is your brain’s ability to defend itself against cognitive decline
  • May repair existing damage
  • Added protection against disease

• Physical signs of more cognitive reserve:
  • Increase in brain volume
  • Decrease in excess brain activity?

• Build up cognitive reserve with:
  • Training
  • New life activities
  • Happy thoughts
TAKE ACTION NOW!

TRAIN YOUR BRAIN

LEARN NEW THINGS

MAKE LIFE FUN
THANK YOU FOR JOINING US!

ANY QUESTIONS?
REFERENCES


