The Role of Physical and Social Activation in Cognitive Function

Bryan P. McCormick, PhD, CTRS
Indiana University
USA
10/4/13
What’s Cognition?
Understanding Cognition

- Thinking generically
- Mental Functions Specifically
  - Intelligence & Creativity
  - Learning & Memory
  - Sensory Perception
  - Language & Communication
  - Reasoning & Decision Making
  - Attention
  - Social Cognition
Understanding Cognition

• Executive Function
  Set of mental processes
  Connect past experience to present action
Executive Function

• Basic processes related to:
• Organization
  Gathering/Structuring/retaining information
• Regulation
  Examining environment & modifying behavior
Executive Function

- Implicated in:
  Planning,
  Organization,
  Strategizing,
  Paying attention,
  Remembering details,
  Managing time/space
Higher Order Cognition

- "thinking about thinking"
  Social Cognition
  Meta Cognition
  Theory of Mind
- Knowledge of others’ mental states
- Example of False Belief Task
So, which disorders have problems with cognition?
Disorders with Cognitive Dysfunction
Commonly identified
• Dementia/Alzheimer’s Disease
• Parkinson’s Disease
• Developmental Disability
• Psychiatric Disability
Others?
• Multiple Sclerosis
<table>
<thead>
<tr>
<th>Disorder</th>
<th>Attention and/or vigilance</th>
<th>Working memory</th>
<th>Executive function</th>
<th>Episodic memory</th>
<th>Semantic memory</th>
<th>Visual memory</th>
<th>Verbal memory</th>
<th>Fear extinction</th>
<th>Processing speed</th>
<th>Procedural memory</th>
<th>Social cognition (theory of mind)</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major depression</td>
<td>(++)</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>(+)</td>
<td>0/+?</td>
<td>++(+)</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
</tr>
<tr>
<td>Bipolar disorder</td>
<td>++(+)</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+?</td>
<td>++</td>
<td>0</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Schizophrenia</td>
<td>+++M</td>
<td>+++M</td>
<td>++++M</td>
<td>+++</td>
<td>+(+)M</td>
<td>+++M</td>
<td>++</td>
<td>+++M</td>
<td>+</td>
<td>++++M</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>ASD</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>(+)</td>
<td>++(+)</td>
<td>+</td>
<td>++</td>
<td>0/+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>ADHD</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>0/+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>0/+</td>
<td>0/+</td>
</tr>
<tr>
<td>OCD</td>
<td>+++(†)</td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>0/+</td>
<td>++</td>
<td>0/+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>0/+</td>
</tr>
<tr>
<td>PTSD</td>
<td>+++(†)</td>
<td>(+)</td>
<td>(+)</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++(+)</td>
<td>+++</td>
<td>+</td>
<td>0</td>
<td>0/+</td>
<td>0</td>
</tr>
<tr>
<td>Panic disorder</td>
<td>+++(†)</td>
<td>+</td>
<td>0/+</td>
<td>0/+</td>
<td>0/+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GAD</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0/+</td>
<td>0</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>++</td>
<td>++(+)</td>
<td>++</td>
<td>0/+</td>
<td>+</td>
<td>++</td>
<td>0?</td>
<td>+++</td>
<td>+++</td>
<td>(+)</td>
<td>+(+)?</td>
<td>++</td>
</tr>
<tr>
<td>Alzheimer’s disease</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>+++</td>
<td>+++</td>
<td>++(+)</td>
<td>0?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

Neurodegenerative Processes & Aging

- **Normative cognitive decline in aging**
  - Declines in integrative functions
  - Less robust coordination between brain regions

- **Mild Cognitive Impairment (MCI)**
  - Deficits in Memory, Language, Mental Function
  - Not severe enough to interfere with daily life

- **Alzheimer’s Disease**
  - Pervasive impairment in mental function
  - Interferes with daily functioning
Impact of Cognitive Impairment

- Declines in independent functioning
- Negative effect on quality of life
- Affects well-being of spouses/caregivers
- Impairs family relationships
- Affects family financial resources
Environmental Factors in Cognitive Function

- Physical activity (PA)
- Social Isolation & Loneliness
Neural Plasticity

Experience-dependent changes across the lifespan

- Typical Development (Hebbian Learning, etc.)
- Brain insult (Injury, Disease, Drug Use)
- Behavioral Demand → physical exercise (motor learning) → brain exercise

*Image: Theresa Jones, UT-Austin*
Exercise Training & Animals

- Voluntary (Wheel-Running) & Forced (Treadmill, Swimming)*

- **Structural**: hippocampal neurogenesis, synaptogenesis, gliogenesis, arborization, cell proliferation, angiogenesis & brain blood volume

- **Chemical**: promote neurotrophins (BDNF, VEGF, IGF-1) & mRNA, neurotransmission (strengthen receptors and transporters, including Glu, Da, 5-HT, ACh), reduce/counter stress hormones

- **Functional**: improved learning and memory (maze tasks, object recognition, fear conditioning), increased exploratory activity, enhanced LTP

*5 days to 4 months of exercise
Exercise training & Humans

- Reduced risk for cognitive decline and depression
- Neuroprotective function (insult, aging/dementia)
- Maintenance of structural integrity as well as supporting structures in areas associated
- Improved performance and activation (fMRI) during response inhibition tasks (Flanker) in aging groups
- Improved performance in memory, executive function (task-switch, inhibition), processing speed, verbal reasoning
Physical Activity (PA) & Brain Health

• Impacts on:
  Brain Physiology
  Cognition
  Dementia
  • Risk
  • Progression
PA & Brain Physiology

- Pajonk et al (2010) studied adults with Sz
  3 month aerobic cycling training
  🕹️ hippocampal volume vs. control
  🕹️ hippocampal volume assoc with ↑ in short-term memory
PA & Cognition

- Systematic review of 15 existing studies of healthy older adults
- Exercise improved
  - Memory
  - Information Processing
  - Executive Function


- Randomized Clinical Trials (RCT) of a variety of PA trials
  - Increases in hippocampal volume
  - Increases in neocortical volume

PA & Dementia Risk

- Routine participation in PA in midlife
  - Reductions in Dementia Risk
  - Reductions in mild cognitive impairment (MCI)
- Regular PA
  - Improved Vascular Health Generally
  - Reduced risk of vascular dementia

Ahlskog JE, Geda YE, Graff-Radford NR, Petersen RC. Physical Exercise as a Preventive or Disease-Modifying Treatment of Dementia and Brain Aging. Mayo Clinic Proceedings. 2011 Sep;86(9):876-84.
PA & Dementia Progression

- Systematic review of 8 studies of cognitively impaired older adults
- Evidence supports exercise as improving
  - General Cognition
  - Memory
  - Executive Function

PA & Dementia Progression

- Example
- 24-week walking program
  - 24 nursing home residents (12 Tx/12 control)
  - Walking 30mins/4x week
  - Walking group no decline in cog function
  - Control significant decline in cog function

Social Isolation & Loneliness

• “Research suggests that the social pain of loneliness evolved as a signal that one’s connections to others are weakening and to motivate the repair and maintenance of connections to others that are needed for our health and well being”
So, which disorders have problems with social isolation?
Social Isolation & Health

• Health Effects
  Elevated BP
  Morning rise in cortisol (stress hormone)
  Reduced PA
  Reductions in Life Satisfaction
Social Isolation, Loneliness & Cognition

- Implicated in:
  - Poorer executive function
  - Reductions in cognitive performance
  - Accelerating cognitive decline

Social Isolation, Loneliness & Cognition

• Possible Mechanisms (animal models)
  Less dendritic arborization
  Decreased BDNF
  Diminished inhibitory/extinction function
Social Isolation & Executive Function

• Caciappo et al 2000
  • Lonely young adults performed poorer on attentional regulation

• Baumeister et al 2004
  • Social isolation impairs higher order cognitive and self-regulatory processes
  • (e.g. regulation of attention, emotion, behavior)
Social Isolation & Cognitive Performance

• Social Isolation
  • Increases risk for cognitive decline
  • Increases risk for Alzheimer’s disease
Social Isolation & Accelerated Cognitive Decline

- Tilvis et al 2004
  - Population sample of 75-85 year-olds
  - Cognitive function baseline, one-, five-, ten- year
  - Loneliness one independent predictor of cognitive decline

- Wilson et al 2007
  - 823 Older adults without dementia at baseline
  - 65 month study period
  - Loneliness associated with poorer cognitive function at baseline, and study completion
Limitations of Research

- Limited information on nature of PA
  - Variety of physical activities
  - Variety of intensities
  - Variety of duration
- Limited research on social isolation/social activity
  - Few studies
  - Weak research designs
Conclusions & Recommendations

- Physical Activity (PA)
  - Generally some PA is better than no PA
  - Strongest evidence for long-term regular PA that elevates heart rate
  - 20-30 minutes in duration
  - Consider contraindications & adherence

- Social Isolation/Loneliness
  - Social support enhances PA participation
  - In recent RCT, simple socially stimulating group significantly improved cognition in lonely older adults
Practical Recommendations

- Greater understanding of cognitive processes may improve:
  - Inter-professional Communication
  - Progress observation
  - Identifying functional gains/losses

- Role in evidence-based practice
  - Justification for interventions
  - Specification of outcome goals
Thank You

10/4/13
References


