A Life Course Perspective on Activity and Neurocognitive Health: Results from The Baltimore Experience Corps

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Overview

• Why do community interventions?
• Any movement is good (Revenge of the Sit I & II)
• Building Metrics Around Movement- incorporating wearable devices to develop indices that inform evaluation, mechanism and intervention design
• Why do people move? Social, purposeful and other motivations to tap into
• Why don’t people move? Barriers related to the individual’s health and to the environment
• Environment as key intervention design factor- includes safety, available infrastructure, community partners
• Can we apply retrospective measures to capture the benefits of early life environmental enrichment?
Guiding Hypotheses

• Neuroplasticity occurs throughout the life course
• Those at greatest sociodemographic risk will benefit most from enrichment
  – Experience Corps
• Environmental factors contribute to individual risk (double jeopardy)
Modifiable risk factors of age-related cognitive decline & dementia in mid- and late- life

“Preliminary evidence suggests beneficial associations of physical activity and other leisure activities (such as club membership, religious services, painting, or gardening) with preservation of cognitive function”

“..the committee identifies three actions, supported by scientific evidence, that everyone can take to...reduce the effects of cognitive aging.”

1. Be physically active
2. Engage in leisure activities
3. Control vascular risk

Environmental Enrichment as a Vehicle to Neurocognitive Health: Animal Models

- **New neurons in adult animals** (Briones, Klintsova, & Greenough, 2004; Van Praag et al., 1999)
- **20% more synapses/neuron v. cage** (Turner & Greenough, 1983)
- **7-10% greater brain volume in young rats in enriched vs cage** (Kolb, 1995)
- “In animals, most if not all aspects of cognition are inseparable from locomotion and physical activity. Exploration, spatial navigation, and most types of learning accessible in a rodent are based on its movement in the outer world” (Kempermann et al., 2010)
Small Increases in Daily Step Activity Cross-sectionally Associated with Larger Hippocampal Volume

Even small increases in physical activity may matter

Varma, Chuang, Harris, Tan, & Carlson, 2014, *Hippocampus*
Physical Activity (PA) Guidelines for Older Adults: Determined by Environment

- Current Guidelines: 30 minutes/day of moderate-intensity PA; 20 minutes/day of vigorous-intensity PA three days/week
- Difficulties in reaching PA targets for older adults; particularly those of low socioeconomic status (SES)
- Benefits of low-intensity physical activity in enriched, daily environments?

Linking Physical Activity to Social Engagement with a Purpose: Volunteering

- Desire to remain generative & productive
- Harnessing one’s lifetime of accumulated wisdom

- Volunteers 60 and older
- Serve in public elementary schools: K-3
- Multiple roles to exercise executive function, memory
  - Reading literacy
  - Library support
  - Math support
  - Behavioral support
- >15 hours per wk
- Travel to & from schools; walking within schools
- Sustained dose: full school year

Freedman & Fried, 1997; Fried et al., 2004; Fried et al., 2013; Glass et al., 2004
Value of a Model of Generativity: Merging 2 Developmental Needs

- What older adults do affects their health
  - remaining relevant, engaged, & active
  - access to health promotion varies, particularly among those at risk for health disparities

- Teaching children during critical developmental window:
  - Pressing need to close the achievement gap among socioeconomically disadvantaged students

- An aging society can share wisdom & compassion with a generation of young minds:
  - Potential societal “win-win” on both ends of the life course
Experience Corps Improves Executive Function & Related Prefrontal Networks

Carlson, Erickson, Kramer, Colcombe, Bolea, Mielke, Rebok & Fried, 2009

Reduction in Flanker Interference by Group and Cue Size

Carlson et al., 2008

Carlson et al., 2009

Carlson, Erickson, Kramer, Colcombe, Bolea, Mielke, Rebok & Fried, 2009
Baltimore Experience Corps Trial

- Evaluation funded by NIA BSR: initiated in 2006 & concluded in Dec. 2011
- Randomized:
  - 702 60 yrs. and older to EC or low-activity control
  - Matched 25 public elementary schools with EC to control
- Exposure: 2 years of high-intensity service
- Outcomes:
  - Physical: Disability, mobility, walking speed
  - Cognitive: Memory, executive function
  - Psychosocial well-being
- Nested Brain Health Substudy (N=120)
Experience Corps Led to Changes in Psychosocial Health: Generativity

Table 3. Regression Coefficients Representing Mean Difference in Experience Corps Intervention Versus Control Group Participants for Each Generativity Measure at the 4-, 12-, and 24-Month Evaluations in ITT and CACE Analyses Utilizing Graded Definitions of Exposure to Define Compliance With the Intervention

<table>
<thead>
<tr>
<th></th>
<th>ITT</th>
<th>CACE (20th percentile of exposure)</th>
<th>CACE (40th percentile of exposure)</th>
<th>CACE (60th percentile of exposure)</th>
<th>CACE (80th percentile of exposure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generative Desire (subscale)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>0.075* (0.031)</td>
<td>0.124* (0.054)</td>
<td>0.186* (0.080)</td>
<td>0.247* (0.112)</td>
<td>0.456* (0.211)</td>
</tr>
<tr>
<td>ES = 0.182</td>
<td></td>
<td>ES = 0.263</td>
<td>ES = 0.394</td>
<td>ES = 0.523</td>
<td>ES = 0.966</td>
</tr>
<tr>
<td>12 months</td>
<td>0.075* (0.034)</td>
<td>0.036 (0.033)</td>
<td>0.203** (0.005)</td>
<td>0.341** (0.127)</td>
<td>0.652* (0.310)</td>
</tr>
<tr>
<td>ES = 0.173</td>
<td></td>
<td>ES = 0.070</td>
<td>ES = 0.393</td>
<td>ES = 0.660</td>
<td>ES = 1.260</td>
</tr>
<tr>
<td>24 months</td>
<td>0.132*** (0.039)</td>
<td>0.242*** (0.068)*</td>
<td>0.357*** (0.101)</td>
<td>0.560** (0.179)</td>
<td>1.120*** (0.249)</td>
</tr>
<tr>
<td>ES = 0.256</td>
<td></td>
<td>ES = 0.436</td>
<td>ES = 0.643</td>
<td>ES = 1.009</td>
<td>ES = 2.018</td>
</tr>
<tr>
<td>Generative Achievement (subscale)</td>
<td></td>
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<tr>
<td>4 months</td>
<td>0.151*** (0.040)</td>
<td>0.056 (0.050)</td>
<td>0.041 (0.060)</td>
<td>0.677* (0.305)*</td>
<td>0.747** (0.284)</td>
</tr>
<tr>
<td>ES = 0.290</td>
<td></td>
<td>ES = 0.080</td>
<td>ES = 0.059</td>
<td>ES = 0.969</td>
<td>ES = 1.069</td>
</tr>
<tr>
<td>12 months</td>
<td>0.110* (0.044)</td>
<td>0.021 (0.049)</td>
<td>0.009 (0.059)*</td>
<td>0.348* (0.156)</td>
<td>0.933* (0.466)</td>
</tr>
<tr>
<td>ES = 0.189</td>
<td></td>
<td>ES = 0.028</td>
<td>ES = 0.012</td>
<td>ES = 0.465</td>
<td>ES = 1.249</td>
</tr>
<tr>
<td>24 months</td>
<td>0.101* (0.047)</td>
<td>0.009 (0.044)</td>
<td>0.297** (0.104)*</td>
<td>0.442** (0.167)</td>
<td>1.792* (0.827)</td>
</tr>
<tr>
<td>ES = 0.159</td>
<td></td>
<td>ES = 0.012</td>
<td>ES = 0.398</td>
<td>ES = 0.592</td>
<td>ES = 2.399</td>
</tr>
</tbody>
</table>

Notes. All outcome models include the following covariates: baseline level of generativity outcome variable, age, sex, race, education, income, depression, number of major morbid conditions, and trial cohort year. Exposure percentile cutpoints (number of cumulative hours of Experience Corps participation): 4 months (20th = 143 hr; 40th = 179 hr; 60th = 211 hr; 80th = 255 hr); 12 months (20th = 279 hr; 40th = 450 hr; 65th = 501 hr; 80th = 573 hr); 24 months (20th = 291 hr; 40th = 684 hr; 65th = 945 hr; 80th = 1,061 hr). Cohen’s d ES estimates calculated as: (mean generativity outcome in Experience Corps group – mean generativity outcome in control group)/pooled SD across the two groups. ES can be interpreted against the following conventions: small: >0.20, medium: ~0.50, large: >0.80. CACE, complier average causal effects; ES, effect size; ITT, intention to treat.
Did We Increase Daily Physical Activity Following Program Participation? Step Activity (N=115):

Women in Experience Corps maintained average steps/day over 24 months *post-intervention* while Controls declined.

Men had significantly higher baseline levels of daily physical activity than women and maintained these levels.

Varma, Tan, Gross, Harris, Romani, Fried, Rebok, Carlson, 2015 AJPM
How did we increase daily physical activity in women by Year 2?
Answer: Higher levels of activity sustained through the day from 9am-4 pm
Does Experience Corps Lead to Changes in Brain Health?

- Men in the Experience Corps arm showed a 0.8-1.6% **increase** in total cortical and hippocampal brain volumes v. declines in controls.

- Women in Experience Corps also tended to exhibit modest gains of 0.3-0.54% by 24 months of exposure.

- 2-year improvement in memory related to 2-year increase in whole brain volume in EC (blue).

Carlson, Kuo, Chuang, Varma, et al., 2015 Alz & Dementia
Experience Corps also impacts the amygdala, a region important to socially salient information? (see nice meta-review by Bruhl et al., 2014)

- Using shape diffeomorphometry, we see specific patterns of change

Carlson, Varma, Miller, & Tang, under review
BECT Child Academic & Behavior Outcomes: Young Children Benefitted Most

1st graders improved in Stanford Listening Scores after 1 year of EC exposure

- No other significant differences in Stanford 10 reading or math scores between intervention groups

Behavior:
- 1st grade boys in EC schools had fewer principal office referrals for disciplinary reasons compared to 1st grade boys in non-EC matched control schools

Rebok et al., under review
From School to Community: Identify Opportunities for Pro-social Behavior in Daily Life

• Measure real-time contexts in daily life when it occurs by expanding use of real-time mobile assessment in the community
  – Are there “hot spots”?
  – Are there diurnal patterns when individuals are most able to exercise compassion?
  – Does social engagement/lifestyle activity promote compassion?

• Create opportunities, particularly in low-resourced neighborhoods
Aggregating Data to Observe Patterns in Where the Greatest Amounts of Outdoor Activity in Daily Life Occur
Answer: Outdoors in Community Spaces

Carlson, Varma, Adam, Crainiceanu, & Zipunnikov, under review
Activity in social spaces most strongly associated with cognitive health in older adults.
Classify available real-world data coming from individual & community sources into map layers

Spatially link these layers to individual behavior & health & to Identify low-resourced areas with more at-risk individuals where interventions may be targeted
Distribution of BECT participants across Baltimore City (n=535)
HotSpot analysis of study participants with poor global cognition (MMSE scores <26) (left panel) and with poor memory (right panel)
Conclusions: the Benefits of Activity in Daily Life

• Activity in *social contexts* may provide neurocognitive benefits as great as that for physical activity alone
  – *100 steps indoors may not be equivalent to 100 steps outdoors in spatially & socially complex community spaces*

• Activity with generative purpose (e.g., giving back to others) & functional purposes may confer neurocognitive benefits equivalent to exercise
Early Life Activities & Late-life Cognition

• Sum of Activities as a Child (N=90; X= 3.0; SD=1.7):
  – 1) Learned a foreign language
  – 2) Volunteered at church
  – 3) Took lessons (i.e., dance, choir)
  – 4) Played a musical instrument
  – 5) Scouting
  – 6) Played team sports
  – 7) Took vacation

• Results of Multiple Regression Models:
  – Speed of Processing: B = 1.21 (.34), p < .001
  – Memory (RAVLT Immediate Recall): B = 1.35 (.52), p < .05
  – Executive Functioning (Trail Making, Part B, adjusting for Part A): B = -11.51 (4.51), p < .05

Chan, Moored, Parisi, Carlson, under review
Early Life Activities (ELA) Predict Limbic Regional Volumes in Later Life

- **Hippocampus**: 289.9 mm$^3$ (4.3%) increase in men for each added ELA
- **Amygdala**: 67.6 mm$^3$ (2.3%) increase in both sexes for each added ELA

Sex-stratified associations of ELA and ICV-adjusted volumes (N = 90)

Moored, Chan, Varma, Chuang, Carlson, in preparation
It Takes a Village:
Research Team and Collaborators

- Atif Adam- JHU
- Ryan Andrews- JHU
- Jeremy Barron - JHU
- Michelle Carlson – JHU
- Thomas Chan- JHU
- Yi-Fang Chuang - Natl Yang Ming U
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- Linda Fried - Columbia U
- Kevin Frick – JHU
- Alden Gross - JHU
- Tara Gruenewald – Chapman U
- Jin Huang - JHU
- Arthur Kramer - Northeastern U
- Sylvia McGill - EC Baltimore
- Kyle Moored- JHU
- Jeanine Parisi - JHU
- Christine Ramsey – VA CT
- George Rebok - JHU
- William Romani – AARP
- David Roth - JHU
- Roberta Scherer - JHU
- Teresa Seeman - UCLA
- Erwin Tan – AARP
- Elizabeth Tanner – JHU
- Vijay Varma – NIA, LBN
- Qian-Li Xue - JHU