Neuroimaging Approaches to the Study of Financial Decision Making in Old Age

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Judith D. Tamkin Symposium on Elder Abuse
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I figured out what was wrong with my brain; on the left there is nothing right, on the right there is nothing left.
Outline

1. Neural Correlates of Impaired Financial and Healthcare Decision Making in Old Age (NIH/NIA Beeson K23 Career Development Award)

2. FINCHES
Background

• Adults over the age of 65 hold 18.1 trillion of the 53.1 trillion (approximately 1/3rd) in U.S. household net worth (Laibson, 2011).

• Older adults lose more than $3 billion annually to financial scam or fraud (Metlife Inc., 2011), and some estimate this to be as high as $36 billion (True Link Financial, 2015).

• The problem of financial and healthcare fraud targeted at elderly persons is so significant that the FBI maintains a website dedicated to the problem:
Common Fraud Schemes

Fraud Target: Senior Citizens

Our Common Fraud Schemes webpage provides tips on how you can protect you and your family from fraud. Senior Citizens especially should be aware of fraud schemes for the following reasons:

- Senior citizens are most likely to have a “nest egg,” to own their home, and/or to have excellent credit—all of which make them attractive to con artists.
- People who grew up in the 1930s, 1940s, and 1950s were generally raised to be polite and trusting. Con artists exploit these traits, knowing that it is difficult or impossible for these individuals to say “no” or just hang up the telephone.
- Older Americans are less likely to report a fraud because they don’t know who to report it to, are too ashamed at having been scammed, or don’t know they have been scammed. Elderly victims may not report crimes, for example, because they are concerned that relatives may think the victims no longer have the mental capacity to take care of their own financial affairs.
- When an elderly victim does report the crime, they often make poor witnesses. Con artists know the effects of age on memory, and they are counting on elderly victims not being able to supply enough detailed information to investigators. In addition, the victims’ realization that they have been swindled may take weeks—or more likely, months—after contact with the fraudster. This extended time frame makes it even more difficult to remember details from the events.
- Senior citizens are more interested in and susceptible to products promising increased cognitive function, virility, physical conditioning, anti-cancer properties, and so on. In a country where new cures and vaccinations for old diseases have given every American hope for a long and fruitful life, it is not so unbelievable that the con artists’ products can do what they claim.

What to Look For and How to Protect Yourself and Your Family

Common Frauds

Common Fraud Scams
- Telemarketing Fraud
- Nigerian Letter or “419” Fraud
- Identity Theft
- Advance Fee Schemes
- Health Care Fraud/Health Insurance Fraud
- Redemption/Strawman/Bond Fraud

Investment-Related Scams
- Letter of Credit Fraud
- Prime Bank Note Fraud
- Ponzi Schemes
- Pyramid Schemes

Internet Scams
- Internet Auction Fraud
- Non-Delivery of Merchandise
- Credit Card Fraud
- Investment Fraud
- Business Fraud
- Nigerian Letter or “419” Fraud

Fraud Target: Senior Citizens
- Health Care Fraud/Health Insurance Fraud
- Counterfeit Prescription Drugs
- Funeral and Cemetery Fraud
Renee Packel used to have a typical suburban life. Her husband, Arthur, was a lawyer and also sold insurance. They lived in a town house just outside Philadelphia, and Mrs. Packel took care of their home and family.

The Vanishing Mind
Dollars and Dementia

Articles in this series are examining the worldwide struggle to find answers about Alzheimer's disease.

One day, it all came crashing down. The homeowners' association called asking for their fees. To Mrs. Packel's surprise, her husband had simply stopped paying them. Then she learned he had stopped writing checks to his creditors, too.

It turned out that Mr. Packel was developing Alzheimer's disease and had forgotten how to handle money. When she tried to pay their bills, Mrs. Packel, who enlisted the help of a forensic accountant, could not find most of the couple's money.

"It just disappeared," she said.

Alzheimer's experts say. New research shows that one of the first signs of impending dementia is an inability to understand money and credit, contracts and agreements.

What happened to the Packels is all too common.
Mild Cognitive Impairment Is Associated with Poorer Decision-Making in Community-Based Older Persons
S. Duke Han, PhD, Patricia A. Boyle, PhD, Bryan D. James, PhD, Lei Yu, PhD, and David A. Bennett, MD

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Mild Cognitive Impairment and Susceptibility to Scams in Old Age
S. Duke Han, Patricia A. Boyle, Bryan D. James, Lei Yu, and David A. Bennett

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Poor Decision Making Is a Consequence of Cognitive Decline among Older Persons without Alzheimer’s Disease or Mild Cognitive Impairment

Patricia A. Boyle¹,²*, Lei Yu¹,³, Robert S. Wilson¹,³, Keith Gamble¹,⁴, Aron S. Buchman¹,³, David A. Bennett¹,³

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Table 2. Decision making and scams as a function of cognitive decline*.

<table>
<thead>
<tr>
<th></th>
<th>Persons without dementia N = 420</th>
<th>No cognitive impairment only N = 334</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EST (SE)</td>
<td>P</td>
</tr>
<tr>
<td>Decision making</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>−0.057 (0.017)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>1.142 (0.276)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Education</td>
<td>0.154 (0.042)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Starting level of cognition</td>
<td>2.284 (0.286)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cognitive decline</td>
<td>0.229 (0.041)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Susceptibility to scams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.019 (0.005)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>0.030 (0.080)</td>
<td>0.703</td>
</tr>
<tr>
<td>Education</td>
<td>−0.019 (0.012)</td>
<td>0.106</td>
</tr>
<tr>
<td>Starting level of cognition</td>
<td>−0.152 (0.082)</td>
<td>0.085</td>
</tr>
<tr>
<td>Cognitive decline</td>
<td>−0.039 (0.012)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Parameter estimates of cognitive decline per 0.01 unit increase in rate of change; estimated from regression models adjusted for age, sex, education, and starting level of cognition.

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Discrepancies between cognition and decision making in older adults

S. Duke Han¹,²,³,⁵ · Patricia A. Boyle¹,² · Bryan D. James²,³,⁴ · Lei Yu²,³ · Lisa L. Barnes¹,²,³ · David A. Bennett²,³

- N=648 nondemented older adults
- Mean age=81.8, s.d.=7.6; mean number of years of education=15.2, s.d=3.1; 76.8% female
Global Cognition and Decision Making Z-scores by Discrepancy Group

DM>COG
DM within 1 SD of COG
DM<COG
The Mortality of Elder Mistreatment

Mark S. Lachs, MD, MPH; Christianna S. Williams, MA; Shelley O'Brien, MS;
Karl A. Pillemer, PhD; Mary E. Charlson, MD

JAMA, August 5, 1998—Vol 280, No. 5

Diagram: Survival (%) over years from baseline interview at cohort entry. Lines represent:
- Not Investigated
- Elder Mistreatment
- Self-neglect
Poor Decision Making Is Associated with an Increased Risk of Mortality among Community-Dwelling Older Persons without Dementia

Patricia A. Boyle\textsuperscript{a,b} Robert S. Wilson\textsuperscript{a–c} Lei Yu\textsuperscript{a,c} Aron S. Buchman\textsuperscript{a,c} David A. Bennett\textsuperscript{a,c}

\textsuperscript{a}Rush Alzheimer’s Disease Center, \textsuperscript{b}Department of Behavioral Sciences and \textsuperscript{c}Department of Neurologic Rush University Medical Center, Chicago, Ill., USA

\textbf{Fig. 1.} Cumulative hazard of mortality for participants with poor (dotted line) versus good (solid line) decision making derived from a model adjusted for age, sex and education.
Age-Associated Financial Vulnerability: An Emerging Public Health Issue

Mark S. Lachs, MD, MPH, and S. Duke Han, PhD

Various processes common in the aging brain may affect an older adult's ability to manage personal finances, the most recognized of which are dementing illnesses (1). These conditions can affect cognitive abilities, which may jeopardize an older adult's financial well-being over their longitudinal course. However, recent studies suggest that even cognitively intact older adults can have “functional” changes that may render them financially vulnerable. Social isolation also increases dramatically with age, which places older persons at risk for exploitation from predators. Furthermore, capitalistic enterprises can threaten the financial security of this group, which is perceived to be a large untapped market and, in an era of information overload, is often presented with a dizzying array of products and services.

We propose the concept of age-associated financial vulnerability (AAFV) and discuss aspects of its epidemiology from the vantage of a neuropsychologist (S.D.H.) and geriatrician-epidemiologist (M.S.L.) who are both researchers and clinicians working in the field of elder abuse. We believe that considering AAFV a clinical syndrome may be advantageous to further critical research, promote public policy work, and encourage physicians to recognize it.

Epidemiology of AAFV: Prevalence and Risk Factors

Although a precise determination of the prevalence of AAFV would require assessment of a large population-based sample of older adults, community-
If an older adult shows impaired financial decision making or becomes a victim of a scam, the burden is not only experienced by the older adult, but is often displaced upon family members, caregivers, or society.

There is some suggestion that poor financial decision making may be an early sign of Alzheimer’s disease; however, cognitive measures may not be sensitive to this in all situations.

Poor financial decision making is associated with increased risk of mortality.

Therefore, understanding the susceptibility of older persons to impaired decision making or fraud is a significant public health concern, as this understanding may inform prevention and intervention strategies.

- How can we understand this complex issue?
Neuroeconomics

• Integration of the fields of economics and neuroscience

• Neuroscience methods are used to elucidate the biology of economic principles

• Methods include brain imaging and computational neuroscience

Schiller, 2011; Camerer et al., 2005
Paul B. Beeson Career Development Award in Aging Research

Neural Correlates of Impaired Financial and Healthcare Decision Making in Old Age (K23AG040625; PI: Han)

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• Harvard University: Randy Buckner, PhD
• Weill Cornell Medical College: Mark Lachs, MD
• USC Keck School of Medicine: Laura Mosqueda, MD
RADC Studies Supported by NIA

• Rush Memory and Aging Project (MAP; R01AG017917 PI: David Bennett)
  – Longitudinal clinicopathologic study of aging and AD
  – Participants come from over 50 residential facilities, retirement communities, retirement homes, local churches, etc.
  – Through Sept 2015, > 1,800 persons have agreed to participate in MAP (26.6% men, 93.1% non-Hispanic white; mean age of 88.8 (SD=9.4) and mean education of 14.7 (SD=4.8)).

• Decision Making Study (R01AG033678 PI: Patricia Boyle)
  – Longitudinal study of factors and outcomes associated with decision making
  – Decision making, cognitive, affective, and contextual data collected on over 800 MAP participants
Methods

• Decision Making
  – Cognitive processing
  – Affective processing
  – Personality styles
  – Behavioral Economics

• Neuroimaging
  – Volumetry
  – Diffusion Tensor Imaging
  – Functional connectivity

\[
GP_{ij} = \frac{0.5 \times \text{Gain}_{ij}^{1 - \gamma_i}}{1 - \gamma_i} \quad SP_{ij} = \frac{\text{Safe}_{ij}^{1 - \gamma_i}}{1 - \gamma_i}
\]

\[
\text{logit}(P(Y_{ij} = 1)) = GP_{ij} - SP_{ij}
\]

\[
\text{logit}(P(Y_{ij} = 1)) = \frac{0.5 \times \text{Gain}_{ij}^{1 - \gamma_i} - \text{Safe}_{ij}^{1 - \gamma_i}}{1 - \gamma_i}
\]

R01AG033678; PI: Patricia Boyle
Age-Associated Neuropathology

Buckner et al., 2008; Buckner et al., 2005; Lustig et al., 2003
Hypothetical Model of Impaired Decision Making in Old Age

- ACC
- vmPFC
- DLPFC
- PCC
- Angular Gyrus
- TPJ
- hippocampus
- amygdala (amyg)
- insula
- striatum
- VTA
- OFC

Connections:
- Superior Long. Fasciculus
- Uncinate Fasciculus
Using a seed region of interest (ROI) in the anterior cingulate cortex (ACC); we investigated whether there were rs-fMRI differences between older adults high and low in risk aversion.

N=54 (27 high and 27 low) nondemented older adults

High risk averse mean age=83.9, s.d.=6.9; mean number of years of education=14.8, s.d.=2.5; 74% female; low risk averse mean age=80.0, s.d.=6.5; mean number of years of education=15.3, s.d.=2.8, 70.3% female; age and total gray matter used as a covariate
Risk Aversion

HIGH/LOW Risk Aversion Contrast
N=54 (27/27)
Temporal Discounting

Temporal discounting refers to the discounting of greater delayed rewards for smaller immediate rewards and is associated with a number of real-world outcomes.

Using a seed region of interest (ROI) in the left and right fronto-insular cortex (FI); we investigated whether there were rs-fMRI correlations with temporal discounting, accounting for age, education, gender, and global cognition.

N=123 nondemented older adults

Mean age=82.95, s.d.=6.64; mean number of years of education=15.67, s.d=3.20; 82.1
Temporal Discounting

HIGH→LOW Temporal Discounting

FC of R Parahippocampal Seed ROI
Using a seed region of interest (ROI) in the posterior cingulate cortex (PCC), we investigated whether financial literacy was associated with greater functional connectivity to ventromedial prefrontal cortex, accounting for age, education, gender, and global cognition.

- N=139 nondemented older adults
- Mean age=82.08, s.d.=7.17; mean number of years of education=15.70, s.d=3.29; 80.6% female
Financial Literacy

Cluster level p<0.0001

T=-3

T=4

Keck School of Medicine of USC
Using diffusion tensor imaging (DTI), we investigated whether financial literacy was associated with greater white matter integrity, accounting for age, education, gender, and global cognition.

N=346 nondemented older adults

Mean age=81.36; mean number of years of education=15.39; 77.2% female
GLM models adjusted for age, education, sex, and global cognition showing greater financial literacy is associated with greater white matter integrity in specific pathways.
Susceptibility to Scams

Voxel-based morphometry (VBM) to assess grey matter density at the voxel level

N=348 nondemented older adults

Mean age=81.55, s.d.=7.25; mean number of years of education=15.30, s.d=2.91; 74.10% female
Assessment of susceptibility to scams

The susceptibility to scams scale is a five-item self-report measure in which participants rated their agreement to a statement according to a 7-point Likert scale (strongly agree to strongly disagree). The five statements included in the measure have been previously reported (James et al. 2014) and address topics such as telemarketing behaviors, older adults being targeted by con-artists, and suspiciousness of claims that seem too good to be true. The statements are:

1. I answer the phone whenever it rings, even if I do not know who is calling.
2. I have difficulty ending a phone call, even if the caller is a telemarketer, someone I do not know, or someone I did not wish to call me.
3. If something sounds too good to be true, it usually is.
4. Persons over the age of 65 are often targeted by con-artists
5. If a telemarketer calls me, I usually listen to what they have to say.

Each question corresponds to a Likert scale and has a total possible range of 1 to 7 (1 = strongly agree, 2 = agree, 3 = slightly agree, 4 = neither agree or disagree, 5 = slightly disagree, 6 = disagree, 7 = strongly disagree). The total score for susceptibility to scams was calculated by averaging the five items (with items 1, 2, and 5 reverse coded). The statements were based generally on findings from the AARP and the Financial Industry Regulatory Authority Risk Meter, a measure of poor and risky financial decision making that is widely used in finance studies (AARP 1999; Financial Industry Regulatory Authority 2013). The intraclass correla-
Susceptibility to Scams
Take Home Points

• Neuroimaging is a non-invasive tool that can be used to study brain characteristics associated with susceptibility to scams and financial fraud among older adults.

• Cognition may not fully explain poorer financial decision making among all older adults.

• NIA-funded Alzheimer’s Disease Research Centers may provide a strong infrastructure to study these issues and fine-tune research approaches.

• Financial fraud among older adults is not well-understood...
Finance, Cognition, and Health in Elders Study (FINCHES – Pilot Phase)
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