The cognitive and economic impact of social activities in older age: evidence from 17 European countries

by

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Outline of the talk

• Economic importance of cognition in older age
• Reasons why being socially active can affect cognition
• Estimation methodology
• Data
• Results
• Discussion
Economic importance of cognition in older age

- Can lead to positive economic and other outcomes
- Strong positive association with:
  - financial literacy (Delavande, Rohwedder and Willis 2008)
  - wealth and risky portfolio choice (Lee and Willis, 2001; McArdle, Smith and Willis, 2009 Smith, McArdle and Willis, 2010; Christelis, Jappelli and Padula, 2010)
  - consumption smoothing and life-satisfaction in retirement (Banks, O’Dea and Oldfield, 2010)
  - health outcomes and behavior (Cutler and Lleras-Muney, 2010; Plassman et al. (2010) and Deary et al., 2009)
Stylized fact: strong positive association between cognition and social activities

• Lack of social networks in which social activities are performed can lead to loneliness, which can lead to depression, which can lead to cognitive decline

• Social activities can provide a meaningful social role and a sense of purpose in old age, and thus could have direct neurohormonal influences on the brain, including the reduction of the stress response
Stylized fact: strong positive association between cognition and social activities (cont.)

- As social activities often involve the challenge of effective communication and participation in complex interpersonal exchanges, they are likely to inhibit cognitive decline in the elderly.

- Social activity might also require a degree of physical activity above and beyond regular exercise and walking, which could enhance physical health, which can also delay cognitive decline.
Challenges for identification

• Unobserved individual characteristics (e.g. intellectual curiosity, zest for life, ease of relating, listening to and learning from others) affect both social activities and cognition

• Time varying circumstances like the death of a partner, divorce, a new partner or health problems could affect social activities and cognition in the same direction

• Simultaneity: cognition could also affect social activities
Observable and unobservable magnitudes

• Outcome $Y$, observed treatment $w$, generic value $d$. Two possible values in our case: 0, 1.

• Average potential outcome for treatment $t$
  \[ E[Y(d)] = E[Y(d)|w = d] P(w = d) + E[Y(d)|w \neq d] P(w \neq d) \]

• **We do not observe** $E[Y(d)|w \neq d]$, i.e. the counterfactual

• **We observe** everything else
Observable and unobservable magnitudes (cont.)

- $E[Y(d)|w = d] = E[Y(d)|w \neq d] \rightarrow$
  the treatment is exogenous \( \rightarrow \)
  $E[Y(d)] = E[Y(d)|w = d]$, which is observed in the data

- Average treatment effect for \( w = t, u \) with \( u \geq t \)
  
  \[
  E[Y(u)] - E[Y(t)]
  \]

- Interpretation: give everybody treatment \( u \) and treatment \( u \)
  and take the average difference, taking all other observables
  and unobservables as given
Observable and unobservable magnitudes (cont.)

- Under exogenous treatment selection,
  \[
  ATE(u, t) = E[Y(u)] - E[Y(t)] =
  E[Y(u)|w = u] - E[Y(t)|w = t]
  \]

- In other words the \(ATE\) is equal to the difference in observed means (or dummy variable coefficient in a OLS regression)
Observable and unobservable magnitudes (cont.)

- In most cases, however,
  \[ E[Y(d)|w = d] \neq E[Y(d)|w \neq d] \]

- Treatment is not randomly assigned, units choosing different treatments are not homogeneous \rightarrow endogeneity

- Need to replace \( E[Y(d)|w \neq d] \) with something observable
Bounds – Partial Identification

• We replace \( E[Y(d)|w \neq d] \) with observable magnitudes \( M_L \) and \( M_U \) such that

\[
M_L \leq E[Y(d)|w \neq d] \leq M_U
\]

• Then we calculate lower and upper bounds \( LB[d] \) and \( UB[d] \) for \( E[Y(d)] \). We thus obtain partial identification (Manski 1989, 1997; Manski and Pepper, 2000)

\[
LB[t] = E[Y(d)|w = d] P(w = d) + M_L P(w \neq d) \\
\leq E[Y(d)] \leq E[Y(d)|w = d] P(w = d) + M_U P(w \neq d) = UB[d]
\]
Observable and unobservable magnitudes (cont.)

• Suppose we have two treatments $u$ and $t$ with $u > t$. We then have

\[
\begin{align*}
LB[t] & \leq E[Y(t)] \leq UB[t] \\
LB[u] & \leq E[Y(u)] \leq UB[u]
\end{align*}
\]

• The average treatment effect $ATE(u, t) = E[Y(u)] - E[Y(t)]$ can then be bounded.
Observable and unobservable magnitudes (cont.)

• Suppose we have 2 treatments $u$ and $t$ with $u > t$. We then have

\[
LB[u] - UB[t] 
\leq
ATE(u, t) = E[Y(u)] - E[Y(t)] 
\leq
UB[u] - LB[t]
\]
Numerical example

• Suppose

\[ 2 \leq E[Y(t)] \leq 5 \]
\[ 6 \leq E[Y(u)] \leq 10 \]

• Then

\[ 1 \leq ATE(u, t) = E[Y(u)] - E[Y(t)] \leq 8 \]
No assumptions bounds

- If in $M_L \leq E[Y(d)|w \neq d] \leq M_U$ we put $M_L = Y_{min}$ and $M_U = Y_{max}$ Then we have

$$E[Y(d)|w = d]P(w = d) + Y_{min}P(w \neq d) \leq E[Y(d)] \leq E[Y(d)|w = d]P(w = d) + Y_{max}P(w \neq d)$$

- These bounds tend to be very wide, which is the price for making no assumptions. Narrower bounds require additional assumptions.
Monotone Treatment Response (MTR)

- If treatment $u > t \rightarrow E[Y(u)|w = d] \geq E[Y(t)|w = d], \forall d$

- In our context, being socially active has a weakly positive effect on cognition on average

- Use the assumption to narrow identification range
Monotone Treatment Response (cont.)

- \( E[y(1)] = E[y(1)|w = 0]P(w = 0) + E[y(1)|w = 1]P(w = 1) \)

- \( MTR \rightarrow E[y(1)|w = 0] \geq E[y(0)|w = 0] \)

- Get an lower bound on \( E[y(1)] \) by replacing the unobservable \( E[y(1)|w = 0] \) with the observable \( E[y(0)|w = 0] \)
Monotone Treatment Response (cont.)

• Since $E[Y(0)|w = 0] \geq Y_{min}$ the lower bound becomes larger and the width of the identification range of $E[Y(0)]$ becomes smaller
Monotone Treatment Selection (MTS)

- If treatment $u > t \rightarrow E[y(d)|w = u] \geq E[y(d)|w = t], \forall d$

- More socially active individuals have characteristics (intelligence, curiosity, resourcefulness) which lead to higher cognition for any level of social activity actually observed
MTR + MTS are testable

- Manski and Pepper (2000): \( u > t \rightarrow E[y(u)|w = u] \geq E[y(t)|w = t] \)

- Hence MMTR + MTS implies weak monotonicity in the observed mean outcomes. This can be tested

- In our data MTR+MTS are not refuted
Instruments

• One can use instruments to further narrow the bounds

• Instruments are useful if one wants the lower bound of the ATE to become larger than zero. With only MTR+MTS this is not possible (Manski, 2000).
Exogenous instruments

• An instrument $z$ is exogenous if
  \[ E[y(d)|z = m] = E[y(d)], \forall m \]

• Hence one can increase the lower bound by maximizing over all values of the instrument, and decrease the upper bound by minimizing over all values of the instrument, i.e.
  \[
  \max_{m} LB[d|z = m] \\
  \leq E[y(d)] \\
  \leq \min_{m} UB[d|z = m]
  \]
Monotone instruments

• Exogenous instrument are hard to find

• A weaker instrument is a monotone one. An instrument $z$ is monotone if

$$l \leq o \rightarrow E[y(d)|z = l] \leq E[y(d)|z = o]$$

$$\sum_{m} P(z = m) \left( \max_{m_1 \leq m} LB[d|z = m_1] \right)$$

$$\leq \sum_{m} P(z = m) E[y(d)|z = m] = E[y(d)] \leq$$

$$\sum_{m} P(z = m) \left( \min_{m_2 \geq m} UB[d|z = m_2] \right)$$
Role of instruments

• They help identify the ATE and not the local average treatment effect (LATE), which is what conventional IV estimation identifies under heterogeneity of the treatment

• They can, however, lead to the lower bound being greater than the upper bound, either in the point estimate or the bootstrap
Role of instruments (cont.)

• If the lower bound greater than the upper bound then not all assumptions are compatible with the data

• Up to the researcher to judge which combination of assumptions is more plausible

• Manski (2003) suggests the possibility to apply the instrument to part of the estimation, i.e. to only some $E[y(d)]$
Role of instruments (cont.)

• In our case, bounds cross for $E[y(0)]$

• The identification region for $E[y(0)]$ is about 4 times narrower than those of $E[y(1)]$

• Narrow region due to small $P(w = 1) \approx 21\%$

• We use MTR+MTS for $E[y(0)]$ and MTR+MTS+MIV for $E[y(1)]$
Data – Survey of Health, Ageing and Retirement in Europe (SHARE)

- 15 countries in all: Sweden, Denmark, Germany, the Netherlands, Belgium, France, Switzerland, Austria, Italy, Spain, Greece, Czech Republic, Poland, Slovenia, Hungary, Portugal, Estonia
- About 94,000 obs (numeracy), 113,000 (other scores)
- Modules: demographics, children, physical and mental health, cognition, income, assets, social activities, expectations
SHARE (cont.)

- Numeracy: 4 questions asked with possible answers suggested

- How many people out of 1,000 would be expected to get the disease if the chance of getting a disease is 10%

- What is the sale cost of a sofa, given the initial price and a 50% discount

- What is the initial price of a car if two-thirds of what it costs new is 6,000 euro

- What is the final balance of a savings account that initially hold 2,000 euro, at 10% interest after 2 years
SHARE (cont.)

- Fluency: number of animals respondents can enumerate in one minute

- Immediate recall: respondents are read ten words and are asked to repeat them immediately after. The score is the number of correctly recalled words

- Delayed recall: respondents are asked to recall again the ten words after the fluency and numeracy tests are conducted. The score is again the number of correctly recalled words
SHARE (cont.)

• Respondents are asked whether in the last month (waves 1 and 2) or year (wave 4) they
  • engaged in voluntary or charity work
  • participated in an educational or training course
  • went to a sport, social or other kind of club
  • participated in a political or community-related organization

• Respondents are asked whether they engaged in these activities daily, almost every week, or less often

• We use as our main measure of social activities whether they engaged in any of the four activities at least once a week
Instrument

- Monotone instrument used: whether one smokes

- Negative association between smoking and cognition well established empirically. Smoking associated with cerebral lesions, decreased oxygenation, increased cardiovascular risk, Alzheimer’s disease

- Hypothesis behind monotone instrument untestable, as it refers to the unobserved $E[y(d)]$. However, monotonicity weaker than exogeneity, which is also untestable
## Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Median</th>
<th>N</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeracy</td>
<td>2.19</td>
<td>1.18</td>
<td>0</td>
<td>4</td>
<td>93,756</td>
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<tr>
<td>Fluency</td>
<td>18.13</td>
<td>7.65</td>
<td>0</td>
<td>100</td>
<td>113,015</td>
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<tr>
<td>Immediate Recall</td>
<td>4.84</td>
<td>1.91</td>
<td>0</td>
<td>10</td>
<td>113,616</td>
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<td>Delayed Recall</td>
<td>3.39</td>
<td>2.09</td>
<td>0</td>
<td>10</td>
<td>113,627</td>
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<td>Social activities</td>
<td>0.21</td>
<td>0.41</td>
<td>0</td>
<td>1</td>
<td>117,819</td>
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</table>
Results

• Results will be presented by adding assumptions progressively

• Identifying power of each assumption becomes clear

• 95% confidence intervals for the ATE computed as in Imbens and Manski (2004)
## Results – Numeracy, Fluency

<table>
<thead>
<tr>
<th>Method</th>
<th>Numeracy</th>
<th>Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Exogenous Treatment Selection</td>
<td>0.564</td>
<td>0.533</td>
</tr>
<tr>
<td>No Assumptions</td>
<td>-1.939</td>
<td>2.061</td>
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<tr>
<td>MTR</td>
<td>0.000</td>
<td>2.061</td>
</tr>
<tr>
<td>MTR + MTS</td>
<td>0.000</td>
<td>0.564</td>
</tr>
<tr>
<td>MTR + MTS + MIV</td>
<td>0.164</td>
<td>0.566</td>
</tr>
<tr>
<td>Number of observations</td>
<td>92,582</td>
<td></td>
</tr>
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</table>
Other Results

- Similar results for immediate and delayed recall (lower bound about 30% of 1 std)
- Results stronger for females than for males (esp. for numeracy and fluency)
- Results consistent across European regions (Northern, Middle, Southern and Eastern Europe)
- Results robust to alternative definition of cognition (binary, above/below median)
Economic impact of social activity

• Does social activity impact, through increased cognition, economic welfare?
• Examine the effect of cognition on household net financial assets, household net worth
• Use binary indicator for cognition being above/below the median
Economic impact of social activity - results

<table>
<thead>
<tr>
<th>Method</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Low 95% CI</th>
<th>High 95% CI</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Low 95% CI</th>
<th>High 95% CI</th>
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<tbody>
<tr>
<td><strong>Panel A. Numeracy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Exogenous Treatment Selection</td>
<td>1.402</td>
<td>1.281</td>
<td>1.524</td>
<td>2.144</td>
<td>1.965</td>
<td>2.322</td>
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<tr>
<td>No Assumptions</td>
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<td>17.655</td>
<td>-17.232</td>
<td>17.800</td>
<td>-15.538</td>
<td>17.159</td>
<td>-15.651</td>
<td>17.272</td>
</tr>
<tr>
<td>MTR</td>
<td>0.000</td>
<td>17.655</td>
<td>0.000</td>
<td>17.800</td>
<td>0.000</td>
<td>17.159</td>
<td>0.000</td>
<td>17.272</td>
</tr>
<tr>
<td>MTR + MTS</td>
<td>0.000</td>
<td>1.402</td>
<td>0.000</td>
<td>1.508</td>
<td>0.000</td>
<td>2.144</td>
<td>0.000</td>
<td>2.298</td>
</tr>
<tr>
<td>MTR + MTS + MIV</td>
<td>0.000</td>
<td>0.970</td>
<td>0.000</td>
<td>1.080</td>
<td>0.002</td>
<td>1.827</td>
<td>0.000</td>
<td>2.005</td>
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<td>Number of observations</td>
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<td>61,275</td>
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<tr>
<td><strong>Panel B. Fluency</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Exogenous Treatment Selection</td>
<td>1.188</td>
<td>1.057</td>
<td>1.319</td>
<td>1.882</td>
<td>1.707</td>
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<tr>
<td>MTR</td>
<td>0.000</td>
<td>20.129</td>
<td>0.000</td>
<td>20.264</td>
<td>0.000</td>
<td>18.632</td>
<td>0.000</td>
<td>18.744</td>
</tr>
<tr>
<td>MTR + MTS</td>
<td>0.000</td>
<td>1.188</td>
<td>0.000</td>
<td>1.305</td>
<td>0.000</td>
<td>1.882</td>
<td>0.000</td>
<td>2.035</td>
</tr>
<tr>
<td>MTR + MTS + MIV</td>
<td>0.000</td>
<td>0.654</td>
<td>0.000</td>
<td>0.763</td>
<td>0.000</td>
<td>1.461</td>
<td>0.000</td>
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<td>73,652</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
Economic impact of social activity – cont.

• Combining
  • the lower bound estimates of the effect of social activity on cognition
  • A 5% elasticity of household net worth and net financial assets with respect to cognition
  • One gets a 0.195% increase due to numeracy, corresponding effects of fluency and immediate and delayed recall are equal to 0.26%, 0.34%, and 0.31%. Total effect is about 1.11%.
Discussion

• Advantages of the method
  • Non-parametric: no assumptions about functional form
  • Does not involve any other control variables. No need to worry about their endogeneity, interactions or intermediate outcomes
  • Allows for complete heterogeneity of the treatment effect
  • No assumptions about the error
  • Deals with all forms of endogeneity of the treatment
  • Allows the use of instruments if available, and they need not be exogenous – being monotonic can suffice
  • Estimates the average treatment effect and not the local average treatment effect as in most IV estimation contexts
Discussion (cont.)

• Advantages of the method
  • Uses relatively mild assumptions, some of which are testable (MTR + MTS)
  • Is completely transparent about how each assumption affects the outcome. It’s up to the modeler/reader to assess the plausibility of the assumptions
  • Makes no assumption about behavior or expectations
  • Can be used in difficult estimation circumstances, e.g. cross-sectional data with no exogenous instruments
  • The ATE can be computed for quantiles as well
  • Analysis can be done within subsamples of interest
  • No need to use complicated empirical models (no need to maximize likelihoods, worry about numerical issues like convergence, local maxima etc.)
Discussion (cont.)

- Disadvantages of the method
  - Sometimes the width of the range defined by the bounds can be large – but one should be wary of unwarranted certainty
  - MTR and/or MTS need not hold. Judgment needed.
  - Not easy to bound the ATE away from zero – importance depends on the context. Instruments are needed
  - As in conventional estimation, assumptions about instrument are untestable. Judgment needed.
  - More complicated than OLS, IV, panel data methods, although not terribly so
  - Estimation is done in subsamples defined by the treatment/instrument combination – large samples might be needed
  - Continuous monotone instruments need to be discretized
Summary

• Used non-parametric methods based on bounds in order to assess the effect of being socially active on the cognition of older individuals

• The lower bound of the effect is about 15-30% of a standard deviation – smaller than the one assuming exogeneity. Upper bound about 50% of a standard deviation

• Effect is much and more uncertain than the one estimated under exogeneity
Summary (cont.)

• Results are much stronger for females than for males
• Through increased cognition, social activities have an economically significant impact on economic welfare