Neuropsychological correlates of young drivers’ performance

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Cognitive skills and driving

• Problems with inattention, avoiding distraction, sharing/switching attention contribute to crashes among novice drivers based on incident reports
• Relatively little known about specific neurocognitive processes associated with driving performance in healthy young drivers
  — Poorer executive functioning related to worse simulated driving performance in high school students
  — Adolescents with ADHD/attention problems have riskier driving behavior/more citations

McKnight and McKnight 2003
Pollatsek, Fisher et al. 2006
Thompson, Molina et al 2007
Barkley 2004
The role of executive functioning

• Cognitive processes are foundation of safe driving

• Gaps:
  – Which cognitive processes?
  – Can we use common psychological tests to predict driving behavior?

Adapted from Laapoti (2001) and Mishon (1979)
Research questions

1. Are common measures of neurocognitive functioning associated with young driver’s performance in a driving simulator?

2. Is the relationship between neurocognitive performance and driving different under conditions of high and low cognitive and driving demand?
Participants & Procedures

- 74 youth ages 16-24 with valid permit or license recruited from fliers, social media and driving schools
  - Mean age: 20, 54% male,
  - Mean driving experience: 123 miles per week
- Neurocognitive battery with trained psychologist
- After training drive, drove for 40 minutes in high fidelity virtual reality simulator under 4 conditions:
  1. Baseline highway drive
  2. Bus stopping challenge
  3. Verbal challenge
  4. Texting challenge
Highway drive

Challenges

“The boy parked the car”
“The keys received the dog”

“I'm going to the store to buy bread and milk. I'll be back in 15 minutes”
Measures

Driving Measures
• Variability in acceleration, velocity, braking and steering
• Bus challenge only: Stop distance, stop time, lane deviation

Neurocognitive Measures
• Wechsler Abbreviated Scale of Intelligence (WASI)
  – FSIQ: IQ
  – Similarities: abstract verbal reasoning
  – Block Design: visuospatial/motor
  – Matrix Reasoning: Problem solving/spatial reasoning
• Wisconsin Card Sorting
  – Categories: EF, set shifting
• Stroop Color/Word Task
  – Color-word t-score: EF, selective attention
Analysis

• Separate multivariable linear regression models to estimate the relationship between neurocognitive measures (independent vars) and driving performance measures (dependent vars) for the baseline and challenge situations

• Adjusted for: age, sex, education (years), driving experience (years), and family socioeconomic status (Family Affluence Scale)
# Multivariable regression results

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Verbal</th>
<th>Texting</th>
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<tbody>
<tr>
<td></td>
<td>Velocity</td>
<td>Steering</td>
<td>Velocity</td>
</tr>
<tr>
<td>Global intelligence (FSIQ)</td>
<td>0.24</td>
<td>0.12</td>
<td>0.42**</td>
</tr>
<tr>
<td>Abstract verbal reasoning (Similarities)</td>
<td>0.13</td>
<td>0.20</td>
<td>0.35**</td>
</tr>
<tr>
<td>Visuospatial reasoning (Block Design)</td>
<td>0.19</td>
<td>0.06</td>
<td>0.19</td>
</tr>
<tr>
<td>Spatial reasoning (Matrix Reasoning)</td>
<td>0.35**</td>
<td>0.05</td>
<td>0.25</td>
</tr>
<tr>
<td>EF, shifting: (WCST Categories)</td>
<td>0.13</td>
<td>0.26*</td>
<td>0.27*</td>
</tr>
<tr>
<td>EF, selective attention (Stroop C-W score)</td>
<td>0.002</td>
<td>0.31*</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01

Adjusted for: age, sex, education (years), driving experience (years), and SES
## Multivariable regression results

<table>
<thead>
<tr>
<th></th>
<th>Bus</th>
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<tbody>
<tr>
<td></td>
<td>Stop distance</td>
</tr>
<tr>
<td>Global intelligence (FSIQ)</td>
<td>.40**</td>
</tr>
<tr>
<td>Abstract verbal reasoning (Similarities)</td>
<td>.33*</td>
</tr>
<tr>
<td>Visuospatial reasoning (Block Design)</td>
<td>.30*</td>
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Conclusions

• Neurocognitive correlates of driving performance are different under baseline and challenge conditions
  – Young drivers with better spatial reasoning skills and EF more consistent driving behavior in the simulator
    • Lower standard deviation of speed, braking, steering
  – Those with better verbal and attention shifting capacities demonstrated better driving during the verbal and texting challenges
  – The in-drive bus challenge drew on the most diverse set of neurocognitive skills: verbal, spatial, visuospatial and abstract reasoning, and attention shifting

• Largest effect sizes for FSIQ, but only evident under challenge conditions.
Limitations

• Small sample of relatively high-performing young drivers
• No consensus on validated driving measures
• Generalizability to real-world driving conditions always a concern with simulation studies
Implications

• Supports existing research from neuroscience that shows that adolescents/young adults demonstrate different neurocognitive abilities under conditions of high and low stress/demand

• Young drivers with higher global intelligence may place less load on neurocognitive systems under stress, allow for more allocation of cognitive resources to driving tasks
Bottom Line

• Hi IQ and better driving are correlated
• Smart kid discounts on car insurance may be more than a gimmick