Students’ Motivational Attitudes about Statistics: Results from the S-SOMAS Pilot

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S-SOMAS: Overview

- Student Survey of Motivational Attitudes toward Statistics (S-SOMAS)
  - For more information see Unfried et al. (2018) and Whitaker et al. (2019)
  - Based on Expectancy-Value Theory (Eccles (Parsons) et al., 1983; Eccles & Wigfield, 2020)

<table>
<thead>
<tr>
<th></th>
<th>Student Instrument</th>
<th>Instructor Instrument</th>
<th>Environment Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statistics</strong></td>
<td>S-SOMAS</td>
<td>I-SOMAS</td>
<td>E-SOMAS</td>
</tr>
<tr>
<td><strong>Data Science</strong></td>
<td>S-SOMADS</td>
<td>I-SOMADS</td>
<td>E-SOMADS</td>
</tr>
</tbody>
</table>

PI: Unfried; Co-PIs: Posner, Bond, Whitaker, and Kerby-Helm
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MASDER Team

The Motivational Attitudes in Statistics and Data Science Education Research (MASDER) team:

• Leyla Batakci  Elizabethtown College
• Wendi Bolon  Monmouth College
• Marjorie Bond  Monmouth College
• April Kerby-Helm  Winona State University
• Michael Posner  Villanova University
• Alana Unfried  California State University, Monterey Bay
• Douglas Whitaker  Mount Saint Vincent University

Also: numerous undergraduate and graduate student assistants (including Matt Dunham); Research On Statistics Attitudes (ROSA) Working Group; USCOTS 2015 and 2017 Workshop participants; many more!
Expectancy-Value Theory (EVT)

- Originally developed to explain motivation for learning mathematics among students in grades 5-12 (Eccles (Parsons) et al., 1983) and is actively developed (Eccles & Wigfield, 2020)
- Widely used across disciplines and age (Eccles & Wigfield, 2002)
- Has been applied with university students (Eccles & Wigfield, 2020)
## Scales on Pilot 0

<table>
<thead>
<tr>
<th>Form 1</th>
<th>Form 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs &amp; Stereotypes about Statistics</td>
<td>Academic Self-Concept</td>
</tr>
<tr>
<td>Intrinsic Goal Orientation</td>
<td>Statistics Self-Concept</td>
</tr>
<tr>
<td><strong>Extrinsic Goal Orientation</strong></td>
<td>Expectancies</td>
</tr>
<tr>
<td>Interest/Enjoyment Value</td>
<td>Perception of Difficulty</td>
</tr>
<tr>
<td>Utility Value</td>
<td>Costs &amp; Benefits</td>
</tr>
<tr>
<td><strong>Attainment Value</strong> (on both forms)</td>
<td><strong>Attainment Value</strong> (on both forms)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>49 items</th>
<th>50 items</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 1155 intro. stats. students</td>
<td>N = 1159 intro. stats. students</td>
</tr>
</tbody>
</table>
Challenges to using EVT for S-SOMAS

• *How should the EVT constructs be operationalized as scales?*
  • Want the S-SOMAS to be useful longitudinally... and not require enrolment in a statistics course
  • Some EVT constructs have been researched less than others
    • Especially *Costs & Benefits* (e.g., Flake et al., 2015; Wigfield et al., 2017)

• We will briefly examine EFA, PCA, and IRT results for one scale (Extrinsic Goal Orientation).
Extrinsic Goal Orientation

1. I need to know statistics.
2. I need to know statistics because it is required of me.
3. I need to know statistics to obtain a degree/certification.
4. I need to know statistics to satisfy employers.
5. I need to know statistics because it will be expected of me in the future.
6. I need to know statistics so that I appear intelligent to my peers.
7. I need to know statistics because someone important to me wants me to.
8. I need to know statistics because my family wants me to.

Definitions

“Extrinsically motivated behavior is defined as engaging in an activity to obtain an outcome that is separable from the activity itself (deCharms, 1968; Lepper & Greene, 1978)” (Vansteenkiste et al., 2006, p. 20)

“Individuals with ego-involved [extrinsic] goals seek to maximize favorable evaluations of their competence and minimize negative evaluations of competence.” (Eccles & Wigfield, 2002, p. 115)

Note: The term Extrinsic Motivation is sometimes used instead.
Exploratory Factor Analysis

• Extension of work by Unfried et al. (2018); a lot of credit to Matthew Dunham (2020)

• Exploratory Factor Analysis (EFA) with:
  • Polychoric correlations
  • Promax rotation
  • fa function in R
EFA Results

Sankey Diagram from networkD3 R package
(Allaire et al., 2017)
EFA Results

Sankey Diagram from networkD3 R package
(Allaire et al., 2017)
EFA Results

Sankey Diagram from networkD3 R package
(Allaire et al., 2017)
Dimensionality

- PCA used to assess unidimensionality assumption for IRT
  - Gifi package in R (Mair & De Leeuw, 2019)

- Roughly homogenous loadings on the first two components suggests items are measuring the same construct (Mair, 2018)
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| Extrinsic_1 | 0.509 |
| Extrinsic_2 | 0.556 |
| Extrinsic_3 | 0.512 |
| Extrinsic_4 | 0.661 |
| Extrinsic_5 | 0.732 |
| Extrinsic_6 | 0.487 |
| Extrinsic_7 | 0.500 |
| Extrinsic_8 | 0.585 |
| Utility_1 | 0.634 |
| Utility_2 | 0.476 |
| Utility_3 | -0.422 |
| Utility_8 | -0.553 |
| Attain_5 | 0.457 |
| Attain_6 | 0.618 |
| Attain_7 | 0.458 |
Item Response Theory

• Graded Response Model (GRM; Samejima, 1969)
  • Under the GRM, the probability that person \( n \) responds in category \( j \) or higher is given as

\[
P_{nij}^* = \frac{\exp\left[\alpha_i \left(\theta_n - \delta_{ij}\right)\right]}{1 + \exp\left[\alpha_i \left(\theta_n - \delta_{ij}\right)\right]}
\]

  • where \( \theta_n \) represents the ability of person \( n \),
  • \( \alpha_i \) is the discrimination parameter for item \( i \), and
  • \( \delta_{ij} \) represents the point at which endorsing category \( j \) or higher is 0.50. (The \( \delta_{ij} \) values are the locations of the boundaries between categories.)

• mirt R package (Chalmers, 2012)

<table>
<thead>
<tr>
<th>item</th>
<th>outfit</th>
<th>z.outfit</th>
<th>infit</th>
<th>z.infit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrinsic_1</td>
<td>0.812331</td>
<td>-3.647524</td>
<td>0.839815</td>
<td>-3.407616</td>
</tr>
<tr>
<td>Extrinsic_2</td>
<td>0.917320</td>
<td>-1.634018</td>
<td>0.945811</td>
<td>-1.130446</td>
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<tr>
<td>Extrinsic_3</td>
<td>0.916533</td>
<td>-1.512248</td>
<td>0.956632</td>
<td>-0.846541</td>
</tr>
<tr>
<td>Extrinsic_4</td>
<td>0.814624</td>
<td>-3.776179</td>
<td>0.795204</td>
<td>-4.561520</td>
</tr>
<tr>
<td>Extrinsic_5</td>
<td>0.698351</td>
<td>-5.946859</td>
<td>0.703567</td>
<td>-6.550707</td>
</tr>
<tr>
<td>Extrinsic_6</td>
<td>0.934298</td>
<td>-1.718547</td>
<td>0.940876</td>
<td>-1.627520</td>
</tr>
<tr>
<td>Extrinsic_7</td>
<td>0.940678</td>
<td>-1.485473</td>
<td>0.958320</td>
<td>-1.122843</td>
</tr>
<tr>
<td>Extrinsic_8</td>
<td>0.913790</td>
<td>-1.580124</td>
<td>0.956166</td>
<td>-0.825954</td>
</tr>
</tbody>
</table>

GRM Trace Lines for Extrinsic_6
Conclusions, Limitations, and Next Steps

• Lots of information for the MASDER team to review when revising the S-SOMAS instrument
  • EFA, PCA, IRT
  • Improved definitions

• Decision to split constructs into two forms limits interpretations
  • Pilot 1 includes all constructs on one form

• Next steps:
  • Revise items, remove items, write new items
  • Change number of response points (e.g., go from 7 to 5)
  • (Change response options? Rewrite items? [Drop Agree/Disagree?])
  • Use lessons when developing I-SOMAS, S-SOMADS
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Questions?  
Live Q&A Wednesday, June 30th  
2:45pm-3:30pm ET