Measuring Statistics
Attitudes and Anxieties

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Data Collection Plan (Spring 2020)

Phase 1: Technology Pilot

• Sample: students enrolled in *Introduction to Statistics II* (no compensation)

• Scales and items:
  • *Task Effort Cost* ( Flake et al., 2015)
  • *Emotional Cost* (Flake et al., 2015)
  • In-development *Cost* scale (S-SOMAS Project, see supplementary material)
  • Additional assorted items

Phase 2: Full Pilot

• Sample: students enrolled in *Introduction to Statistics I* (with compensation)

• Scales and items:
  • Four scales from Flake et al. (2015)
  • Statistics Anxiety Rating Scale ( Cruise et al., 1985)
  • In-development *Cost* scale (S-SOMAS project)
  • Additional assorted items and scales
Phase 1: Technology Pilot

• Sample: students enrolled in *Introduction to Statistics II* (no compensation)

• Scales and items:
  • *Task Effort Cost* (Flake et al., 2015)
  • *Emotional Cost* (Flake et al., 2015)
  • In-development *Cost* scale (S-SOMAS Project, see supplementary material)
  • Additional assorted items

Phase 2: Full Pilot

• Sample: students enrolled in *Introduction to Statistics I* (with compensation)

• Scales and items:
  • Four scales from Flake et al. (2015)
  • *Statistics Anxiety Rating Scale* (Cruise et al., 1985)
  • In-development *Cost* scale (S-SOMAS project)
  • Additional assorted items and scales

All new ethics clearance applications suspended until May due to COVID-19.
Background

- **Attitudes** are commonly measured by the *Survey of Attitudes Toward Statistics* (SATS-36) instrument (Schau, 2003)
- **Anxieties** are commonly measured by the *Statistics Anxiety Rating Scale* (STARS) instrument (Cruise et al., 1985)

A few studies have used both instruments:
- Reports of Encouraging Excellence in Statistics (EncStat), an intervention to address statistics anxiety (e.g. Watson et al., 2002, 2004; Watson, Kromrey, Ferron, et al., 2003; Watson, Kromrey, & Hess, 2003; Watson, Kromrey, Lang, et al., 2003; Watson, Lang, et al., 2003)
- Studies with Italian psychology students (e.g. Chiesi & Primi, 2010; Galli et al., 2008)
- Study with US graduate students in education statistics courses (e.g. Devaney, 2010)
- Few studies report information on the relationship between students’ attitudes and anxieties as measured by these instruments
Evolving Understanding of Constructs

• SATS-36 is aligned with a theoretical framework, *Expectancy-Value Theory* (EVT) (e.g. Eccles, 1983, 2014)

• Because the SATS-36 was aligned to EVT was a posteriori (Ramirez et al., 2012; Schau et al., 1995), there are concerns about the extent to which the alignment is appropriate (Whitaker, Unfried, & Bond, 2019b).

• Decades of research on statistics anxiety exists, much using STARS

• “Research on statistics anxiety has been hampered by the lack of distinction between statistics anxiety and related variables, such as mathematics anxiety and attitudes toward statistics” (Chew & Dillon, 2014, p. 197)
Research Questions

1. How is *Statistics Anxiety* related to *Expectancy-Value Theory* (theoretical framework for SATS-36)?

2. What are students’ attitudes and anxieties (as measured by the scales used in this pilot study)?
   - Task Effort Cost (Flake et al., 2015)
   - Emotional Cost (Flake et al., 2015)
   - In-development Cost scale (S-SOMAS Project)

3. Were students’ perceptions of the cost of learning statistics affected by COVID-19 disruptions?
For more information about the similarities among constructs, please see the supplementary material.
Participants

• Anonymous survey distributed to students enrolled in *Introduction to Statistics II* aged 19 or older

• On Campus and Online courses
  • On Campus courses transitioned to Online courses due to COVID-19 during the study

• Sample size: 42 responses (of 316 students enrolled)

• 19 Likert-type items (9-point scale, higher values indicate more cost)
  • Subset of larger survey
Boxplots: COVID Impact?

- Due to anonymous nature of the survey, exact time data not collected
- Based on incremental downloads of the data, we can form two approximate groups:
  - Before: students who responded prior to COVID disruptions (n=21)
  - After: students who responded after COVID disruptions (n=21)

Boxplots for each of the scale scores look similar. If anything, students might have perceived less emotional cost after the COVID disruptions. A combined group is used for subsequent analyses (n=42).
Histograms of Scale Scores

(Whitaker, Unfried, & Bond, 2019b)
While all scales nominally assess some aspect of the EVT cost construct, ceiling effects do not seem to appear in the three scales used in this study.
Correlation Plots

Correlation Among Scales

Moderate to strong positive correlations exist among the scales and most individual items, as would be expected.

Spearman rank-order correlation coefficient
Conclusion

• The SATS and STARS instruments may be measuring some of the same constructs, but more research is needed

• Positive correlations among different scales measuring Cost in the EVT framework

• Cost scales used in this study do not exhibit ceiling effects (unlike SATS Effort scale)

• On average, students did not perceive statistics as having high or low cost.

• Students scores before and after COVID-19 disruptions seem similar.
Future Steps

• More data collection
  • More participants
  • More scales – especially STARS

• Use of non-Likert type items (e.g. grid items)
  • On-going work (Whitaker, 2020)

• Development of new student attitudes instrument
  • On-going work: S-SOMAS project (e.g. Unfried et al., 2018; Whitaker et al., 2019a, 2018)
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Questions?
Live Q&A on Tuesday,
May 19th at 10:15-11:15 AM
and 5:00-6:00 PM Eastern

Thank you!
References (1 of 3)


http://www.sci.sdsu.edu/CRMSE/STEP/documents/R.Philipp_Beliefs%26Affect.pdf
References (2 of 3)


References (3 of 3)


Wei, T., & Simko, V. (2017). R package “corrplot”: Visualization of a Correlation Matrix (Version 0.84) [Computer software]. https://github.com/taiyun/corrplot


Annotated supplementary material follows.

Measuring Statistics
Attitudes and Anxieties

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<table>
<thead>
<tr>
<th>Task Effort Cost (Flake et al., 2015)</th>
<th>Emotional Cost (Flake et al., 2015)</th>
<th>SOMAS Cost (SOMAS Project)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. This class demands too much of my time.</td>
<td>1. I worry too much about this class.</td>
<td>1. Learning statistics is a good use of my time.</td>
</tr>
<tr>
<td>2. I have to put too much energy into this class.</td>
<td>2. This class is too exhausting.</td>
<td>2. I have more important things to do than spending time learning statistics.</td>
</tr>
<tr>
<td>3. This class takes up too much time.</td>
<td>3. This class is emotionally draining.</td>
<td>3. I avoid working on statistics because it makes me feel bad</td>
</tr>
<tr>
<td>4. This class is too much work.</td>
<td>4. This class is too frustrating.</td>
<td>4. Taking statistics will limit my future prospects (for example, lower my GPA).</td>
</tr>
<tr>
<td>5. This class requires too much effort</td>
<td>5. This class is too stressful.</td>
<td>5. I prioritize other tasks over statistics</td>
</tr>
<tr>
<td>6. This class makes me feel too anxious</td>
<td></td>
<td>6. Acquiring statistical skills is worth the effort.</td>
</tr>
</tbody>
</table>

These items were displayed to respondents in a random order with 10 items on one page and 9 items on another.
### Summary Statistics

Data were analyzed using R 3.6.3 (R Core Team, 2020) with the following packages:
- `corrplot` (Wei & Simko, 2017)
- `ggplot2` (Wickham, 2009)
- `psych` (Revelle, 2018)

<table>
<thead>
<tr>
<th>Vars</th>
<th>n</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Min.</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Effort (Flake et al., 2015)</td>
<td>42</td>
<td>4.62</td>
<td>1.75</td>
<td>1.60</td>
<td>3.00</td>
<td>4.63</td>
<td>6.15</td>
<td>7.50</td>
</tr>
<tr>
<td>Emotional (Flake et al., 2015)</td>
<td>42</td>
<td>4.44</td>
<td>2.03</td>
<td>1.00</td>
<td>2.63</td>
<td>4.67</td>
<td>6.13</td>
<td>9.00</td>
</tr>
<tr>
<td>SOMAS Cost</td>
<td>42</td>
<td>4.33</td>
<td>1.85</td>
<td>1.00</td>
<td>2.63</td>
<td>4.64</td>
<td>5.86</td>
<td>7.40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Task Effort</th>
<th>Emotional</th>
<th>SOMAS Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Effort</td>
<td>1</td>
<td>0.765</td>
<td>0.882</td>
</tr>
<tr>
<td>Emotional</td>
<td>0.765</td>
<td>1</td>
<td>0.851</td>
</tr>
<tr>
<td>SOMAS Cost</td>
<td>0.882</td>
<td>0.851</td>
<td>1</td>
</tr>
</tbody>
</table>

Spearman rank-order correlation coefficient

On all three of these scales, higher responses (closer to 9) and scale scores indicate **more cost** to the student (ostensibly a “negative attitude”), while lower responses (closer to 1) and scale scores indicate **less cost** to the student (ostensibly a “positive attitude”).
SATS and STARS Constructs

• The next few slides quote definitions of constructs measured by the SATS instrument (top) and STARS instrument (bottom).

• Highlighting is used to indicate similarities, with colour used matching the construct mapping.
• **Attitudes:** Manners of acting, feeling, or thinking that show one’s disposition or opinion. Attitudes change more slowly than emotions, but they change more quickly than beliefs. Attitudes, like emotions, may involve positive or negative feelings, and they are felt with less intensity than emotions. **Attitudes are more cognitive than emotion but less cognitive than beliefs.** (Philipp, 2007, p. 259)

  Attitudes and anxieties are conceptually distinct, but the way instruments have operationalized these ideas may have resulted in a lack of distinction.

• **Statistics Anxiety:** a negative state of emotional arousal experienced by individuals as a result of encountering statistics in any form and at any level; this emotional state is preceded by negative attitudes toward statistics and is related to but distinct from mathematics anxiety (Chew and Dillon, 2014, p. 199)
SATS and STARS Constructs

• **Value**: students’ attitudes about the usefulness, relevance, and worth of statistics in personal and professional life (Schau, 2005, p. 2)

  *Both definitions emphasize the usefulness and relevance of statistics.*

• **Worth of Statistics**: This factor has to do with the student’s perception of the relevance of statistics. A person scoring high on this factor sees no purpose in taking a statistics course and no possible future personal or professional application. Another aspect is that the students find statistics pointless because it does not fit their personality. It can also indicate a negative attitude toward statistics. (Cruise et al., 1985, p. 93)
SATS and STARS Constructs

- **Cognitive Competence:** students’ attitudes about their intellectual knowledge and skills when applied to statistics (Schau, 2005, p. 1)  
  
  *Both definitions indicate students’ perceptions of their abilities to engage with statistics.*

- **Computation Self-Concept:** This factor involves anxiety experienced when doing mathematical problems, as well as the student’s perception of his/her ability to understand and calculate statistics. It doesn’t reflect so much the student’s ability to do mathematics, but rather measures the student’s attitude toward mathematics. A person scoring high on this factor might not mind statistics per se, but experiences anxiety because it involves mathematical calculations, and he/she feels inadequate to comprehend statistics. (Cruise et al., 1985, p. 93)
SATS and STARS Constructs

• **Effort:** amount of work the student expends to learn statistics (Schau, 2005, p. 3)

There does not seem to be alignment between the SATS Effort construct and these STARS constructs, despite all being illustrated as measuring EVT Cost earlier...

• **Interpretation Anxiety:** This factor is concerned with the anxiety experienced when a student is faced with making a decision from or interpreting statistical data.

• **Test and Class Anxiety:** This factor deals with the anxiety involved when taking a statistics class or test.

• **Fear of Asking for Help:** This factor measures the anxiety experienced when asking for help. (Cruise et al., 1985, p. 93)
SATS and STARS Constructs

• **Cost:** any factors that operate to inhibit or deter the performance of a sequence of behavior (Thibaut & Kelley, 1959, p. 12)

... but examining the original conception of Cost in EVT (which draws on Social Exchange Theory) reveals a connection. Anxiety could operate to inhibit performance, and Effort needed might also inhibit performance.

• **Interpretation Anxiety:** This factor is concerned with the anxiety experienced when a student is faced with making a decision from or interpreting statistical data.

• **Fear of Asking for Help:** This factor measures the anxiety experienced when asking for help.

• **Test and Class Anxiety:** This factor deals with the anxiety involved when taking a statistics class or test. (Cruise et al., 1985, p. 93)
SATS and STARS Constructs

• **Cost:** any factors that operate to inhibit or deter the performance of a sequence of behavior (Thibaut & Kelley, 1959, p. 12)

While fearing a statistics teacher could inhibit performance, this STARS construct is seems to be less about anxiety related to statistics as a subject and more about how one views an instructor, which is not unique to statistics.

• **Fear of Statistics Teachers:** This factor is concerned with the student’s perception of the statistics teacher. A person scoring high on this factor perceives the statistics teacher as lacking the ability to relate to the student as a human being. He questions the humanness of the teacher and regards him as someone who the student must fear. (Cruise et al., 1985, p. 94)
SATS and STARS Constructs

• **Affect:** students’ feelings concerning statistics
• **Interest:** students’ level of individual interest in statistics
• **Difficulty:** students’ attitudes about the difficulty of statistics as a subject (Schau, 2005, pp. 1-2)

*These SATS constructs do not seem to have corresponding STARS constructs.*
SOMAS Project

- SOMAS: Surveys of Motivational Attitudes toward Statistics

- Larger project to develop a family of instruments to measure students’ attitudes toward statistics (S-SOMAS), instructors’ attitudes toward statistics (I-SOMAS), and characteristics of the learning environment (E-SOMAS)

- S-SOMAS is in an early pilot phase now

- S-SOMAS and I-SOMAS will be aligned with EVT framework (e.g. Eccles, 1983, 2014) a priori
Selected SOMAS Papers and Presentations

Student Instrument (S-SOMAS)


Instructor Instrument (I-SOMAS)


Environment Instrument (E-SOMAS)

SOMAS Team

The *Surveys of Motivational Attitudes toward Statistics* (SOMAS) team:

- Leyla Batakci, *Elizabethtown College*
- Wendi Bolon, *Monmouth College*
- Marjorie Bond, *Monmouth College*
- April Kerby, *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; Research On Statistics Attitudes (ROSA) Working Group, USCOTS 2015 and 2017 Workshop participants
Challenges to Using and Interpreting the SATS-36 Instrument:

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Marjorie Bond  
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Monmouth College

Do you like statistics?  
Do your students like statistics?  
How do you know?

About the SATS Instrument

- Widely used to measure attitudes toward statistics
- 28-item (Schau, 1992) Affect, Cognitive Competence, Value, and Difficulty
- 36-item (Schau, 2003) the above, with Interest and Effort
- Primarily used with undergraduate, introductory statistics students
- Translated into many languages

Data & Analysis

- Graphs and analysis are based on student data in the SATS data warehouse, collected from 2007-2010
- Students in introductory statistics courses
- Approximately 2300 students across 120 courses
- Missing values excluded from these analyses
- STEM results graph is from internal data collection using adapted instruments for which validity and usefulness are largely unavailable

Other Challenges

- Neutral option included, coupled with non-standard instructions:
  - “If you have no opinion, choose Neither agree nor agree.”
  - Difficulty may depend on type of student/course
  - Example: Engineering students at BYU tend to have higher difficulty scores than for general populations at UNIM
  - Negatively worded items use “not” — may be overlooked by students
  - Claimed congruence with Expectancy Value Theory (EVT, e.g., Eccles, 1983, 2014)
    - Potential misalignment between SATS constructs and EVT constructs (e.g., Cost)
  - Rigid pre/post structure makes longitudinal research (e.g., Kerby & Winoughton, 2017; Miller & White, 2014) difficult at best
  - Not appropriate for use with other populations of interest (e.g., Teachers)

Table 1: Mean difference (Post-Pre), effect size, and interpretation for each SATS construct.

<table>
<thead>
<tr>
<th>Component</th>
<th>Mean Difference</th>
<th>Cohen’s d Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affect</td>
<td>0.48</td>
<td>Large</td>
</tr>
<tr>
<td>Cognitive Competence</td>
<td>0.00</td>
<td>Small</td>
</tr>
<tr>
<td>Value</td>
<td>0.37</td>
<td>Medium</td>
</tr>
<tr>
<td>Difficulty</td>
<td>0.16</td>
<td>Small</td>
</tr>
<tr>
<td>Interest</td>
<td>0.82</td>
<td>Large</td>
</tr>
<tr>
<td>Effort</td>
<td>0.56</td>
<td>Large</td>
</tr>
</tbody>
</table>

References


USCOTS 2019 poster that was referenced in this poster (Whitaker, Unfried, & Bond, 2019b)

Full citation for future reference: