Challenges Assessing Statistics Attitudes

*Opportunities and Costs*

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Overview

• Introduction

• Overview of theoretical framework (EVT) (e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)

• More information about Cost

• Overview of Evaluative Space Grid (ESG) (Cacioppo & Berntson, 1994; Cacioppo et al., 1997; Larsen et al., 2009)

• Current pilot study using ESG to measure Cost
  • Data collection on-going
Acknowledgements: 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.
Background

“People forget what they do not use. But attitudes ‘stick’”

(Ramirez, Schau, & Emmioğlu, 2012, p. 57)

• Long history of measuring attitudes toward statistics
  • Older: SAS (Roberts & Bilderback, 1980) or ATS (Wise, 1985)
  • Widely used: Survey of Attitudes Toward Statistics (SATS) (Schau, 1992, 2003b)
  • Anxieties: Statistics Anxiety Rating Scale (STARS) (Cruise, Cash, & Bolton, 1985)

• Proliferation of instruments (Nolan, Beran, & Hecker, 2012; Ramirez et al., 2012)
  • Two streams: attitudes and anxieties
Larger Context

SOMAS project’s overarching goal:

*Develop a family of instruments to measure attitudes toward statistics for use with students and instructors*

- Expectancy-Value Theory (EVT) (e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002) adopted as theoretical framework (e.g. Whitaker, Unfried, & Batakci, 2018)
- Student instrument: S-SOMAS; instructor instrument: I-SOMAS
Expectancy-Value Theory (EVT)

• Statistics Education has used the language of ‘attitudes’ for decades, but understanding motivation for learning statistics is the ultimately of interest (e.g. Schau, 2003a)

• Contemporary EVT based on the work of Jackie Eccles and her colleagues (e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)

• EVT is consistent with Bandura’s (1977, 1986) self-efficacy model

• EVT is a theory of motivation and includes additional aspects of motivation beyond self-efficacy
Expectancy-Value Theory (Simplified)
S-SOMAS EVT Model

Based on Eccles' Expectancy-Value Theory (EVT) (e.g., Eccles, 1983, 2014; Eccles & Wigfield, 2002)

Survey of Motivational Attitudes toward Statistics (SOMAS)

Student Expectancy-Value Theory Model

Assessed by the S-SOMAS instrument

Not assessed by the S-SOMAS instrument

Subjective Task Value
- Interest/Enjoyment Value
- Attainment Value
- Cost (Value)
- Utility Value

Performance Behaviors

Achievement

Expectancies
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Goals and Self-Schemata
Beliefs & Stereotypes about Statistics
Perception of others’ attitudes and expectations
Aptitude for Learning Statistics
Interpretation of Past Events

Minimum Standard for Achievement
Goal Orientation
Career/Life Goals
Academic Self-Concept

Self-Concept of Statistics Ability
Perception of Difficulty

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“Cost is conceptualized in terms of the negative aspects of engaging in the task, such as performance anxiety and fear of both failure and success, as well as the amount of effort needed to succeed and the lost opportunities that result from making one choice rather than another” (Eccles & Wigfield, 2002, p. 120)
“Cost is conceptualized in terms of the negative aspects of engaging in the task, such as performance anxiety and fear of both failure and success, as well as the amount of effort needed to succeed and the lost opportunities that result from making one choice rather than another” (Eccles & Wigfield, 2002, p. 120)

**S-SOMAS EVT Model**

- **Survey of Motivational Attitudes toward Statistics (SOMAS)**
  - Assessed by the S-SOMAS instrument
  - Not assessed by the S-SOMAS instrument

**Dimensions of Cost:**
- **Effort, Loss of Valued Alternatives, Psychological Cost of Failure** (Eccles et al., 1983)
- **Effort → Task Effort, Outside Effort** (Flake et al., 2015)
Motivation: Difficulty Measuring Cost

• S-SOMAS item writing process: team felt that some constructs were harder to distinguish
  • Group 2: Cost, Difficulty, Expectancies, Academic Self-Concept, Statistics Self-Concept, Attainment Value

• Focus group with undergraduate students (Bond):
  • Gave students items on cards and asked to make six piles for named constructs
  • Of the 7 cost items... 1 was put in the “Cost” pile and no pile had more than 2 Cost items

• Challenges with empirical factor structure (Unfried, Kerby, & Coffin, 2018)

• Subject matter expert (SME) review of items raised concerns about the items being used to measure the Cost construct
More Background on Cost

• Cost is “especially important” to the choices made by students (Wigfield et al., 2017, p. 124)

• Original description of Cost construct:
  
  (Eccles et al., 1983, p. 93)

  **Cost of Success or Failure** The value of a task to an individual is also affected by a set of variables that can be conceptualized best as the cost of success or failure. Borrowing from exchange theorists (e.g., Thibaut and Kelley, 1959), we conceptualize the influence of cost on the value of an activity in terms of a cost/benefit ratio. Assuming that individuals have a conception of both the costs and the benefits of engaging in a variety of activities, then the value of each activity ought to be inversely related to this cost/benefit ratio. Variables influencing
Questions about Cost

• How should Cost be measured? (Wigfield et al., 2017)

• Flake et al. (2015) developed four scales for measuring Cost dimensions
  • Operationalized cost using negative appraisals (e.g. “too much”)
  • “This class is too much work” (Flake et al., 2015, p. 242)

• Currently described as a component of Subjective Task Values – but should it instead influence these values? (Eccles et al., 1983; Wigfield et al., 2017)

• Should the focus be on the Cost-Benefit Ratio rather than just Cost?
• What is the theoretical relationship between statistics anxiety and Psychological Cost? Does EVT bridge the attitudes and anxieties streams?
Motivation for ESG: Beyond Bipolar Scales

Cacioppo and Berntson (1994) articulate three assumptions for using bipolar scales (e.g. Likert-type items) for measuring attitudes:

1. An attitude is a joint function of positive (appetitive) and negative (aversive) affective/motivational reactions to a stimulus.

2. Positive and negative reactions to a stimulus have generally opposing effects on an attitude.

3. The positive and negative reactions that determine an attitude toward a stimulus are essentially reciprocally controlled. (Cacioppo, Gardner, & Berntson, 1997, pp. 5-6)
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What if we do not require a reciprocal relationship between positive and negative reactions?
Evaluative Space Grid: Not requiring a reciprocal relationship

- Labeling of quadrants: (Audrezet, 2014)
- Evaluative Space Grid: (Cacioppo & Berntson, 1994; Cacioppo et al., 1997; Larsen et al., 2009)
ESG in Empirical Literature

• Potential advantages:
  • Better describe respondents’ attitudes that would be ordinarily described as “neutral” (Cacioppo et al., 1997; Larsen et al., 2009)
  • Participants may (mistakenly) respond to unipolar scales as if they are bipolar (Larsen et al., 2009)
  • More efficient than dichotomous-then-unipolar items (Larsen et al., 2009)

• Potential challenges/disadvantages: many?
• Many of these studies have been in the area of marketing/customer satisfaction
  • Restaurant or physician evaluation (Audrezet 2014; Audrezet, Olsen, & Tudoran, 2016; Audrezet & Parguel, 2018)
  • Attitudes of Swiss transit customers (Borriello, 2017)
Current Study: Pilot of Grid Items

Questions:
1. How can grid items be implemented in an online survey platform (LimeSurvey)?
2. Do students understand grid items?
3. How should grid items be constructed?
4. Does a reciprocal relationship appear reasonable?
   • Is there value to using the grid items over Likert-type items?
Current Study: Reciprocal Relationship?

• If there is a reciprocal relationship between positive and negative responses should fall primarily along the diagonal

• Audrezet et al. (2016) shows typical grid format

• But LimeSurvey requires the Y axis to be reversed...

• Graphs later use this format.

Figure 3 The evaluative space GRID (GRID Scale; Larsen et al., 2009) versus the Semantic Differential Scale (SD Scale)
Current Study: Reciprocal Relationship?

- If there is a reciprocal relationship between positive and negative responses, they should fall primarily along the diagonal.
- But LimeSurvey requires the Y axis to be reversed...
  - (Does direction matter?)

<table>
<thead>
<tr>
<th>No agreement at all</th>
<th>Slightly agree</th>
<th>Moderately agree</th>
<th>Greatly agree</th>
<th>Completely agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>No disagreement at all</td>
<td>❌</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly disagree</td>
<td>❌</td>
<td>❌</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately disagree</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td></td>
</tr>
<tr>
<td>Greatly disagree</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Completely disagree</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
</tbody>
</table>
Current Study: Reciprocal Relationship?

- If there is a reciprocal relationship between positive and negative responses, responses should fall primarily along the diagonal.
- Audrezet et al. (2016) shows typical grid format.
- But LimeSurvey requires the Y axis to be reversed...
- Graphs later use this format.
Current Study: Data Collection

• Likert-type and **Grid items:**
  - Flake et al.’s (2015) *Task Effort Cost* scale (5 items)
  - Flake et al.’s (2015) *Emotional Cost* scale (6 items)
  - S-SOMAS *Cost* items (8 items) (Unfried et al., 2018; Whitaker et al., 2019a, 2018)
• Grid-only items developed for this study (3 items)
• Multiple choice (3 items) and free response (1 item) items asking about students’ perceptions of the survey
• Survey distributed to students enrolled in *Introduction to Statistics II* aged 19 or older
• Sample size: 16 (10 essentially complete, 6 partial)
  - Note: on the following graphs, no cell contains more than 3 responses
Note: no cell contains more than 3 responses on any of the heatmaps

Graphs made using R 3.6.2 (R Core Team, 2019) and ggplot2 (Wickham, 2009)
Preliminary Findings

• Across items, it does not seem as if students overwhelmingly respond along the diagonal
• Some evidence there may be value to using grid items
• Some items with patterns suggesting indifferent/ambivalent responses
• Some items do exhibit the diagonal pattern associated with a reciprocal relationship (e.g. Page5Grid2)
Next Steps

• Relationship between participants’ grid and Likert-type responses
• Classification into Negative/Positive/Ambivalent/Indifferent
• Inferential analyses (and power studies)
• Response times and answers to meta questions
• Gather validity evidence (AERA, APA, & NCME, 2014)
• Best practices for writing grid items?
• Revise and collect more data
  • Also include constructs other than cost
  • Incentivize participants
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Questions?

Thank you!
References (page 1)


References (page 2)


Extra Slides

Challenges Assessing Statistics Attitudes

Whitaker – RCML 2020
Selected SOMAS Papers and Presentations

Student Instrument (S-SOMAS)


Instructor Instrument (I-SOMAS)


Environment Instrument (E-SOMAS)

S-SOMAS: Pilot-0 Construct Groups

Based on Eccles' Expectancy-Value Theory (EVT) (e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)

Survey of Motivational Attitudes toward Statistics (SOMAS)

Student Expectancy-Value Theory Model

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Attainment Value
Cost (Value)
Utility Value

Performance Behaviors
Achievement

Self-Concept of Statistics Ability

Perception of Difficulty
Expectancies

Assessed by the S-SOMAS instrument
Not assessed by the S-SOMAS instrument
## S-SOMAS Focus Group Results

### What the focus group said:

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Attainment Value</th>
<th>Beliefs/Stereotype</th>
<th>Extrinsic Motivation</th>
<th>Interest</th>
<th>Intrinsic Motivation</th>
<th>Utility Value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment Value</td>
<td>43%</td>
<td></td>
<td></td>
<td>29%</td>
<td>29%</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Beliefs/Stereotype</td>
<td></td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Extrinsic Motivation</td>
<td>13%</td>
<td></td>
<td>88%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Interest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td>14%</td>
<td></td>
<td></td>
<td>29%</td>
<td>29%</td>
<td></td>
<td>29%</td>
</tr>
<tr>
<td>Utility Value</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td></td>
<td></td>
<td>25%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### What the focus group said:

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Academic Self-Concept</th>
<th>Attainment Value</th>
<th>Difficulty</th>
<th>Cost</th>
<th>Expectancy</th>
<th>Statistics Self-Concept</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Self-Concept</td>
<td>22%</td>
<td>22%</td>
<td>22%</td>
<td>11%</td>
<td>11%</td>
<td>11%</td>
<td>100%</td>
</tr>
<tr>
<td>Attainment Value</td>
<td>14%</td>
<td>29%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>100%</td>
</tr>
<tr>
<td>Difficulty</td>
<td>29%</td>
<td>43%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>100%</td>
</tr>
<tr>
<td>Cost</td>
<td>29%</td>
<td>29%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>100%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>18%</td>
<td>18%</td>
<td>9%</td>
<td>18%</td>
<td>18%</td>
<td>18%</td>
<td>100%</td>
</tr>
<tr>
<td>Statistics Self-Concept</td>
<td>44%</td>
<td>44%</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
Motivation: Difficulty Measuring Cost

• SATS-36 attempts to measure Cost using an Effort scale
  • Graphs and analysis are based on “pre” student data in the SATS data warehouse, collected from 2007-2010
  • Students in introductory statistics courses
  • Approximately 2300 students across 120 courses
• All the Effort items have the word “plan” in them.
  • Example item: I plan to complete all my statistics assignments. (Schau, 2003b, p. 3)
• See Whitaker, Unfried, and Bond (2019b) for more details
Motivation: difficulty measuring Cost

- S-SOMAS Pilot-0 Group 2
- 134 undergraduate students
- Exploratory factor analysis:
  - Six theoretical constructs
  - Five-factor solution


Factor Loadings Graph for Group 2
Motivation: difficulty measuring Cost

- S-SOMAS Pilot-0 Group 2
- 134 undergraduate students
- Exploratory factor analysis:
  - Six theoretical constructs
  - Five-factor solution

Correlations

• Spearman correlations between Likert-type items and Grid-type items

• Grid to Likert-type mapping using $b = -0.5$ (Audrezet et al., 2016)
Correlations

- Spearman correlations between Likert-type items and Grid-type items
- Grid to Likert-type mapping using $b = -1$ (Audrezet et al., 2016)
Evaluative Space Grid (ESG) vs. Affect Grid

- Evaluative Space Grid: (Cacioppo & Berntson, 1994; Cacioppo et al., 1997; Larsen et al., 2009)
- Affect Grid: (Russell, Weiss, & Mendelsohn, 1989)

Next slide:

- Left: Evaluative Space Grid (ESG)
  - Figure 3, p. 33

- Right: Affect Grid
  - Figure 1, p. 494
Figure 3 The evaluative space GRID (GRID Scale; Larsen et al., 2009) versus the Semantic Differential Scale (SD Scale)

(a)

Notes: (a) GRID scale; (b) SD scale

Figure 1. The Affect Grid. (The subject first reads the general instructions [given in the Appendix] and then is given specific instructions, such as “Please rate how you are feeling right now.” The subject places one checkmark somewhere in the grid. The pleasure–displeasure (P) score is taken as the number of the square checked, with squares numbered along the horizontal dimension, counting 1 to 9 starting at the left. The arousal–sleepiness (A) score is taken as the number of the square checked, with squares numbered along the vertical dimension, counting 1 to 9 starting at the bottom.)
Grid Classifications