

# 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:

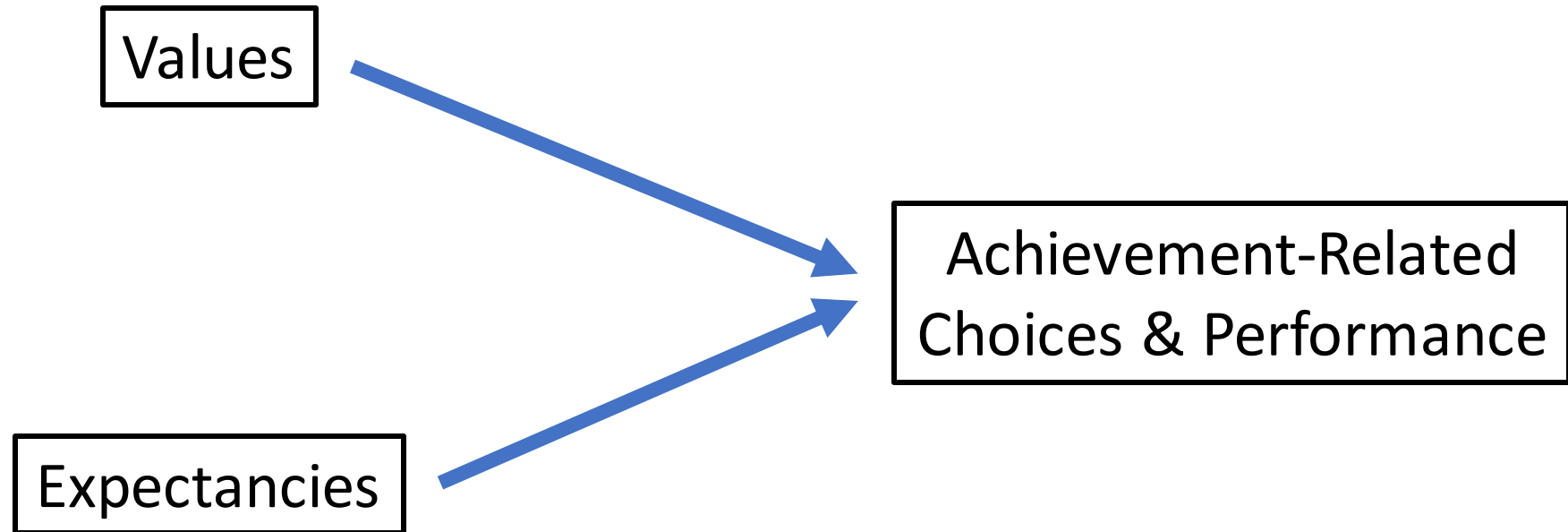
*Develop a family of instruments to measure attitudes toward statistics for use with students and instructors*

- 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

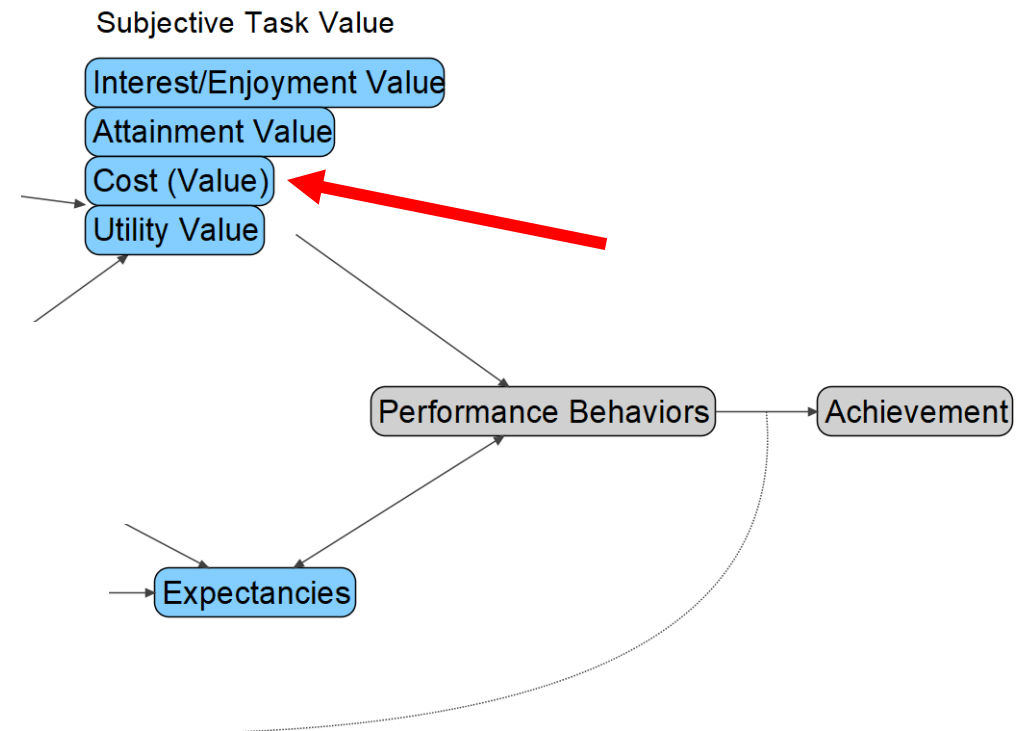
Based on Eccles' Expectancy-Value Theory (EVT)  
(e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)

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





# S-SOMAS EVT Model

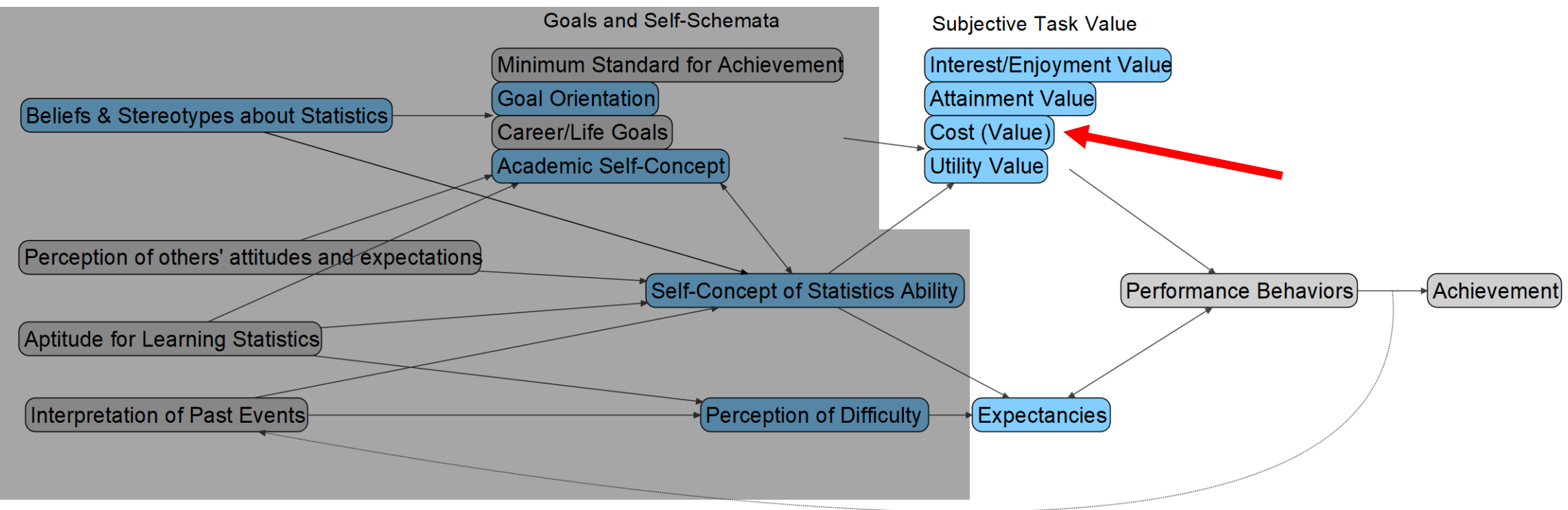
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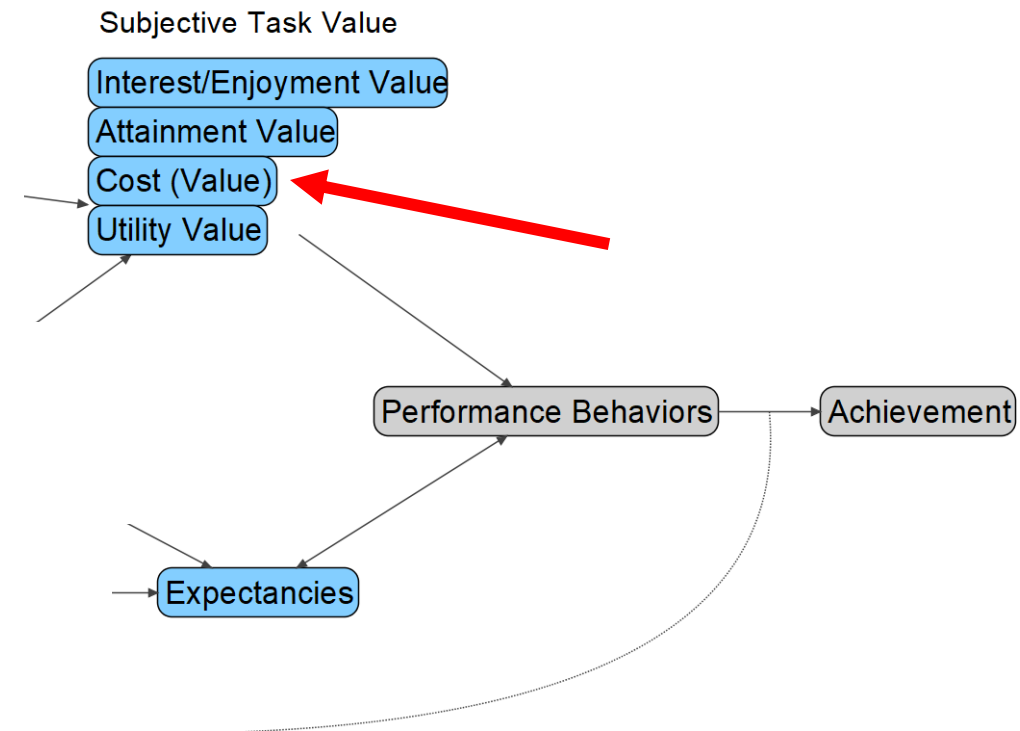
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“**Cost** is conceptualized in terms of the negative aspects of engaging in the task, such as performance anxiety and fear of both failure and success, as well as the amount of effort needed to succeed and the lost opportunities that result from making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



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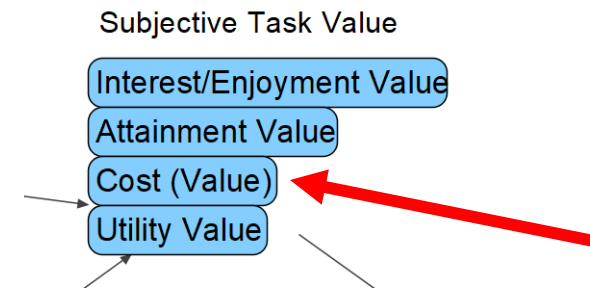
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## Dimensions of Cost:

- 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)

# Motivation for ESG: Beyond Bipolar Scales

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1. An attitude is a joint function of positive (appetitive) and negative (aversive) reactions to a stimulus.  
**What if we do not require a reciprocal relationship between positive and negative reactions?**
2. Positive and negative reactions have 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)



# Evaluative Space Grid:

*Not requiring a reciprocal relationship*

Negative

Ambivalent

*contradictory attitudes*

# Evaluative Space Grid:

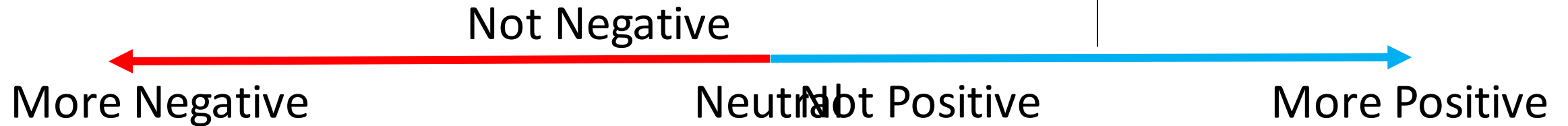
*Not requiring a reciprocal relationship*

Indifferent

*weak attitudes*

Positive

- **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

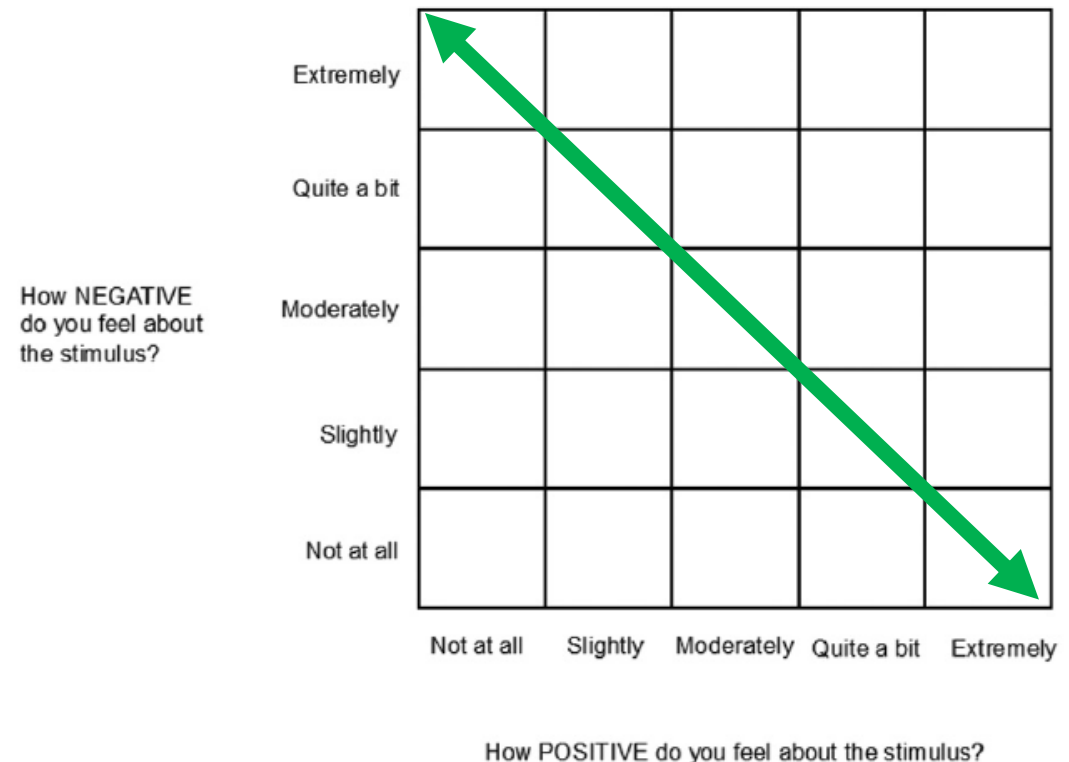
## Questions:

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)



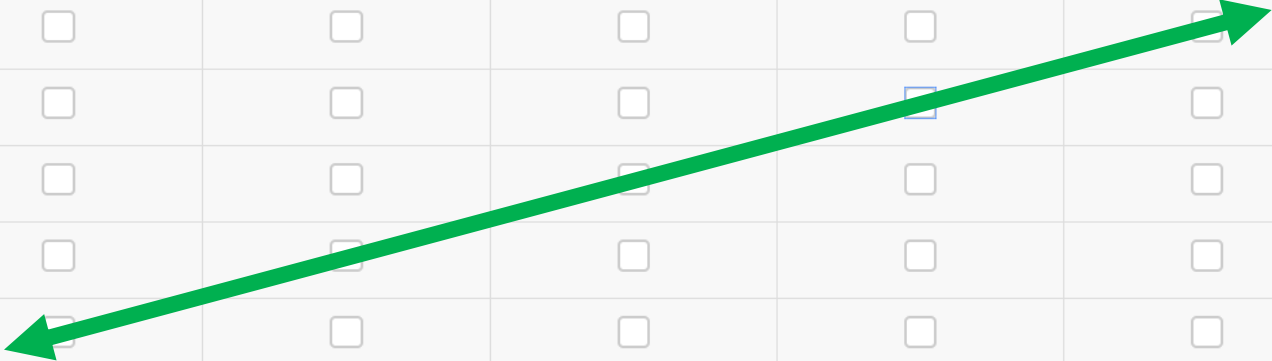
(a)

# Current Study: Reciprocal Relationship?

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

**Please select ONE box.**

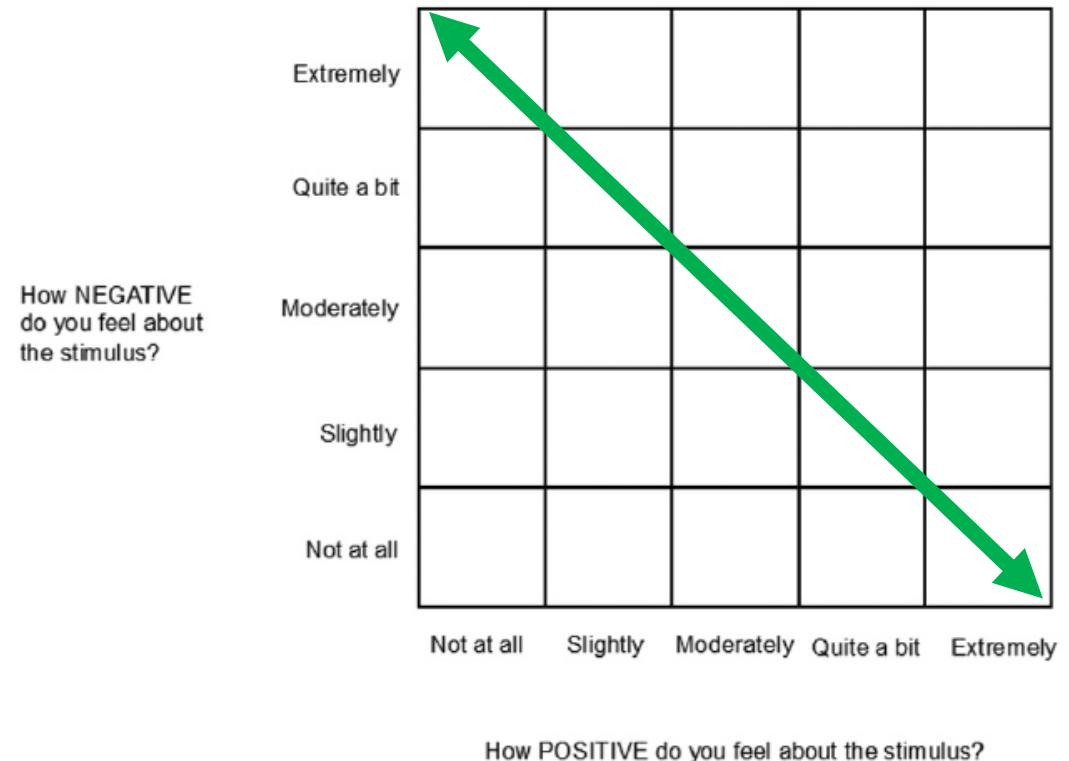
	No agreement at all	Slightly agree	Moderately agree	Greatly agree	Completely agree
No disagreement at all	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Slightly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderately disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Greatly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



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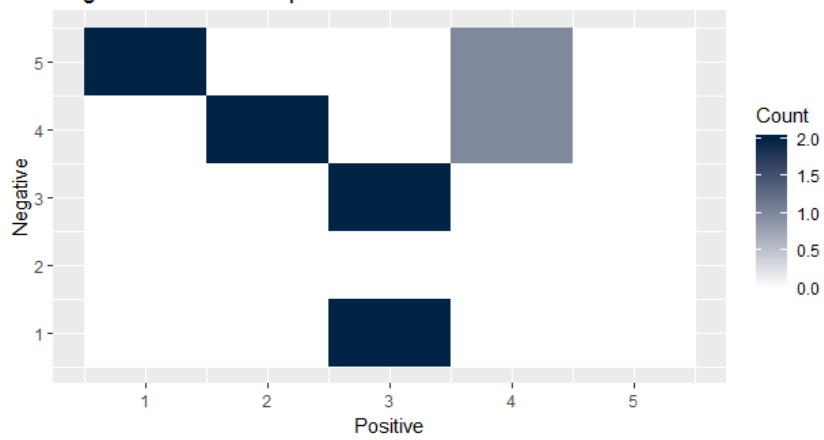


(a)

# 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

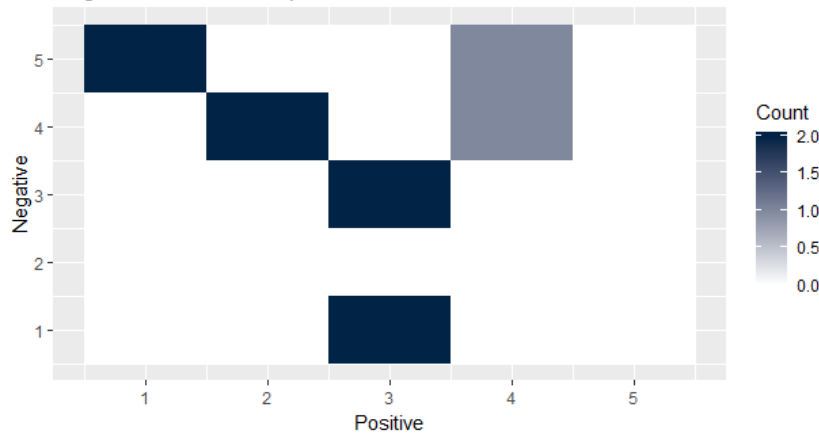
Page4Grid1: Heat Map - Grid Pilot March 2020



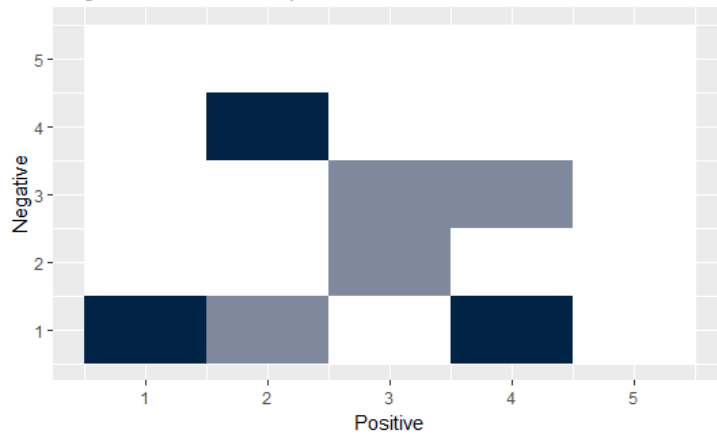
Group A Items 1-9 (Page 4)



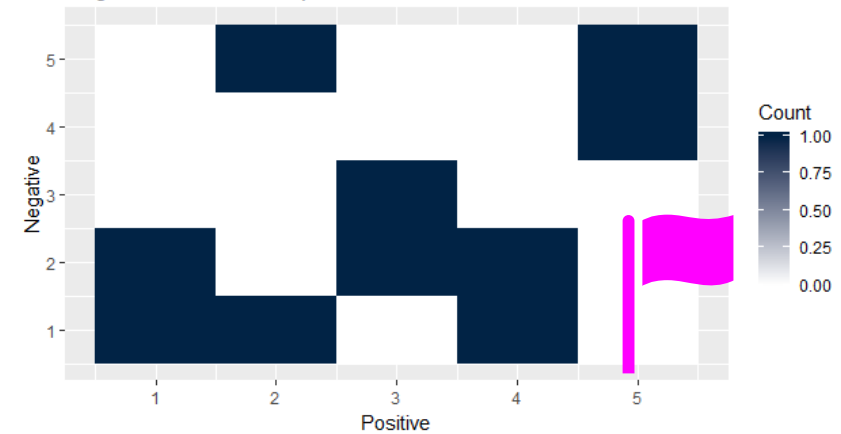
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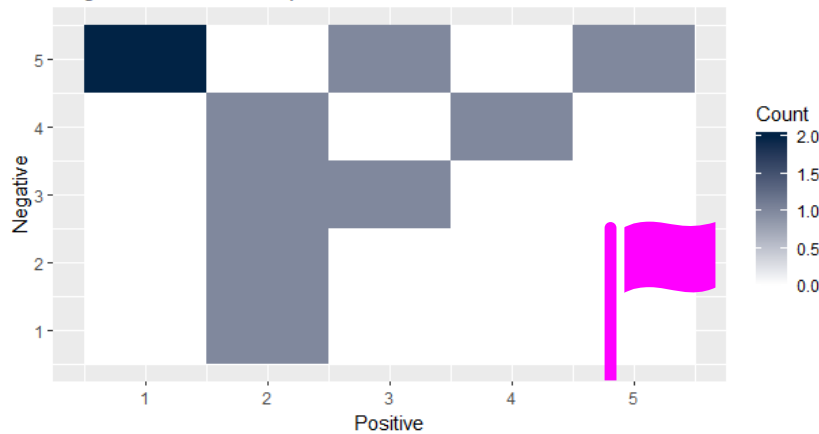
Page4Grid2: Heat Map - Grid Pilot March 2020



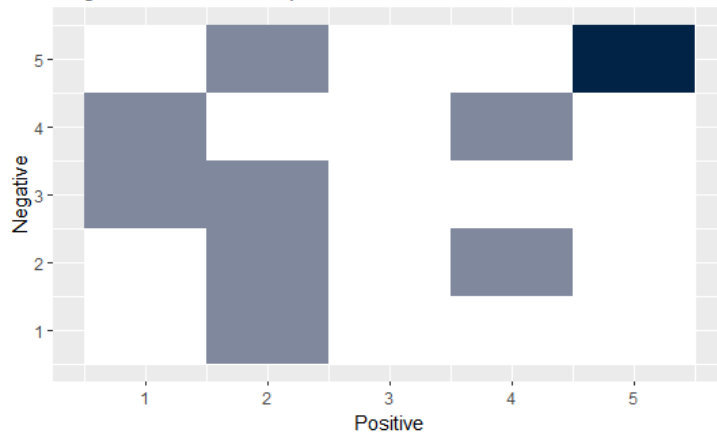
Page4Grid3: Heat Map - Grid Pilot March 2020



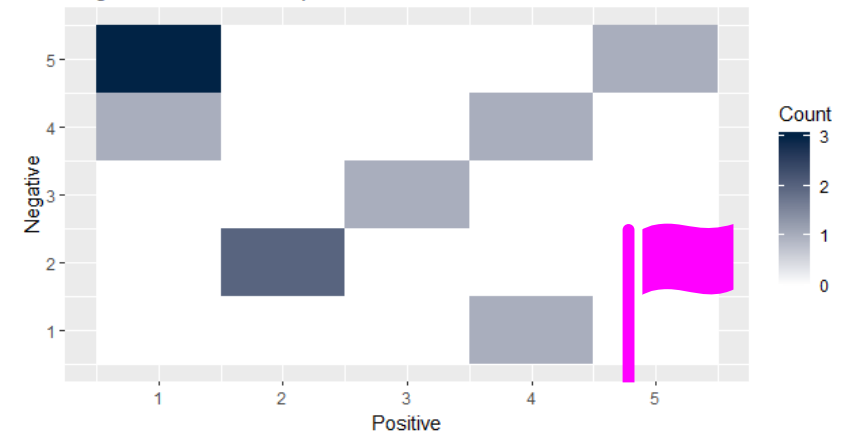
Page4Grid4: Heat Map - Grid Pilot March 2020



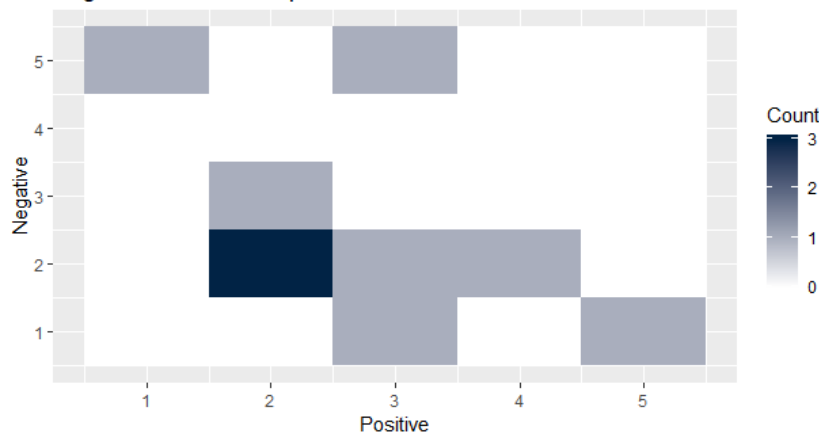
Page4Grid5: Heat Map - Grid Pilot March 2020



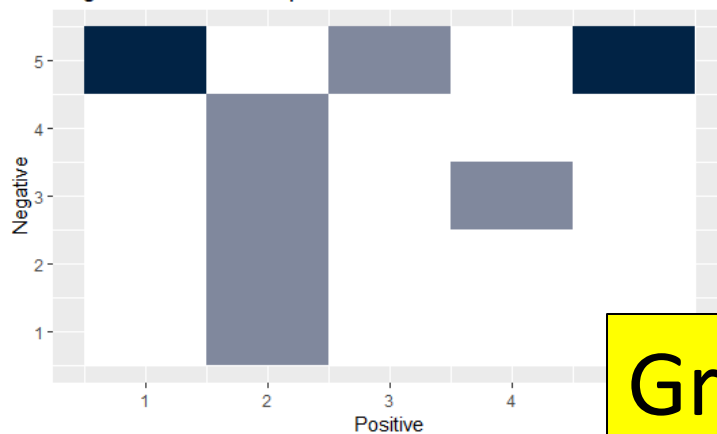
Page4Grid6: Heat Map - Grid Pilot March 2020



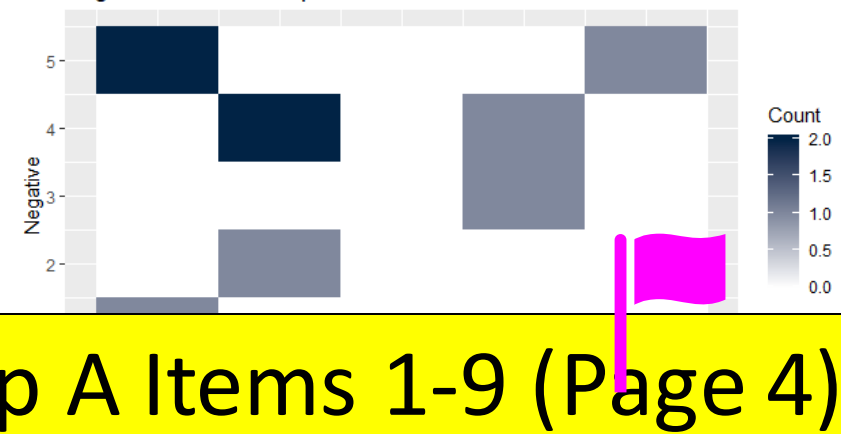
Page4Grid7: Heat Map - Grid Pilot March 2020



Page4Grid8: Heat Map - Grid Pilot March 2020

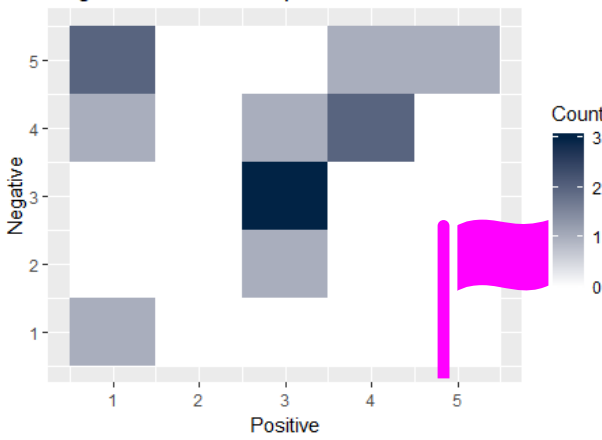


Page4Grid9: Heat Map - Grid Pilot March 2020

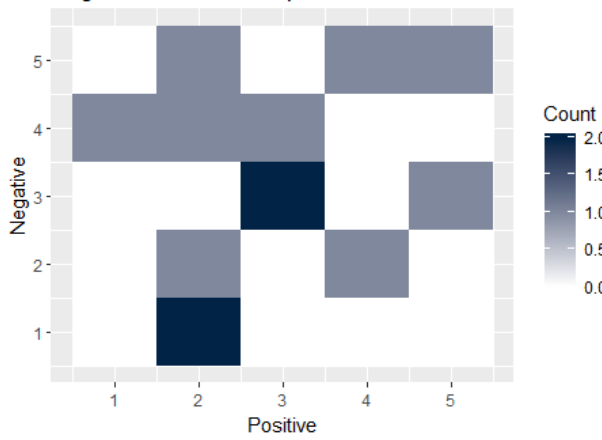


Group A Items 1-9 (Page 4)

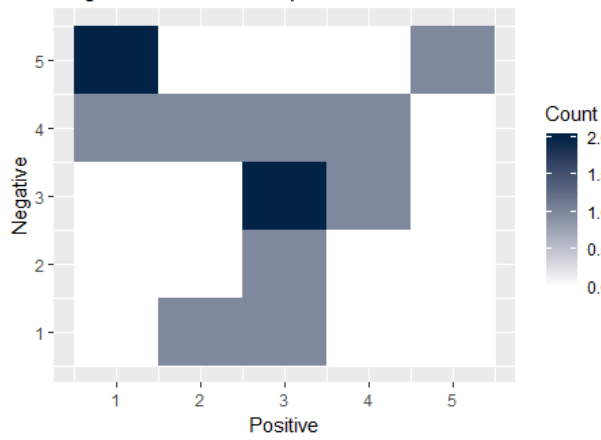
Page2Grid1: Heat Map - Grid Pilot March 2020



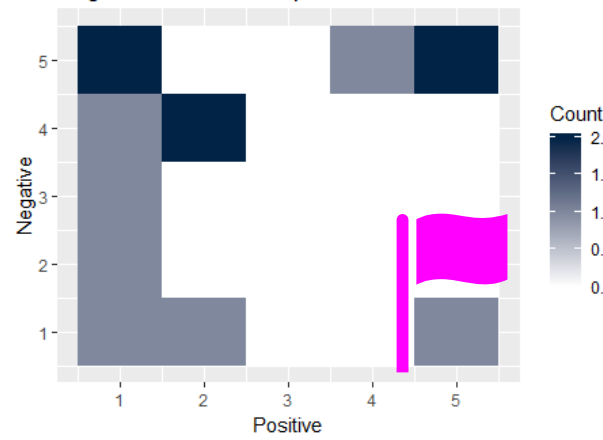
Page2Grid2: Heat Map - Grid Pilot March 2020



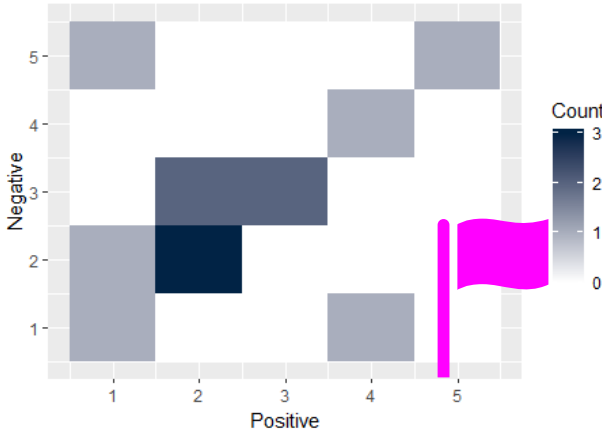
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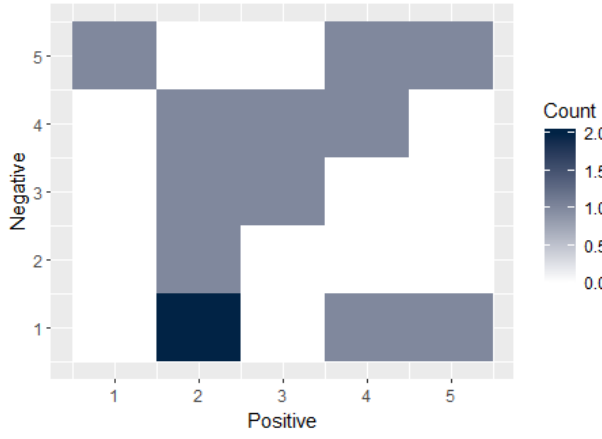
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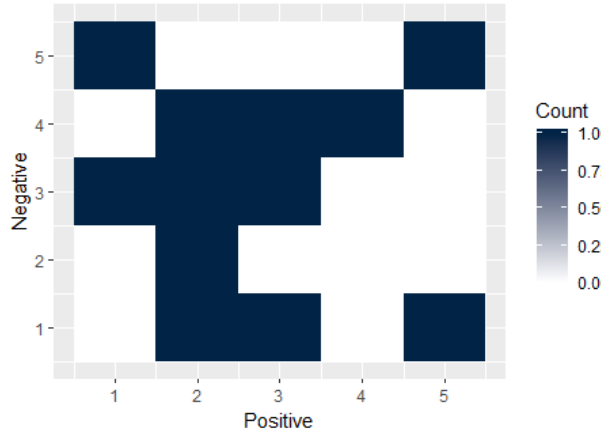
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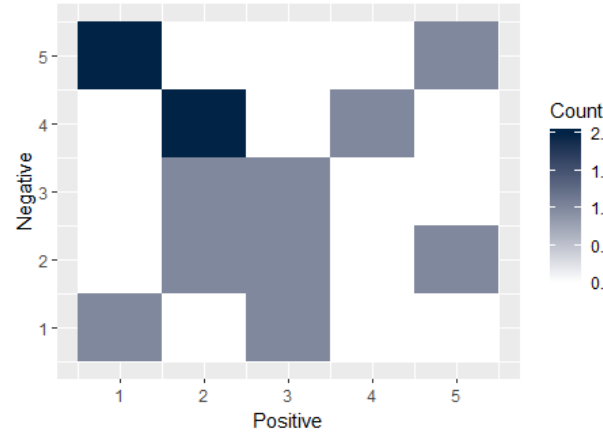
Page2Grid6: Heat Map - Grid Pilot March 2020



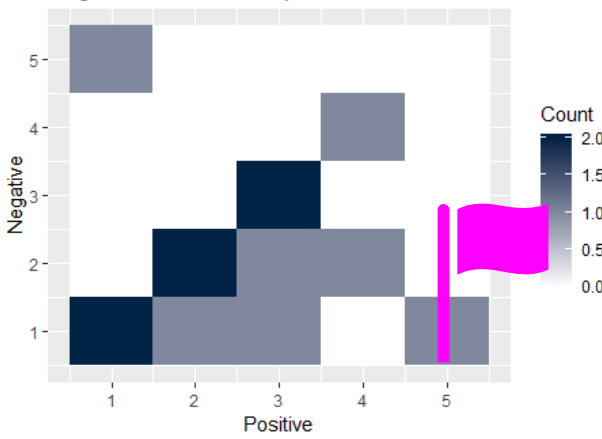
Page2Grid7: Heat Map - Grid Pilot March 2020



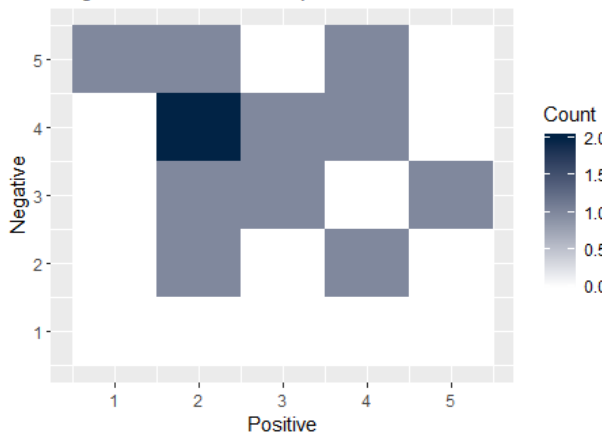
Page2Grid8: Heat Map - Grid Pilot March 2020



Page2Grid9: Heat Map - Grid Pilot March 2020

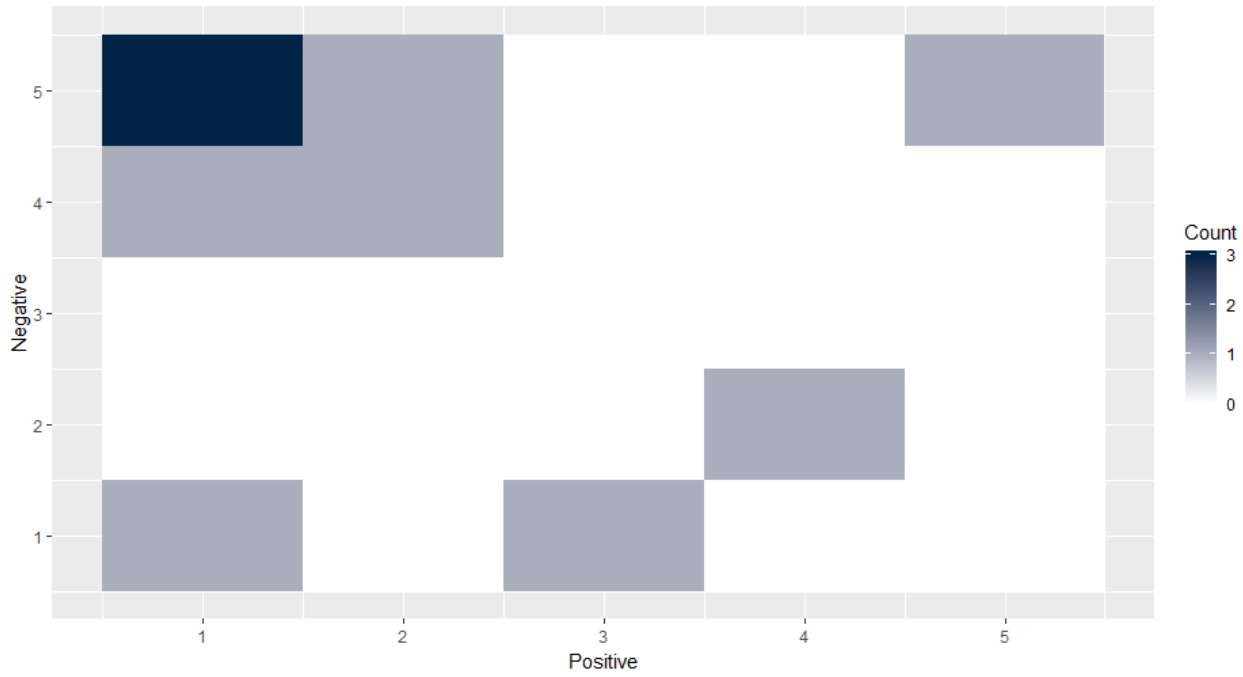


Page2Grid10: Heat Map - Grid Pilot March 2020



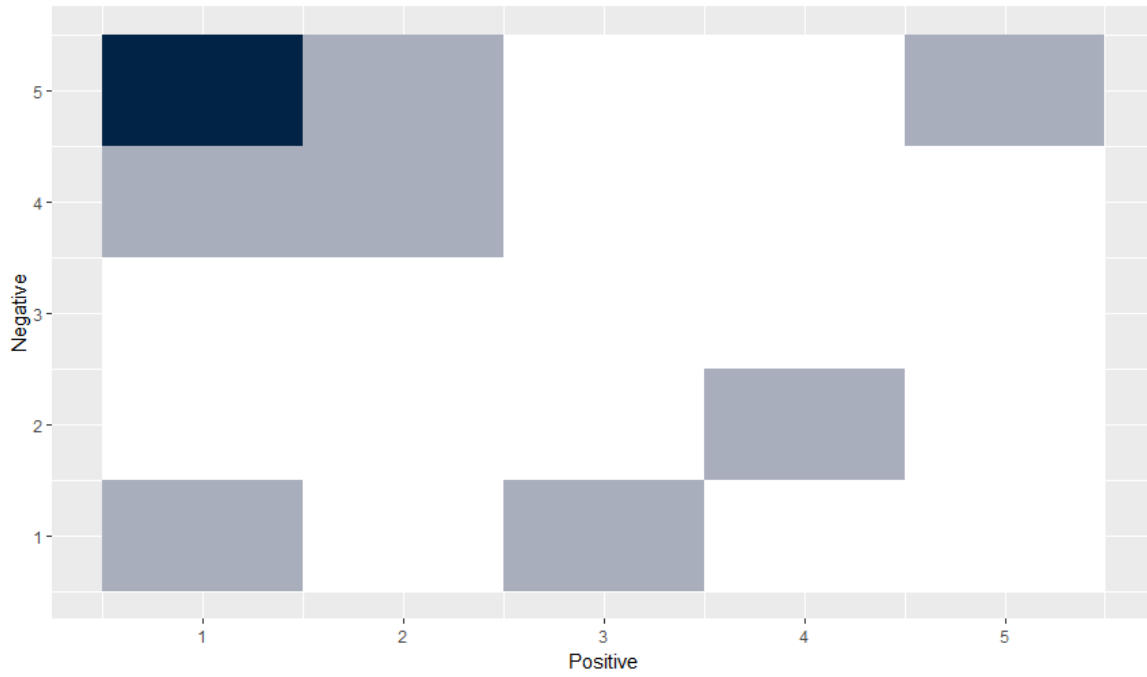
Group B Items 1-10 (Page 2)

Page5Grid1: Heat Map - Grid Pilot March 2020

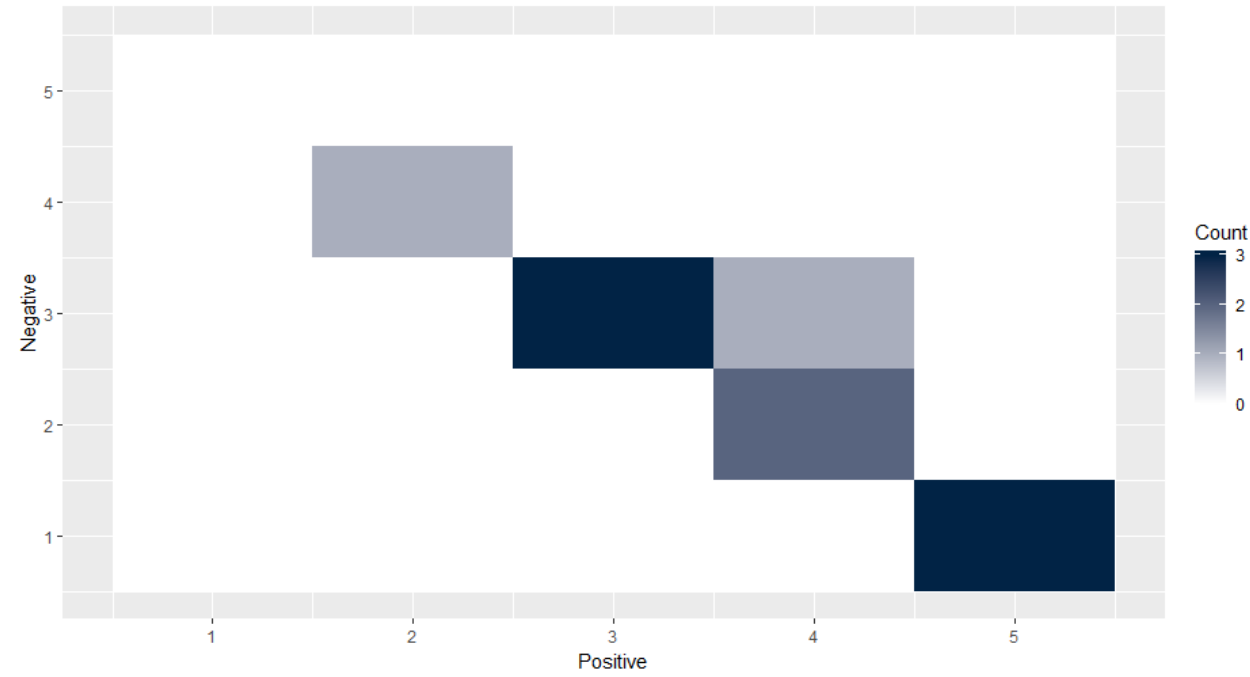


Group C Items 1-3 (Page 5)

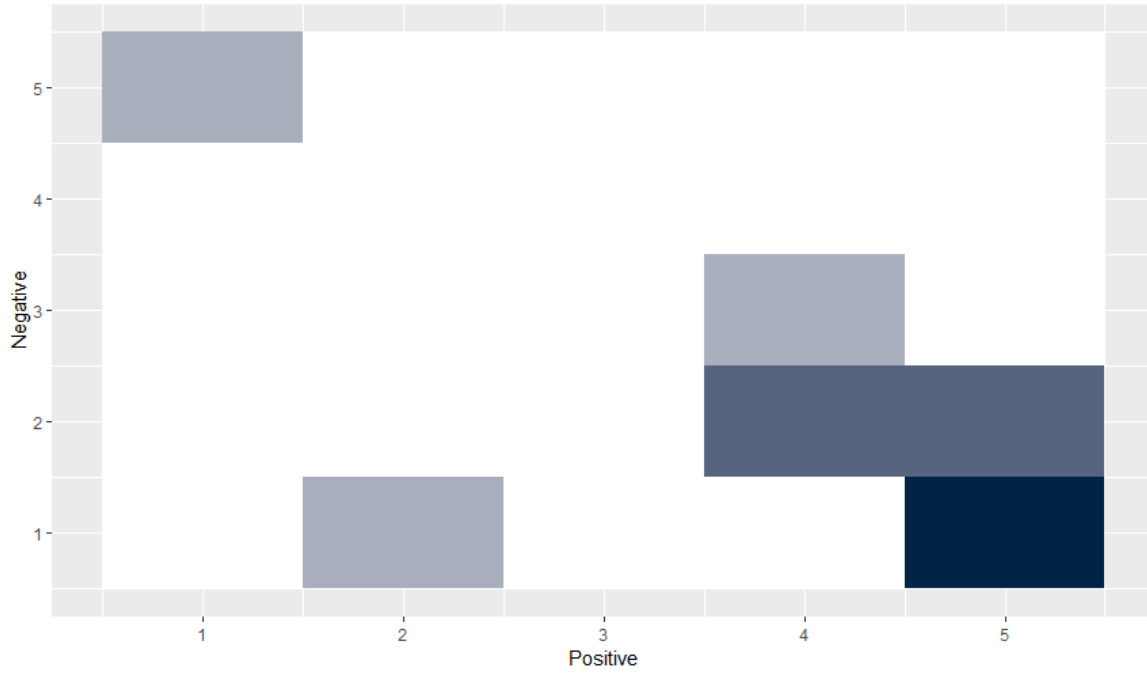
Page5Grid1: Heat Map - Grid Pilot March 2020



Page5Grid2: Heat Map - Grid Pilot March 2020



Page5Grid3: Heat Map - Grid Pilot March 2020



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)

**Group C Items 1-3 (Page 5)**

# 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

Questions?

Thank you!

# Challenges Assessing Statistics Attitudes

*Opportunities and Costs*

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- Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis*. New York: Springer.
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# Extra Slides

Challenges Assessing Statistics Attitudes

Whitaker – RCML 2020

# Selected SOMAS Papers and Presentations

## Student Instrument (S-SOMAS)

- Unfried, A., Kerby, A., & Coffin, S. (2018). Developing a Student Survey of Motivational Attitudes Toward Statistics. *2018 JSM Proceedings*. Presented at the Joint Statistical Meetings 2018, Vancouver, Canada.
- Whitaker, D., Unfried, A., & Batakci, L. (2018). A Framework and Survey for Measuring Students' Motivational Attitudes Toward Statistics. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July, 2018), Kyoto, Japan*. Retrieved from [http://iase-web.org/icots/10/proceedings/pdfs/ICOTS10\\_C200.pdf](http://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_C200.pdf)
- Whitaker, D., Unfried, A., & Bond, M. (2019). Design and Validation Arguments for the Student Survey Of Motivational Attitudes toward Statistics (S-SOMAS) Instrument. In J. D. Bostic, E. E. Krupa, & J. C. Shih (Eds.), *Assessment in Mathematics Education Contexts: Theoretical Frameworks and New Directions* (1st ed., pp. 120–146). New York, NY: Routledge.

## Instructor Instrument (I-SOMAS)

- Batakci, L., Bolon, W., & Bond, M. E. (2018). A Framework and Survey for Measuring Instructors' Motivational Attitudes Toward Statistics. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July, 2018), Kyoto, Japan*. Retrieved from [http://iase-web.org/icots/10/proceedings/pdfs/ICOTS10\\_4J3.pdf](http://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_4J3.pdf)

## Environment Instrument (E-SOMAS)

- Bond, M., Batakci, L., Bolon, W., & Whitaker, D. (2019, May). *Environment Matters: Institution and Course Characteristics and Pedagogy*. Poster presented at the United States Conference On Teaching Statistics (USCOTS) 2019, State College, PA.

# S-SOMAS: Pilot-0 Construct Groups

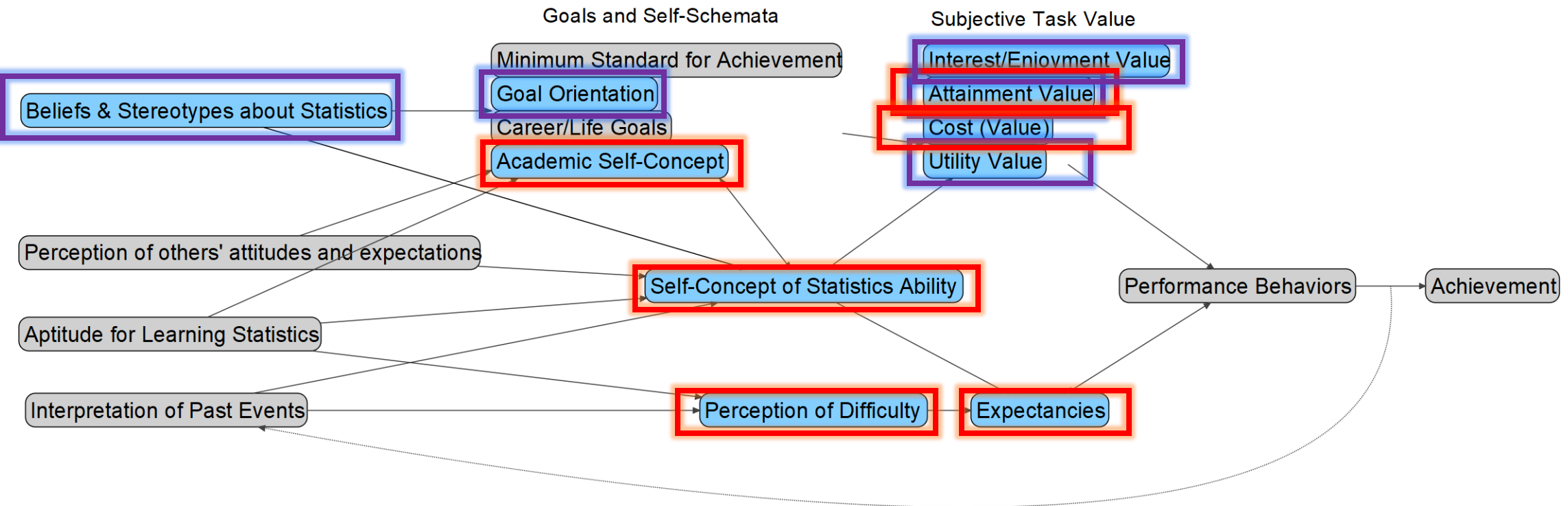
Based on Eccles' Expectancy-Value Theory (EVT)  
(e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)

Survey of Motivational Attitudes toward Statistics (SOMAS)

Student Expectancy-Value Theory Model

Assessed by the S-SOMAS instrument

Not assessed by the S-SOMAS instrument



# S-SOMAS Focus Group Results

What the focus group said:

What we said:

Group 1	Attainment Value	Beliefs/Stereotype	Extrinsic Motivation	Interest	Intrinsic Motivation	Utility Value	Total
Attainment Value	43%			29%	29%		100%
Beliefs/Stereotype		80%				20%	100%
Extrinsic Motivation	13%		88%				100%
Interest				100%			100%
Intrinsic Motivation	14%		29%		29%	29%	100%
Utility Value	25%	25%	25%			25%	100%

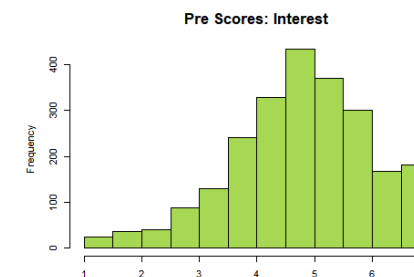
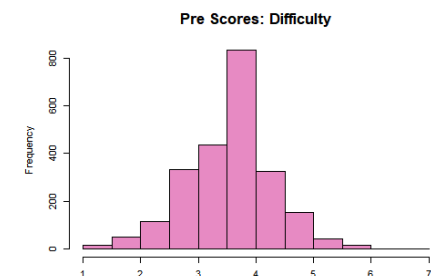
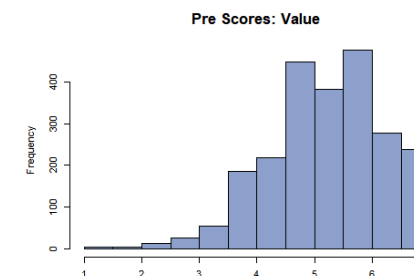
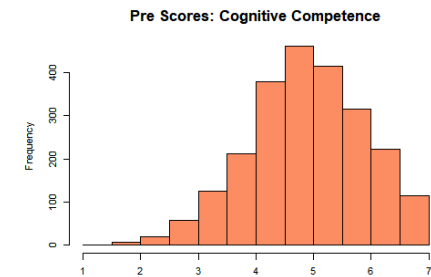
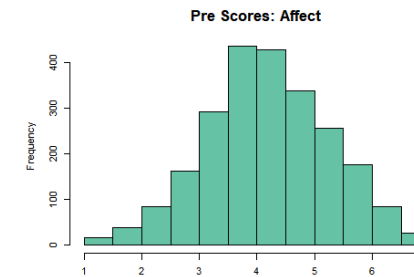
What the focus group said:

What we said:

Group 2	Academic Self-Concept	Attainment Value	Difficulty	Cost	Expectancy	Statistics Self-Concept	Total
Academic Self-Concept	22%	22%	22%	11%	11%	11%	100%
Attainment Value	14%	29%	14%	14%	14%	14%	100%
Difficulty	29%	43%		14%		14%	100%
Cost	29%	29%	14%	14%		14%	100%
Expectancy	18%	18%	9%	18%	18%	18%	100%
Statistics Self-Concept	44%	44%	11%				100%

# 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

**Theoretical**

**Empirical**

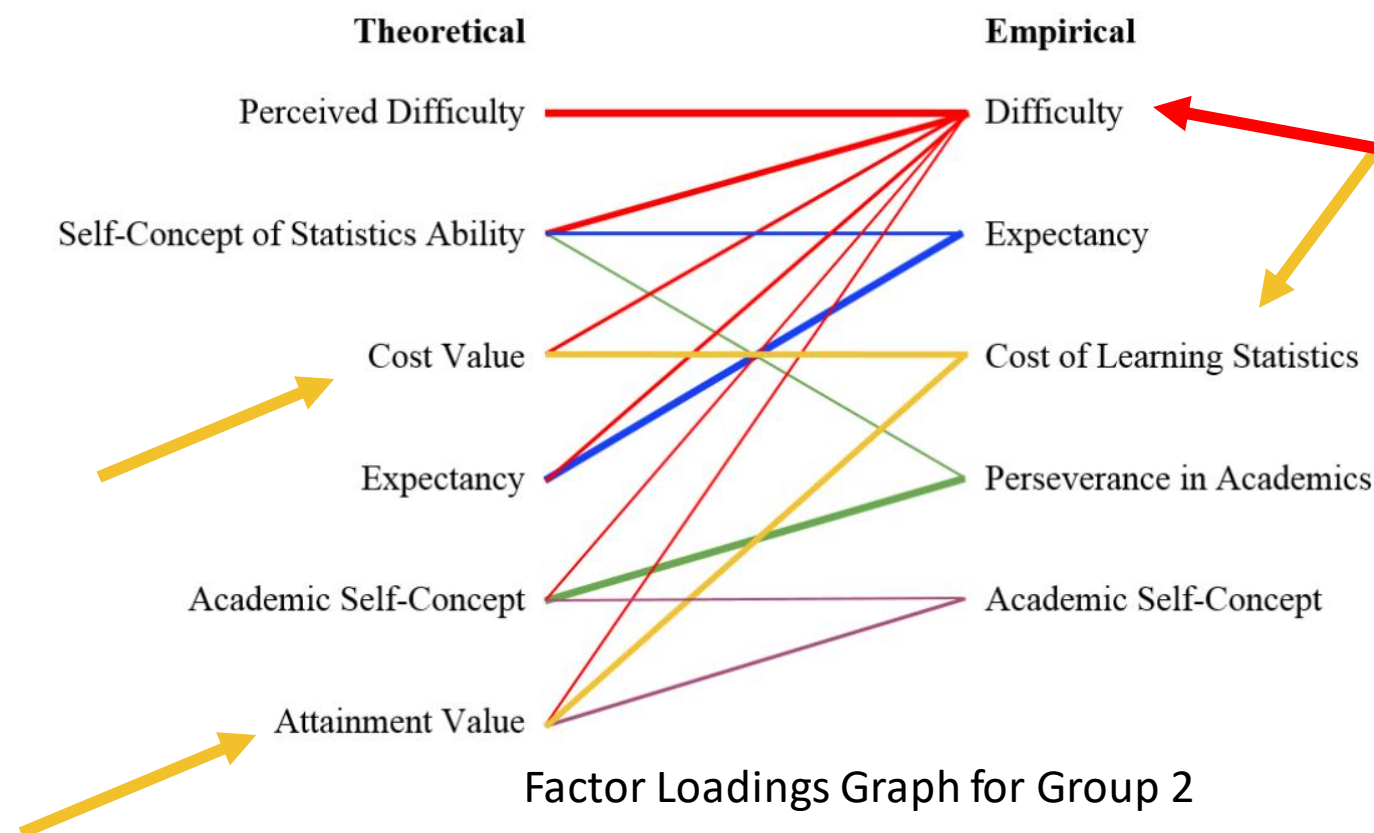


Factor Loadings Graph for Group 2

Unfried, A., Kerby, A., & Coffin, S. (2018). Developing a Student Survey of Motivational Attitudes Toward Statistics. *2018 JSM Proceedings*. Joint Statistical Meetings 2018, Vancouver, Canada.

# Motivation: difficulty measuring *Cost*

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



Unfried, A., Kerby, A., & Coffin, S. (2018). Developing a Student Survey of Motivational Attitudes Toward Statistics. *2018 JSM Proceedings*. Joint Statistical Meetings 2018, Vancouver, Canada.







# 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
  - Audrezet, A., Olsen, S. O., & Tudoran, A. A. (2016). The GRID scale: A new tool for measuring service mixed satisfaction. *Journal of Services Marketing*, 30(1), 29–47. <https://doi.org/10.1108/JSM-01-2015-0060>
- Right: Affect Grid
  - Figure 1, p. 494
  - Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect Grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology*, 57(3), 493–502. <https://doi.org/10.1037/0022-3514.57.3.493>



## Appendix 4

# Grid Classifications

Audrezet, A., Olsen, S. O., & Tudoran, A. A. (2016). The GRID scale: A new tool for measuring service mixed satisfaction. *Journal of Services Marketing*, 30(1), 29–47.  
<https://doi.org/10.1108/JSM-01-2015-0060>

**Figure A2** Delimitation of each evaluative category on the GRID scale and on the SD scale

