

Analyzing Survey Item Data

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SURVEY DATA

- Quantitative Data (not typical for surveys)
 - Age, income, height, weight
 - Counts of things (children, books, credits earned)
- Qualitative Data
 - Nominal Categories (gender, race, political affiliation, state of residence)
 - Ordered Categories (level of satisfaction or agreement, frequency of behaviors)
 - Descriptive Comments (open-ended responses)

STEVEN'S SCALES OF MEASUREMENT¹

- A classification of scales of measurement.
- Nominal, ordinal, interval, ratio.
- "...measurement, in the broadest sense, is defined as the assignment of numerals to objects or events according to rules. The fact that numerals can be assigned under different rules leads to different kinds of scales and different kinds of measurement."
- "...the statistical manipulations that can legitimately be applied to empirical data depend upon the type of scale against which the data are ordered."

QUANTITATIVE ANALYSIS OF QUALITATIVE DATA

- There is a tendency to use numeric labels as category labels or as option labels.

On a scale of 1 to 4, please indicate your level of satisfaction with the following services, where 1 is dissatisfied and 4 is satisfied.

Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Satisfied
1	2	3	4
①	②	③	④

SURVEY PURPOSES

- Collect background information on participants
- Collect information about experiences
- Measure attributes, like
 - Opinions
 - Attitudes
 - Traits
 - Behaviors
 - Beliefs and values

¹ Stevens, S.S. (1946). On the theory of scales of measurement. *Science*, 103, 677-680.

MEASURING ATTRIBUTES

- Continuity is a property of an attribute, not the measurements of that attribute.
 - e.g., Length is a continuous variable but measured in inches it is discrete.
- It is typical to measure continuous attributes in ordinal ways
 - e.g., rating scales for satisfaction, agreement, etc.
 - e.g., preference of one activity over another

PRINCIPLES:

- Use categorical methods for categorical data
- Use ordinal methods for ordinal data

HYPOTHESIS TESTS FOR CATEGORICAL VARIABLES

- Chi-Square Goodness-of-fit test (1 variable)
 - Equal or predetermined expected frequencies like population values or norms
 - Answers the question: Do our observed frequencies fit the expected frequencies?

Example: Is gender balanced?

Across our sample of 300, is there gender balanced, given sampling error?

Gender				Test Statistics	
	Observed N	Expected N	Residual		Gender
Male	138	150.0	-12.0	Chi-Square	1.920
Female	162	150.0	12.0	df	1
Total	300			Asymp. Sig.	.166

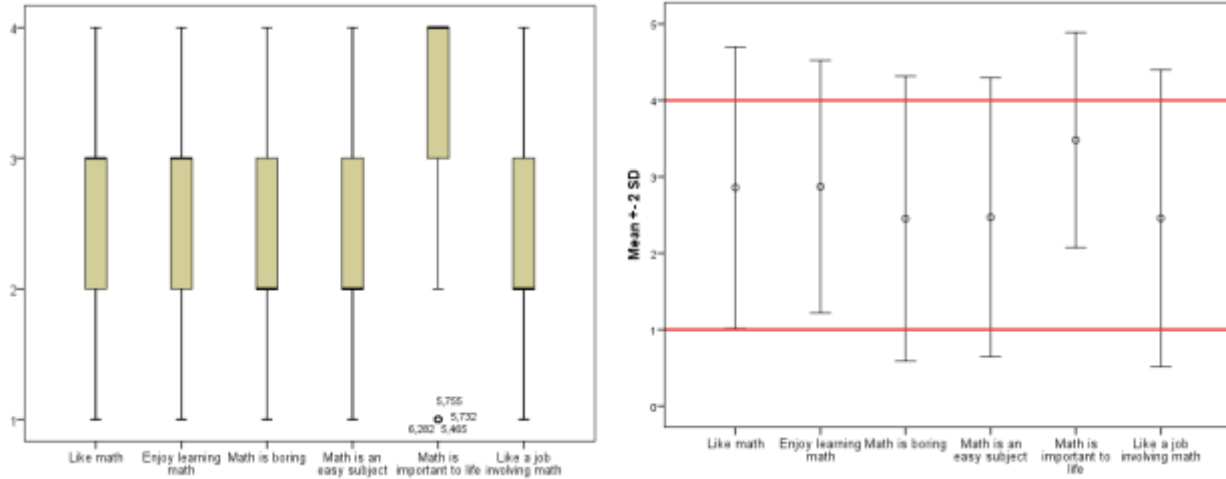
- Chi-Square Test of Independence (2 variables)
 - This is a similar test, where expected frequencies are calculated based on observed data. Null hypothesis is no association – equal frequencies of responses across categories.
 - Answers the question: Are two categorical variables independent (i.e., are they related)?
- Measures of Strength of Association
 - Phi coefficient (2x2 tables)
 - Cramér's phi (larger than 2x2 tables)

Example: SPSS analysis of 6 TIMSS middle school questions.

1=Strongly Disagree to 4=Strongly Agree

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Like mathematics	6847	1	4	2.86	.921
Enjoy learning math	6834	1	4	2.87	.827
Math is boring	6812	1	4	2.45	.932
Math is an easy subject	6796	1	4	2.47	.913
Math is important to life	6831	1	4	3.48	.704
Like a job involving math	6792	1	4	2.46	.971
Valid N (listwise)	6664				

INAPPROPRIATE DISPLAYS OF ORDINAL VARIABLE DISTRIBUTIONS:



APPROPRIATE DISPLAYS OF ORDINAL VARIABLE DISTRIBUTIONS:

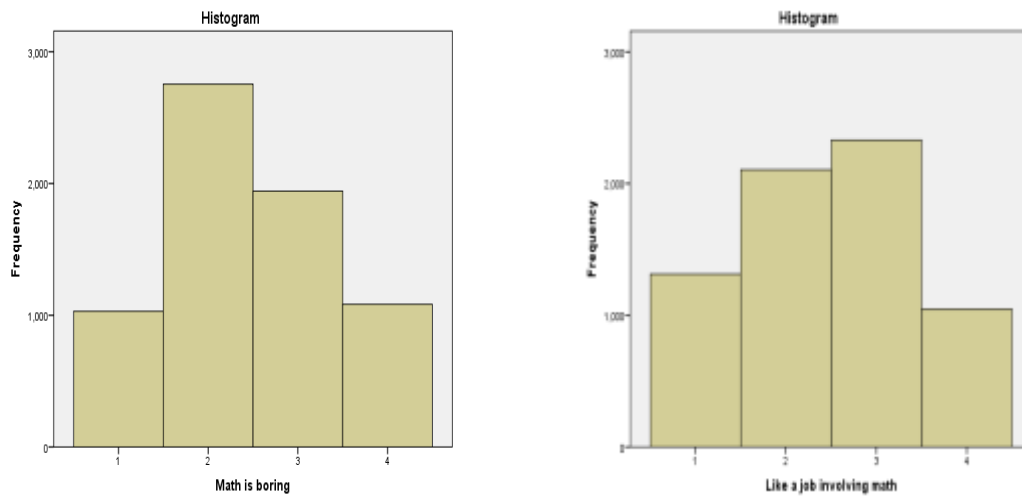


TABLE OF RESPONSE PERCENTAGES

	Strongly disagree	Disagree	Agree	Strongly agree
	Row %	Row %	Row %	Row %
Enjoy learning math	7	21	51	22
Math is boring	15	40	29	16
Math is an easy subject	15	38	33	14
Math is important to life	3	5	35	58
Like a job involving math	19	31	34	15

Is there an association between thinking math is boring and liking a job involving math?

Math is boring * Like a job involving math Crosstabulation

% within Math is boring

		Like a job involving math			
		Strongly disagree	Disagree	Agree	Strongly agree
Math is boring	Strongly disagree	12.1%	13.9%	34.8%	39.2%
	Disagree	7.6%	32.1%	44.4%	15.9%
	Agree	20.6%	41.6%	31.3%	6.5%
	Strongly agree	53.5%	25.5%	13.5%	7.5%

Cramér's phi magnitude of association = .29

PRINCIPLE:

- Estimate continuity from multiple indicators
- Measurement is more than counting or assigning numeric values. It requires a theory supporting an inference from an indicator (item) to the attribute or construct of interest.

BUILDING CONTINUOUS MEASURES

- Methods to build measures
 - Homogenous item sets
 - Exploratory factor analysis for item selection
 - e.g., attitudes, self-efficacy, school climate
 - Logical or rational selection
 - Theory and expert opinion for item selection
 - e.g., values assessment, moral development
 - Empirical criterion
 - Contrasting known groups for item selection
 - e.g., personality disorders

EXPLORATORY FACTOR ANALYSIS

- Factor analysis examines the inter-correlations of items, grouping items that are correlated as sets that are relatively uncorrelated with other sets of items.
- Technically done through finding weighted linear combinations of the items to explain variance in the items.
 - Factor Loadings
 - Variance Explained

- A **factor** is a homogenous set of related items
- A **loading** is a correlation between the item and factor (weighted linear combination of items)

Does the item contribute to the total factor?

- Loadings should be positive and relatively high (.40+); uniformly high for some purposes
- Each item contributes variance
- The total variance is the sum of the item variances
- Each factor accounts for variance from all items

Factor Matrix^a

	Factor
	1
Enjoy learning math	.859
Like mathematics	.841
Math is boring	-.659
Like a job involving math	.639
Math is an easy subject	.481
Math is important to life	.376

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 7 iterations required.

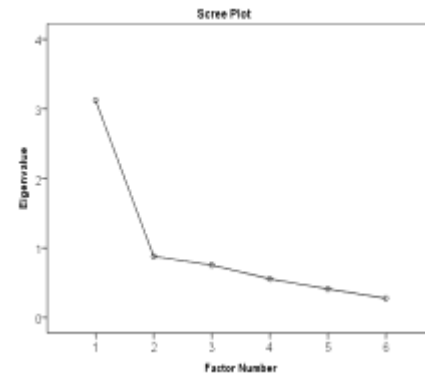
If the factor is an efficient summary of all of the items, it will explain a large percent of the total variance

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.123	52.052	52.052	2.662	44.369	44.369
2	.880	14.665	66.718			
3	.755	12.584	79.302			
4	.556	9.266	88.567			
5	.411	6.850	95.417			
6	.275	4.583	100.000			

Extraction Method: Principal Axis Factoring.

SCREE PLOT

- The scree plot provides a graphical guide to identify the efficient number of factors.



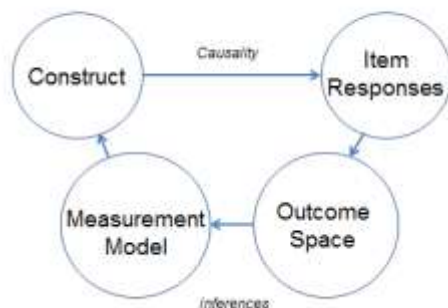
TESTING DIMENSIONALITY

- Exploratory Factor Analysis is useful to identify subsets of homogenous items – for item selection during instrument development.
- EFA does not provide a test of dimensionality.
 - Similarly coefficient alpha is **not** evidence of dimensionality. It assumes dimensionality.
- Confirmatory Factor Analysis is needed to test dimensionality, which provides a formal test of model-data fit. Does a specific dimensional structure (model) fit the data (observations)?

MEASUREMENT MODEL²

- When we need to make inferences about the underlying trait based on observable responses to items, we must employ a measurement model.
- Counting responses is not a measurement model.

From Construct to Item Responses

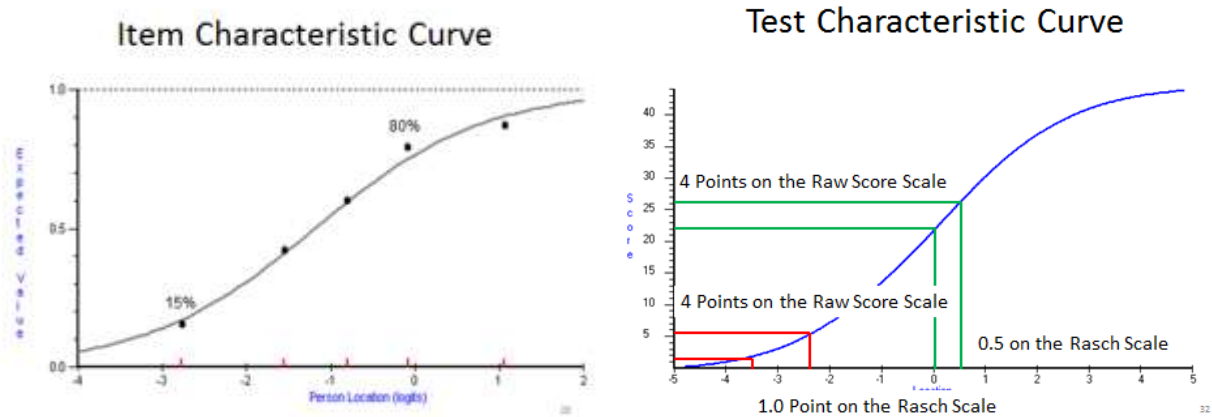


Source: Mark Wilson, 2005

² Wilson, M. (2005). *Constructing measures: An item response modeling approach*. Mahwah, NJ: Erlbaum.

RASCH PHILOSOPHY

- Although it is not uncommon to treat total scores directly as measurements, they are actually counts of discrete observations rather than measurement
- Rasch is an approach that is based on the paradigm of constructing a measure which can characterize a construct on a linear scale



FROM NUMBERS TO MEANING

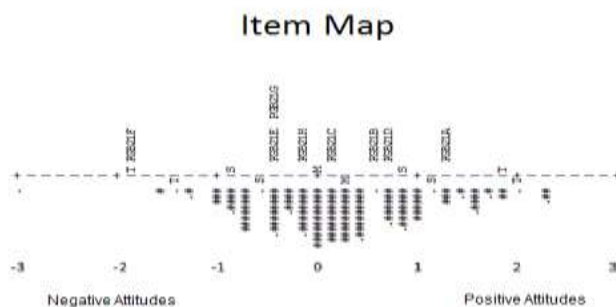
- Numbers themselves do not mean much.
 - Is 10 meters a short distance? Long distance?
- We need context to bring meaning to the measure:
10 meters is a long distance to a caterpillar.
But it's always 10 meters no matter who measures it.

SAMPLE DEPENDENT STATISTICS

- respondents easy to endorse?
 ... 90% endorsed the opinion
- Is a person who endorses 3 out of 10 opinions low on that attitude?
 ... endorsed 30% of the opinions

RASCH SCALING

- Person-free item location
 - Locates the items on the trait (attitude) continuum
- Item-free person trait level
 - Locates the person on the trait (attitude) continuum
 - Places items and persons on the same scale – the ITEM MAP



CONSTRUCT MAP

1. Explains the construct; provides an interpretation guide
2. Enables design of items that will lead persons to give responses that inform important levels of the construct map; identify relevant item features

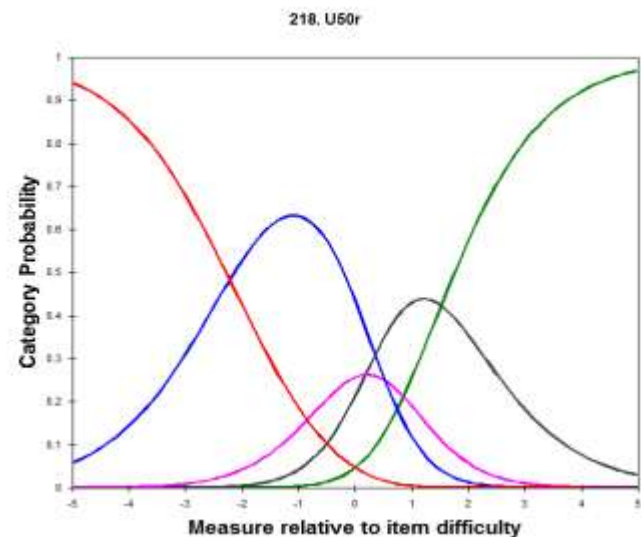
PRINCIPLE:

- Evaluate the functioning of scale properties
- We can ask questions about the response scale:
Does the 5-point scale work as interpreted?
Do we need 5 response points?

MENTAL DISTRESS ITEM U50

During the last 30 days, have you felt you were under any stress or pressure?

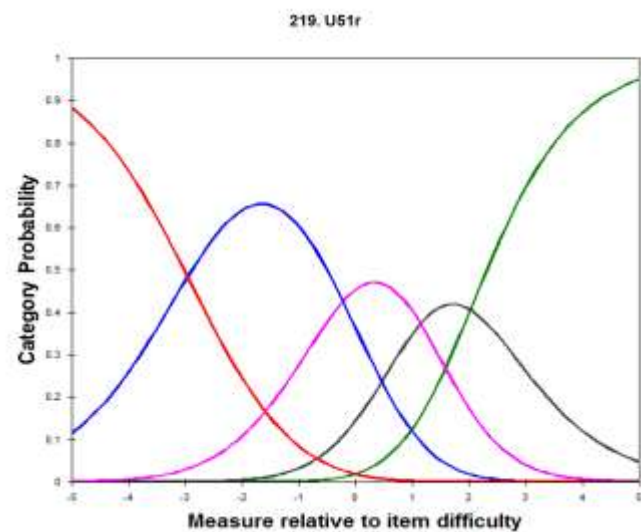
- ☐ Yes, almost more than I could take
- ☐ Yes, quite a bit of pressure
- ☐ Yes, more than usual
- ☐ Yes, a little
- ☐ No



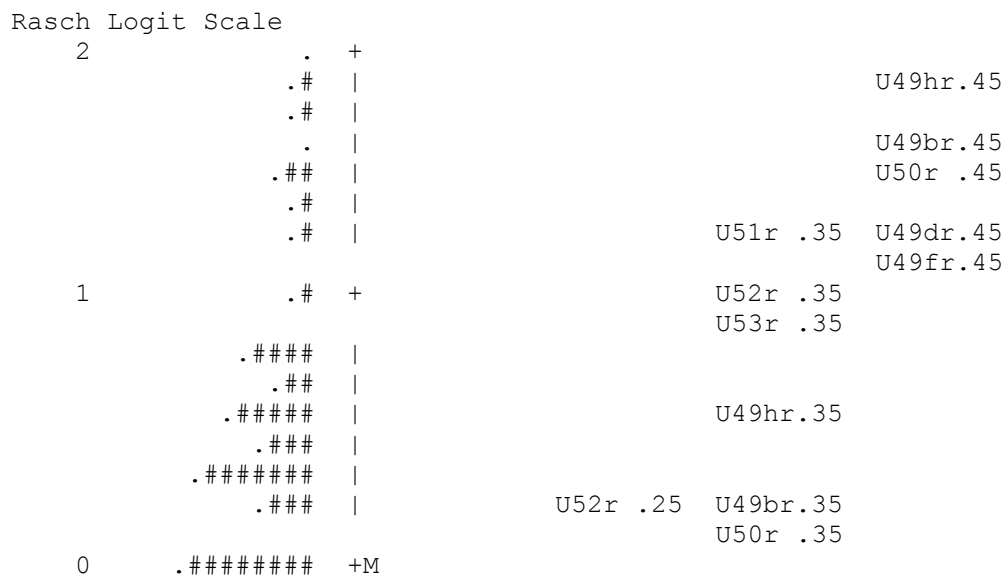
MENTAL DISTRESS ITEM U51

During the last 30 days, have you felt sad?

- ☐ All the time
- ☐ Most of the time
- ☐ Some of the time
- ☐ A little of the time
- ☐ None of the time



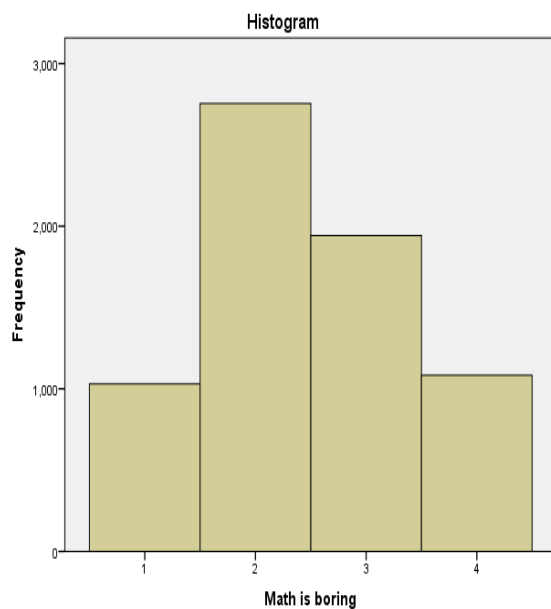
ITEM MAP – THRESHOLDS



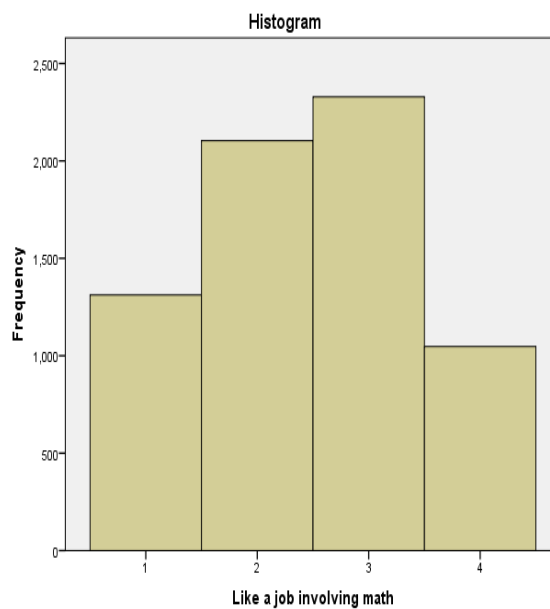
OTHER POSSIBLE ANALYSIS

- Differential Item Functioning
 - Group difference, conditioned on trait level
 - Form of measurement invariance; item bias
- Equating over time
 - Constant score scale location over time
 - Keep item parameters and fix item locations
 - Examine parameter drift over time

RETURNING TO TIMSS LIKING MATH...



Mean = 2.45
Rasch = 0.40



Mean = 2.46
Rasch = 0.60

ORDERING OF ITEMS BY...

Ordering of Items by...

Item Mean	Rasch location
Math is important	Math is important
Enjoy learning math	Enjoy learning math
Like math	Like math
Math is easy	Math is boring
Like a job involving math	Math is easy
Math is boring	Like a job involving math



Stronger
Agreement

