UNIVERSIDADE SÃO FRANCISCO

UIUC Quant Brownbag

Revealing Deep Psychological Insights and Scientific Laws Through Representational Measurement Theory

$$\mathfrak{A} = (A, R, O)$$
$$\mathfrak{B} = (Re, \Delta, \vartheta)$$
$$(\mathfrak{A}, \mathfrak{B}, \mathbb{F})$$

Meeting: 30/10/2024

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What is a measurement?

Stevens (1946)

> *"is defined as the assignment of numerals to objects and events according to rules"*
>
> "*the assignment can be any consistent rule. The only rule not allowed would be random assignment, for randomness amounts in effect to a nonrule*"

The problem: Stevens had an operationalist perspective, Where the operation defines the measure

Stevens, S. S. (1946). On the theory of scales of measurement. *Science*, *103*(2684), 677-680. https://doi.org/10.1126/science.103.2684.677

Is it possible to test the measurement level of an observation?

The operationalist view is still strong in psychology:

If the psychometric model assumes a continuous latent variable, than this is true (Michell, 2008)

If we ask respondents to provide a subjective ratio of a continuous quantity, than the response is also a ratio (Narens, 1996)

And others

Michell, J. (2008). Is psychometrics pathological science? *Measurement, 6*(1-2), 7-24.. https://doi.org/10.1080/15366360802035489

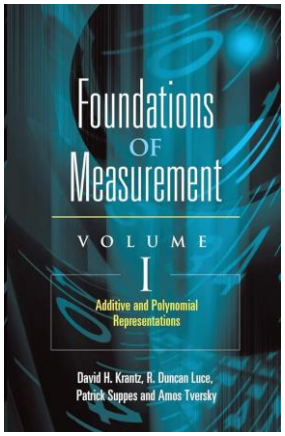
Narens, L. (1996). A theory of ratio magnitude estimation. *Journal of Mathematical Psychology, 40*(2), 109-129. https://doi.org/10.1006/jmps.1996.0011

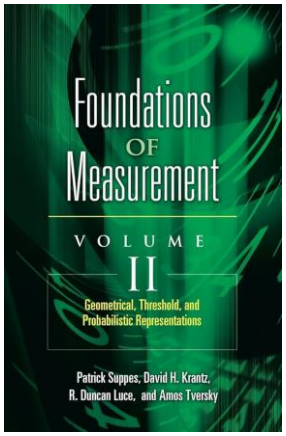
A Possible Solution: RMT

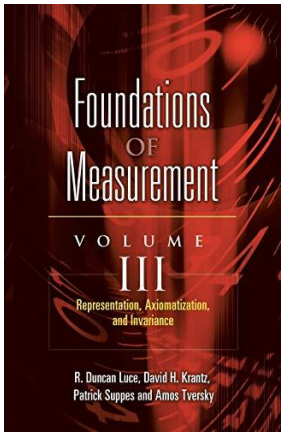
Representational Measurement Theory:

> "*A measurement is defined as the assignment of numerals to objects and events according to* ***empirically testable laws*** *about the attribute*"

RMT says that the qualitative data structure, depending on its complexity, can be related to different types of measure



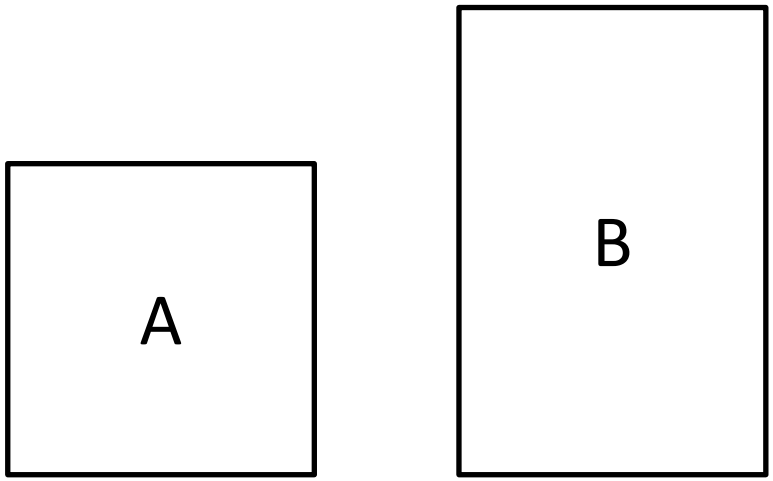




Measurement Axioms

Empirical entities can be related to abstract mathematical objects

Which is bigger?



One can answer:

"B is bigger than A"

Or simply write:

"$B \succ A$"

Or, if we know the actual measure f of the areas:

"$f(B) > f(A)$"

Measurement Axioms

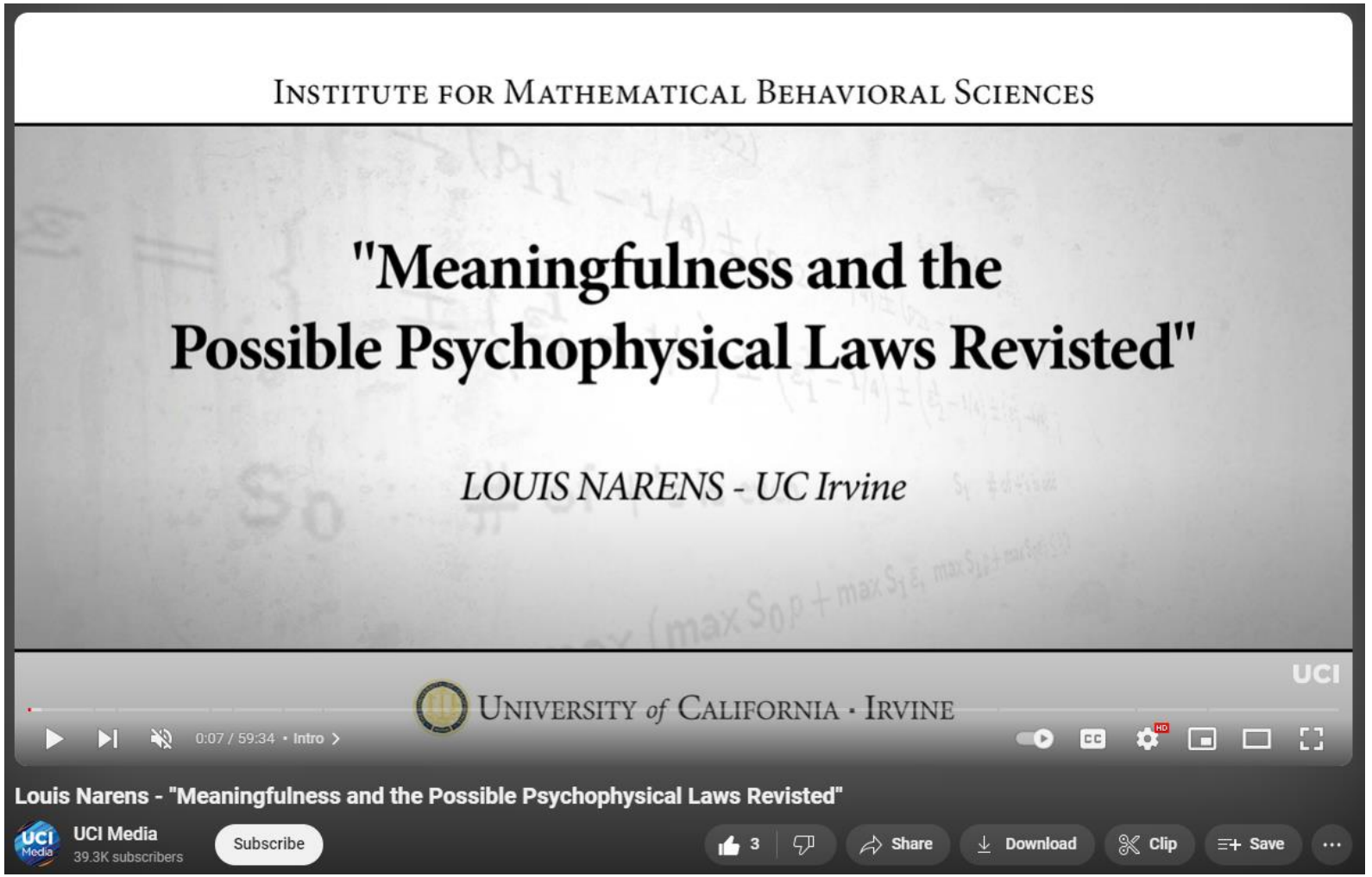
Empirical entities can be related to abstract mathematical objects

- We can perform abstract operations with these mathematical objects and study what the consequences are

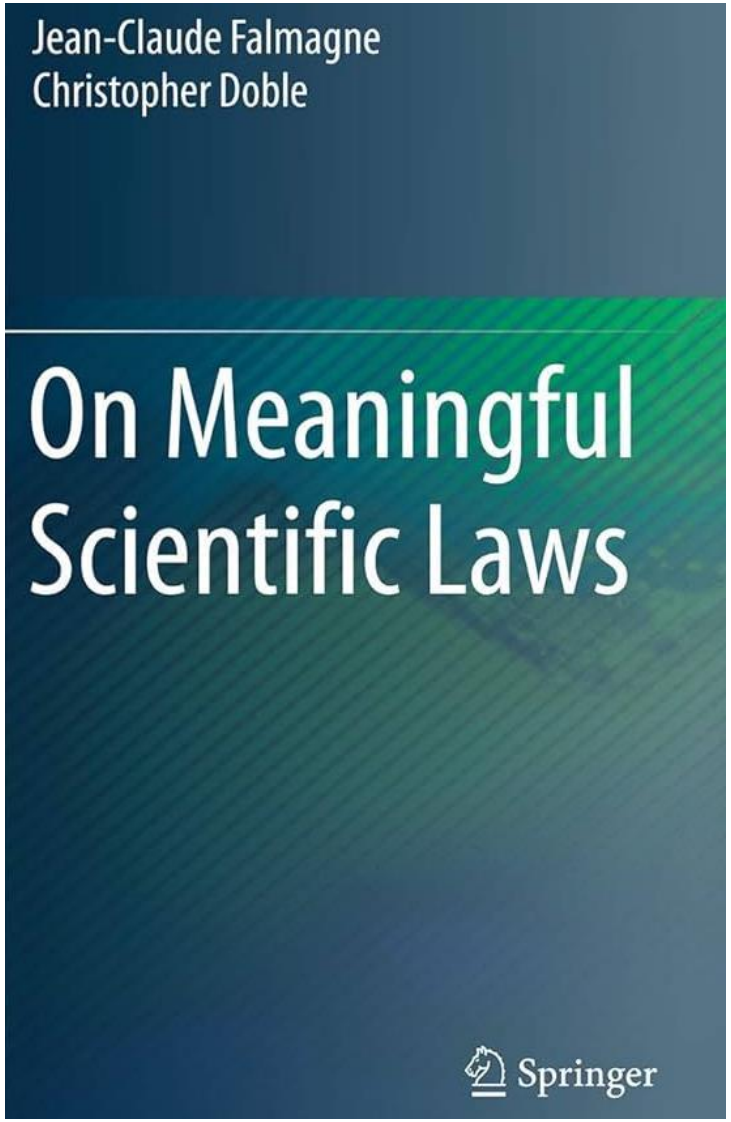
Therefore, RMT is an analytical tool to assess if and how the given data structure can be represented by a numerical system

- If a data structure is isomorphic to a numerical system, we say a representation exist
- The number of properties holding between the empirical and numerical system determine the measurement level (i.e., the uniqueness of the numerical representation)

Meaningfulness



Meaningfulness



"The mathematical expression of a scientific or geometric law typically does not depend on the units of measurement."

The specific measure should not matter.

Meaningfulness

Registered report

https://doi.org/10.1038/s41467-024-51685-z

Testing the convergent validity, domain generality, and temporal stability of selected measures of people's tendency to explore

Received: 23 June 2021

Accepted: 14 August 2024

Published online: 04 September 2024

Check for updates

Farid Anvari[1,2,3,4], Stephan Billinger[2], Pantelis P. Analytis[2], Vithor Rosa Franco[5] & Davide Marchiori[2]

Given the ubiquity of exploration in everyday life, researchers from many disciplines have developed methods to measure exploratory behaviour. There are therefore many ways to quantify and measure exploration. However, it remains unclear whether the different measures (i) have convergent validity relative to one another, (ii) capture a domain general tendency, and (iii) capture a tendency that is stable across time. In a sample of 678 participants, we found very little evidence of convergent validity for the behavioural measures (Hypothesis 1); most of the behavioural measures lacked sufficient convergent validity with one another or with the self-reports. In psychometric modelling analyses, we could not identify a good fitting model with an assumed general tendency to explore (Hypothesis 2); the best fitting model suggested that the different behavioural measures capture behaviours that are specific to the tasks. In a subsample of 254 participants who completed the study a second time, we found that the measures had stability across an 1 month timespan (Hypothesis 3). Therefore, although there were stable individual differences in how people approached each task across time, there was no generalizability across tasks, and drawing broad conclusions about exploratory behaviour from studies using these tasks may be problematic. The Stage 1 protocol for this Registered Report was accepted in principle on 2nd December 2022 https://doi.org/10.6084/m9.figshare.21717407.v1. The protocol, as accepted by the journal, can be found at https://doi.org/10.17605/OSF.IO/64QJU.

“Why should I care?”

Answer 0: Just to be aware about hidden assumptions

How to Think Straight About Psychometrics: Improving Measurement by Identifying its Assumptions

Víthor Rosa Franco[1] · Jacob Arie Laros[2] · Marie Wiberg[3] · Rafael Valdece Sousa Bastos[1]

Accepted: 4 April 2022 / Published online: 29 April 2022

Abstract

The aim of the current study is to introduce three assumptions common to psychometric theory and psychometric practice, and to show how alternatives to traditional psychometric approaches can be used to improve psychological measurement. These alternatives are developed by adapting each of these three assumptions. The assumption of structural validity relates to the implementation of mathematical models. The process assumption regards the underlying process generating the observed data. The construct assumption implies that the observed data on its own do not constitute a measurement, but the latent variable that originates the observed data. Nonparametric item response modeling and cognitive psychometric modeling are presented as alternatives for relaxing the first two assumptions, respectively. Network psychometrics is the alternative for relaxing the third assumption. Final remarks sum up the most important conclusions of the study.

https://doi.org/10.1007/s43076-022-00183-6

Answer 1: New Method = New Science

There Is Nothing So Theoretical as a Good Method

Perspectives on Psychological Science
7(2) 99–108

DOI: 10.1177/1745691611434210
http://pps.sagepub.com
SAGE

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Abstract

This article documents two facts that are provocative in juxtaposition. First: There is multidecade durability of theory controversies in psychology, demonstrated here in the subdisciplines of cognitive and social psychology. Second: There is a much greater frequency of Nobel science awards for contributions to method than for contributions to theory, shown here in an analysis of the last two decades of Nobel awards in physics, chemistry, and medicine. The available documentation of Nobel awards reveals two forms of method–theory synergy: (a) existing theories were often essential in enabling development of awarded methods, and (b) award-receiving methods often generated previously inconceivable data, which in turn inspired previously inconceivable theories. It is easy to find illustrations of these same synergies also in psychology. Perhaps greater recognition of the value of method in advancing theory can help to achieve resolutions of psychology's persistent theory controversies.

Keywords

method, theory, crucial experiments, Nobel Prizes

Answer 2: There are already some alternatives

Situational Optimization Function Analysis: An Ideal Performance Analysis Inspired on Lewin's Equation

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[3] Institute of Psychology, University of Brasília

Abstract

This study presents the situational optimization function analysis (SOFA) and has three aims. First, to develop a Bayesian implementation of SOFA. Second, to compare this implementation with three other maximum likelihood-based models in their accuracy to estimate true scores. The third aim is to show how joint modeling can be used for validity research. A simulation study was used to examine the second aim, while an empirical example was used to illustrate the third aim. The simulation study used three data generating processes, with varying degrees of deviation from linear models and with different sample sizes. Results of the simulation study showed that the Bayesian implementation supersedes the other models. In the empirical example, data collected from 66 participants using an iterated prisoner dilemma and a scale measuring cooperation-competition attitudes were used. Results showed that joint modeling is the best fitting model, also increasing the correlation between the true scores of both measures (deviations from the iterated prisoner dilemma and the scale). Finally, implications, limitations and future studies are discussed.

https://psycnet.apa.org/doi/10.1037/met0000319

Answer 2: There are already some alternatives

A Tutorial on Unidimensional Unfolding:

From Automatic Item Generation to Insightful Inferences

Short title: Complete tutorial on Unidimensional Unfolding

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https://doi.org/10.31234/osf.io/5hnkz

Answer 2: There are already some alternatives

Improved Measures with the Experimental Psychometrics Framework

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Should be published as a preprint soon ☺

In its current version, I show two applications:

Are 4-tuples of items evaluated additively or non-additively?

Results indicate that individuals respond differently

Are ratio responses equivalente to actual ratios?

Results indicate that ratio responses are actually in a log-interval level

Answer 2: There are already some alternatives

PSYCHOMETRIKA—VOL. 79, NO. 1, 1–19
JANUARY 2014
DOI: 10.1007/S11336-013-9342-4

Psychometric Society

EVALUATING THE EQUAL-INTERVAL HYPOTHESIS WITH TEST SCORE SCALES

BEN DOMINGUE

INSTITUTE OF BEHAVIORAL SCIENCE, UNIVERSITY OF COLORADO BOULDER

The axioms of additive conjoint measurement provide a means of testing the hypothesis that testing data can be placed onto a scale with equal-interval properties. However, the axioms are difficult to verify given that item responses may be subject to measurement error. A Bayesian method exists for imposing order restrictions from additive conjoint measurement while estimating the probability of a correct response. In this study an improved version of that methodology is evaluated via simulation. The approach is then applied to data from a reading assessment intentionally designed to support an equal-interval scaling.

Key words: conjoint measurement, Rasch model, interval scale.

https://doi.org/10.1007/s11336-013-9342-4

Final Remarks

Bandura (2001): *"Scientific advances can be achieved by two types of theories: those that simply seek to identify correlations between observable events without regard to linking mechanisms; and those that specify the mechanisms governing the relations between observable events."*

Barrett (2008): *"if we are to generate progress in our science, increasingly sophisticated methods of statistical data-model analysis are not going to help."*

"You don't have to be a mathematician to have a feel for numbers"
John Nash

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*(1), 1-26. https://doi.org/10.1146/annurev.psych.52.1.1

Barrett, P. (2008). The consequence of sustaining a pathology: scientific stagnation—a commentary on the target article "Is psychometrics a pathological science?" by Joel Michell. *Measurement: Interdisciplinary Research and Perspectives, 6*(1-2), 78-83. https://doi.org/10.1080/15366360802035521

Questions?