



University of
Zurich^{UZH}

University Division/Office

Introduction to Rasch Measurement

Psychologische Institut für psychologische Methodenlehre, Evaluation und Statistik

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What is measurement?

Main ideas of measurement

What are the main ideas of measurement?

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- **Objects** have **properties** that can be thought in terms of more or less, larger or smaller, stronger or weaker – example?

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- This **manifestation** can be mapped onto a **scale** – example?

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- This **property** can be measured through its **manifestation** – example?
- This **manifestation** can be mapped onto a **scale** – example?
- **Measurement** can have some **error** involved, and may not be perfectly precise – example?

Main ideas of measurement

Scale types with their properties according to Stanley Smith Stevens				
	Nominal scale	Ordinal scale	Interval scale	Ratio scale
Logical/ math operations	\times	\times	\times	✓
	$+$	\times	✓	✓
	$-$	\times	✓	✓
	\wedge	✓	✓	✓
	\vee	✓	✓	✓
	\equiv	✓	✓	✓

Main ideas of measurement

Scale examples

What are some examples of each type of scale?

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- Interval scale: 0=0°C, 1=1°C, 2=2°C

Main ideas of measurement

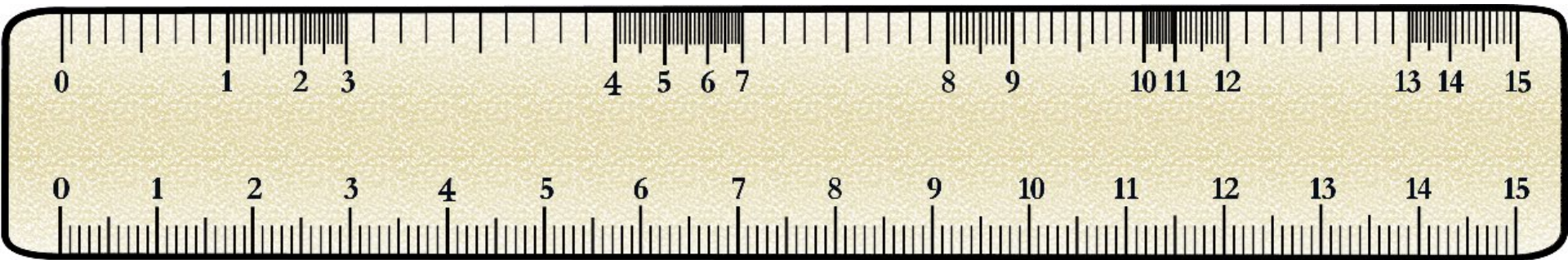
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- Ordinal scale: 0=Never, 1=Sometimes, 2=Often
- Interval scale: 0=0°C, 1=1°C, 2=2°C
- Ratio scale: 0=0cm, 1=1cm, 2=2cm

Our goal

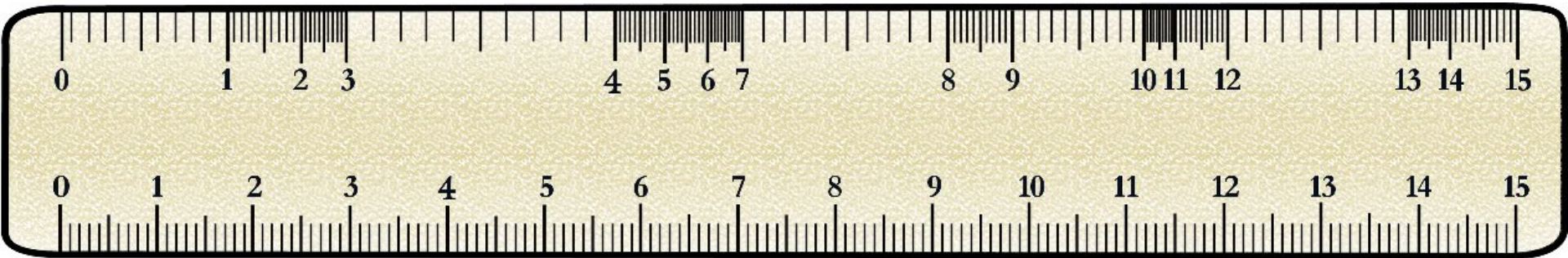
Going from ordinal...



...to interval

Our goal

Going from ordinal...

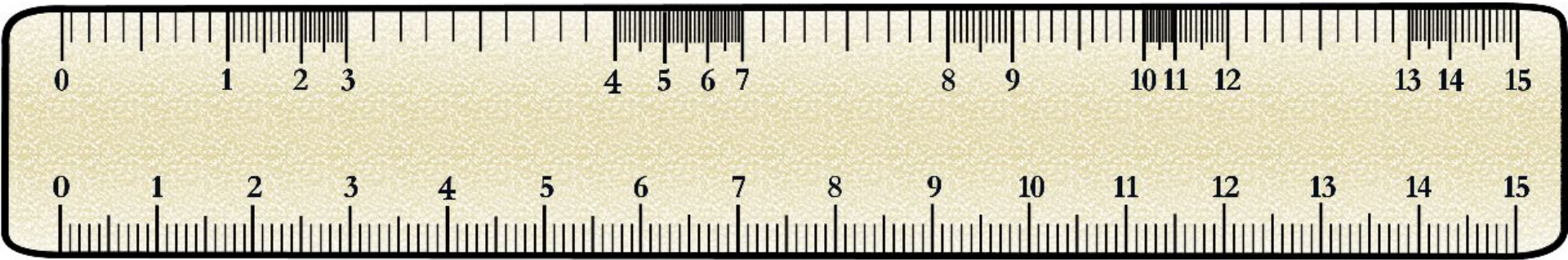


...to interval

How?

Our goal

Going from ordinal...



...to interval

with psychometrics

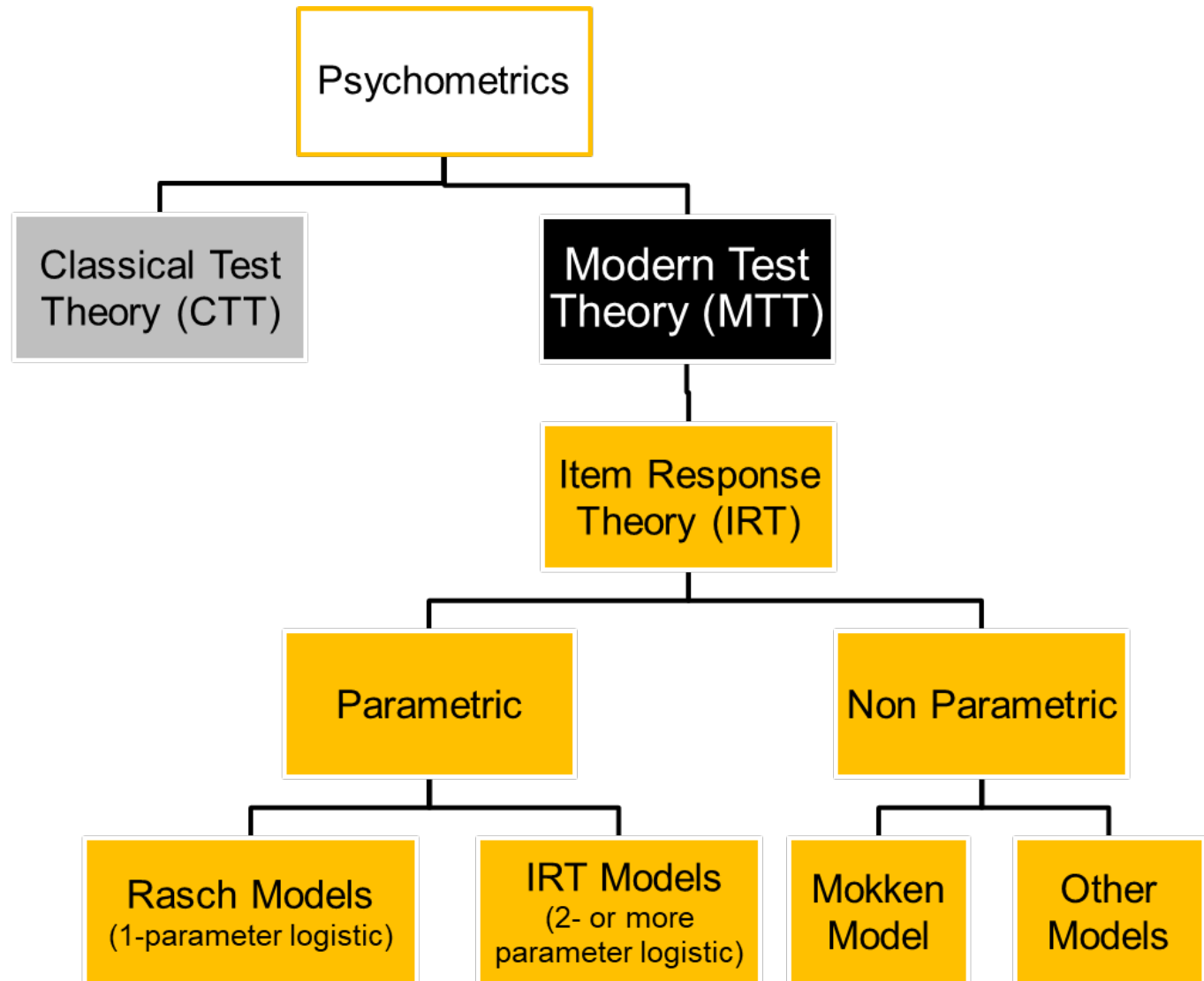
Psychometrics

Psychometrics is understood as the field of study concerned with the theory and technique of psychological measurement including the measurement of knowledge, abilities, attitudes, and personality traits. The field is primarily concerned with the study of differences between individuals.

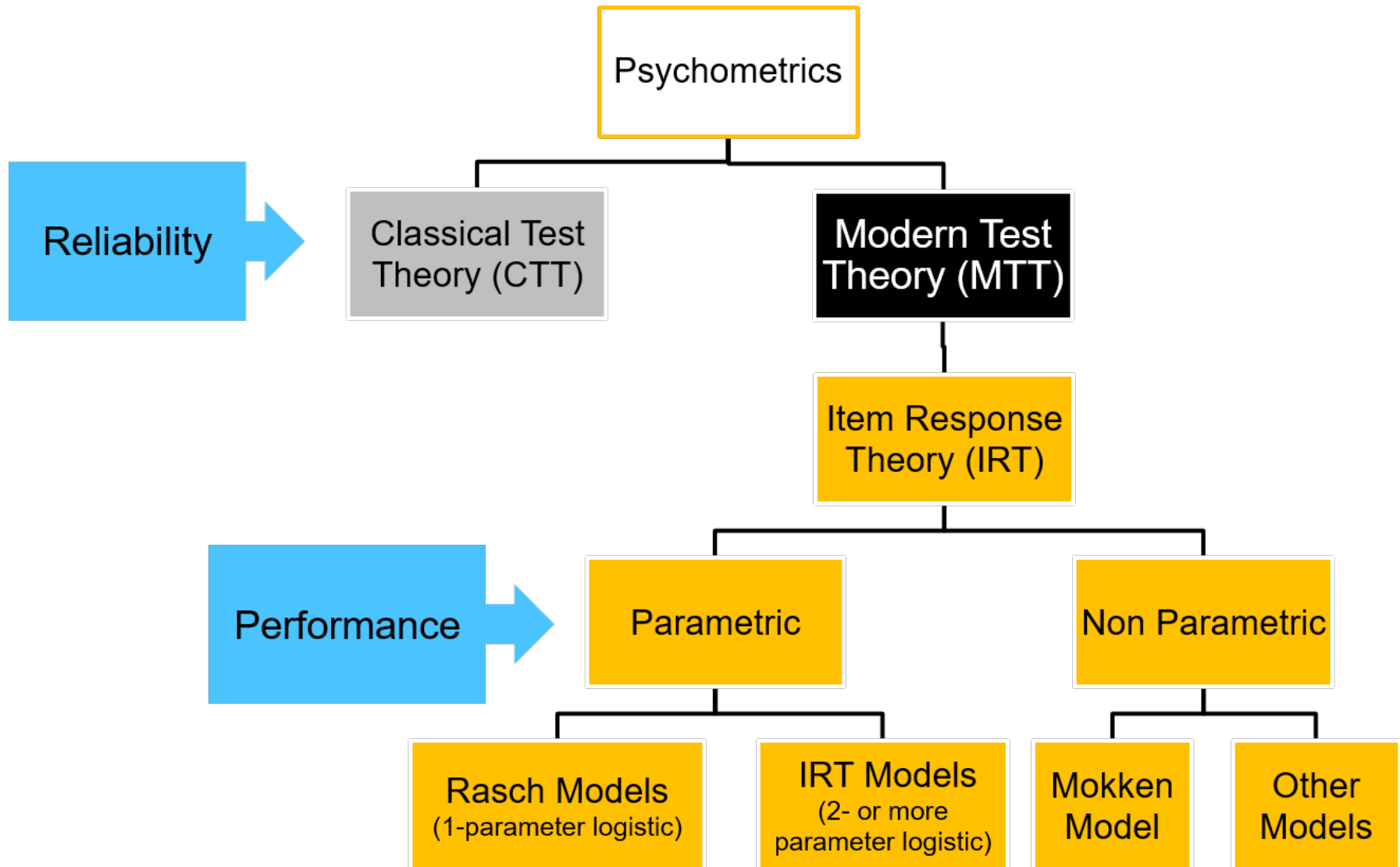
It involves two major research tasks:

- (i) the **construction** of instruments and procedures for measurement; and
- (ii) the **development and refinement of theoretical approaches** to measurement

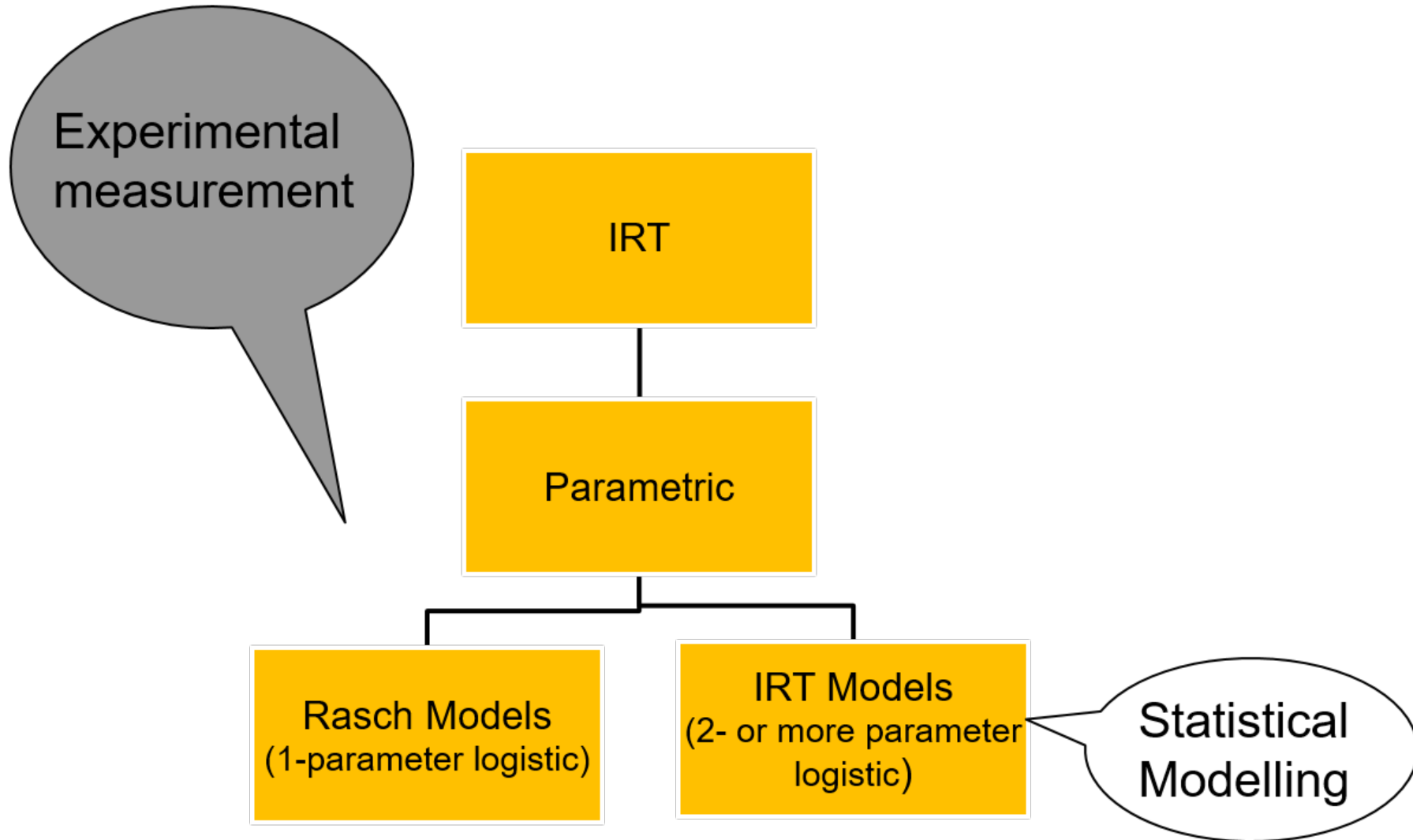
Psychometrics



Psychometrics



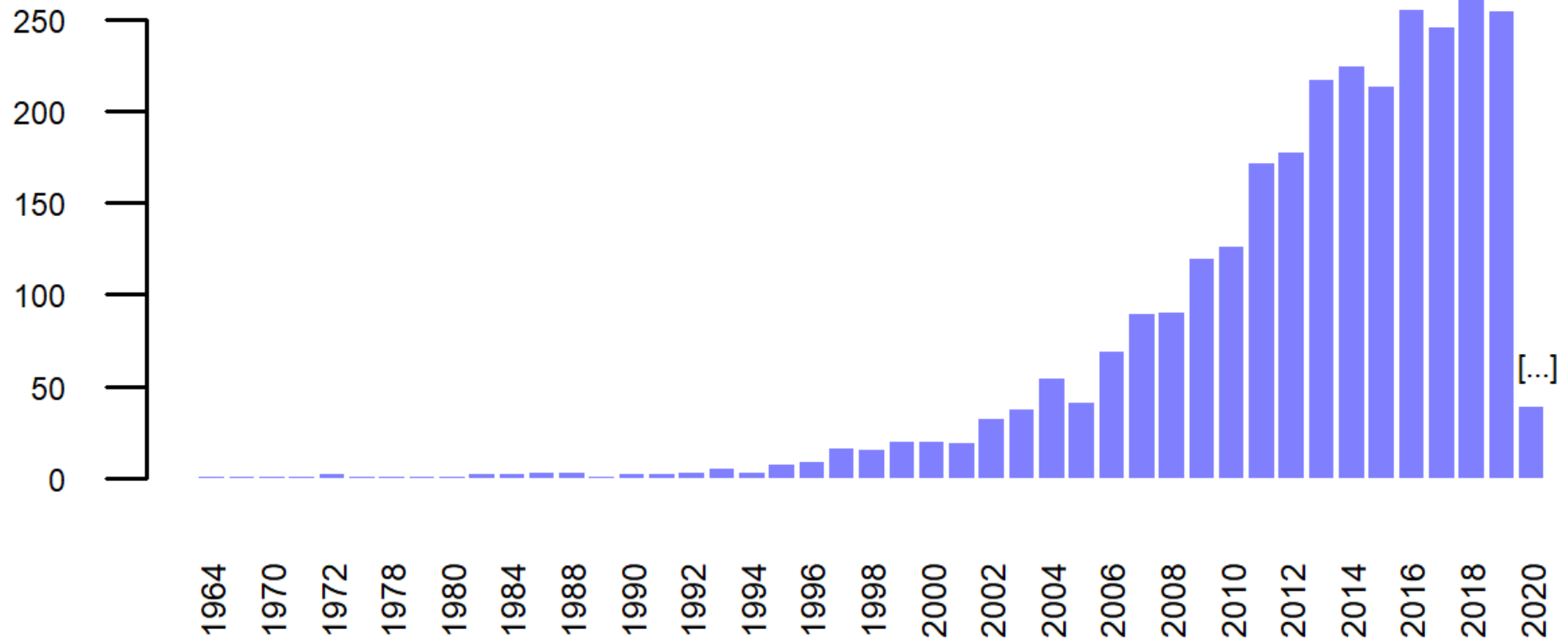
Two Competing Paradigms



Rasch Analysis: What is that?

- This statistical method is named after the Danish Mathematician George Rasch who developed it²
- Statistical method from the field of modern/probabilistic test theory.
- Rasch analysis is mainly used to determine metric properties of questionnaires.
- It is widely used and especially in the fields of educational, psychological, and health assessment.
- Once fit to the Rasch model is established a score is considered interval scaled and a sufficient statistic for measurement and parametric analysis.

Rasch-Publications per Year (N = 2855)



Pubmed search on Feb 2020:

<https://pubmed.ncbi.nlm.nih.gov/>

(Rasch Analysis) AND (Psychometry OR Test Theory OR Methods)

Before the Rasch model :

L.L. Thurstone (1887 - 1955)

Universal characteristics of measurement

- A scale must **transcend** the group measured (1928)
- The measurement of any object or entity describes **only one attribute** of the object measured (1931).
- A unit of measurement is always a process of some kind which **can be repeated** without modification in the different parts of the measurement continuum.
- Thurstone's **Law of Comparative Judgement** makes the link to modern approach for social and psychological measurement.

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A person has to order a number of stimuli (with regard to a property). Repeated comparative judgements will be more efficient in sorting it out than absolute ratings on all stimuli at once. He applied this approach to the measurement of psychological values.

Check: <https://www.nomoremarking.com/demo2#>

Before the Rasch model : N.R. Campbell (1880 - 1949)³

- The first condition for measurement - the number assigned represent a **transitive and asymmetrical** relationship (R) (e.g. heavier as)
- a) Transitive: If A has it to B and B has it to C, then A has it to C
- b) Symmetrical: If A has it to B then B has it to A.

Additivity (whole is the sum of the parts) is the hallmark of measurement.

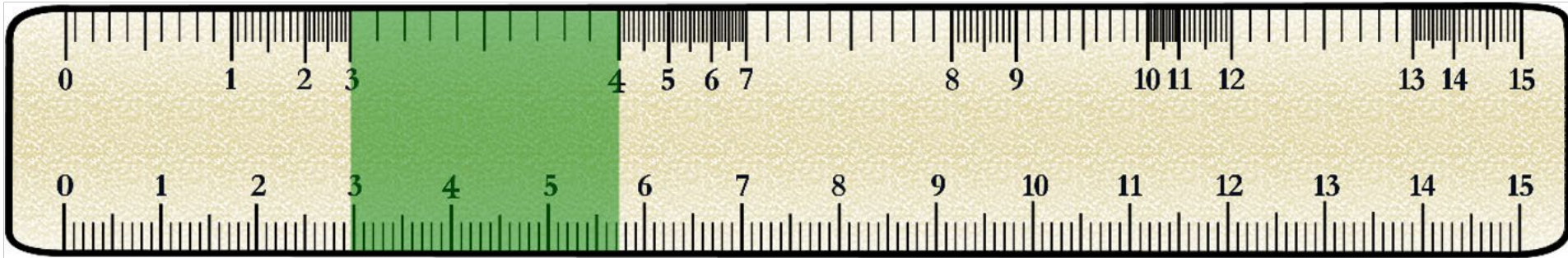
Why is ordinal not good enough?

Pretend you are the CEO of an orange juice company
5000 oranges vs. 750 kg of oranges

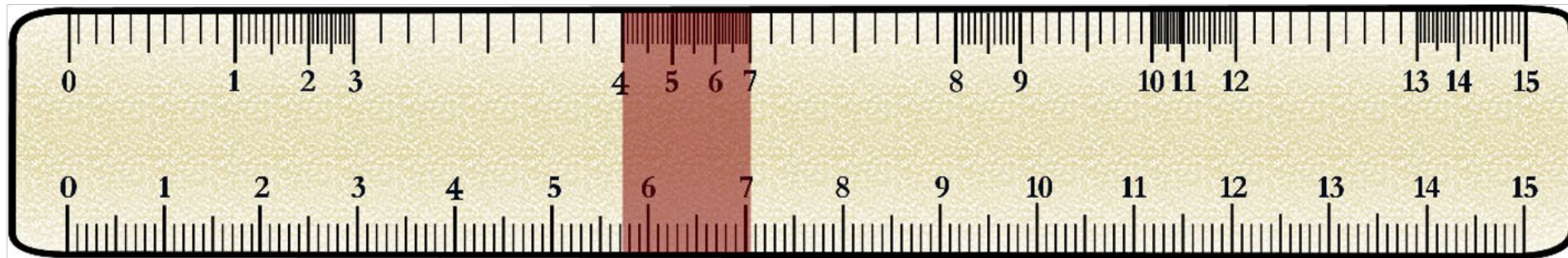


Measurement invariance

Patient One



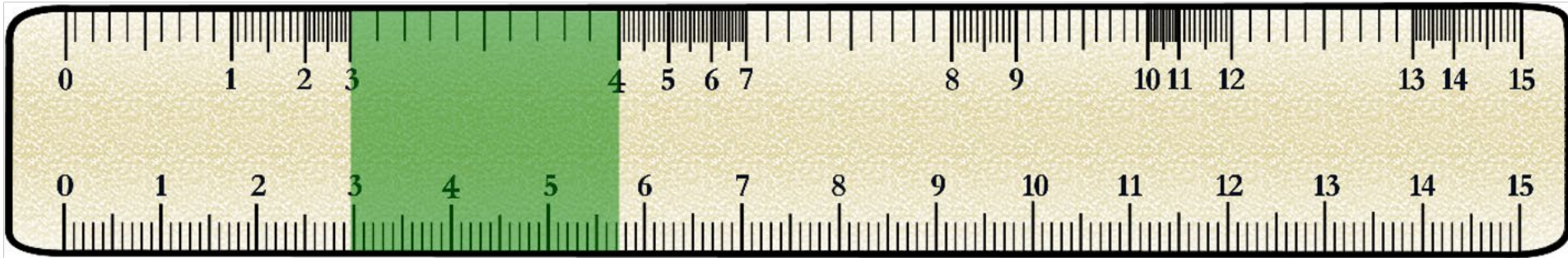
Patient Two



Measurement invariance

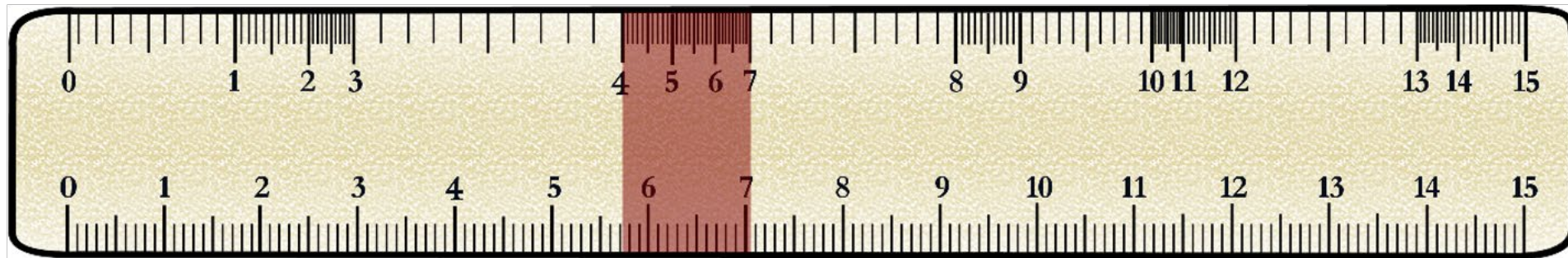
Patient One

+ 1



Patient Two

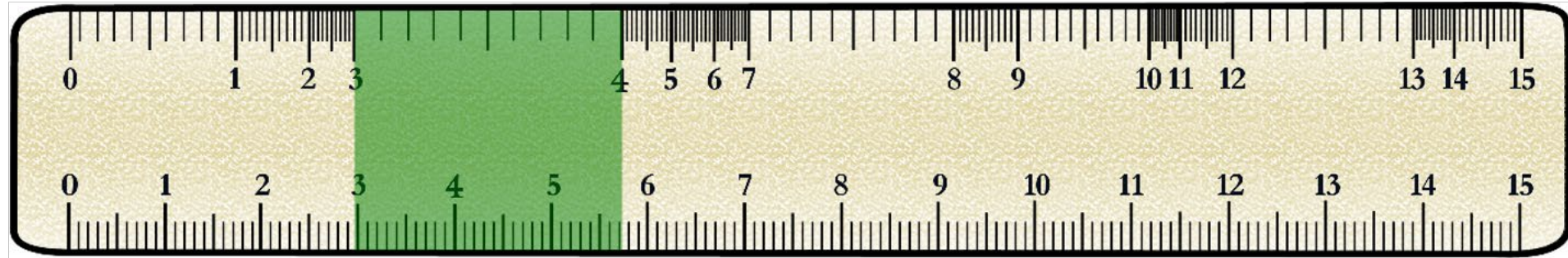
+3



Measurement invariance

Patient One

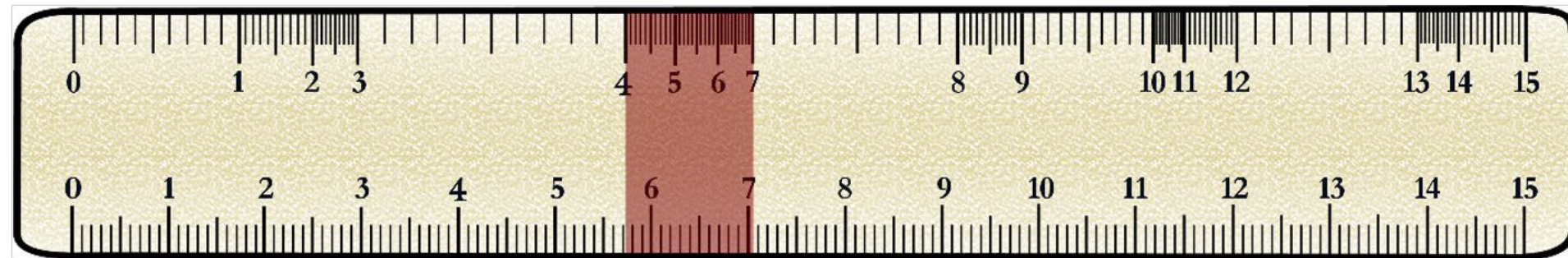
+ 1



Patient Two

+ 2.7

+3



+1.2

Misinference from Ordinal Scales⁴

"Ordinal scales of measurement do not support the mathematical operations needed to calculate means and standard deviations.

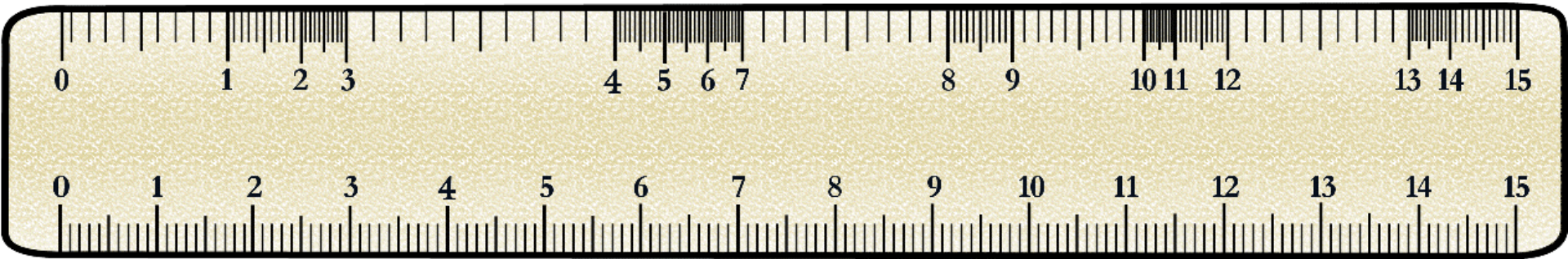
Measuring versus counting

1. Do you have difficulty engaging in vigorous activities, such as playing football or doing sport?
2. Do you have difficulty going outside of your home?
3. Do you have difficulty moving around inside your home?

Not all questions are equally difficult!



How to Make the Transition From the Top to the Bottom of the Ruler?



Rasch Analysis



Guard Satisfaction Questionnaire

Dear Client:

We hope this questionnaire will be helpful to you in the future. The questionnaire is a tool to help you understand your own feelings and attitudes about your job. It is not a test. There are no right or wrong answers. The questionnaire is a tool to help you understand your own feelings and attitudes about your job. It is not a test. There are no right or wrong answers. The questionnaire is a tool to help you understand your own feelings and attitudes about your job. It is not a test. There are no right or wrong answers.

Thank you for your cooperation.

Instructions:

Read each item carefully. Then, for each item, select the answer that best describes you.

1. How do you feel about your job?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

2. How do you feel about your supervisor?

a. I like him/her very much. b. I like him/her. c. I don't like him/her. d. I hate him/her.

3. How do you feel about your coworkers?

a. I like them very much. b. I like them. c. I don't like them. d. I hate them.

4. How do you feel about your work?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

5. How do you feel about your company?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

6. How do you feel about your future?

a. I am very optimistic. b. I am optimistic. c. I am not optimistic. d. I am pessimistic.

7. How do you feel about your life?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

8. How do you feel about your health?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

9. How do you feel about your family?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

10. How do you feel about your friends?

a. I like them very much. b. I like them. c. I don't like them. d. I hate them.

11. How do you feel about your life in general?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

12. How do you feel about your life in general?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

13. How do you feel about your life in general?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

14. How do you feel about your life in general?

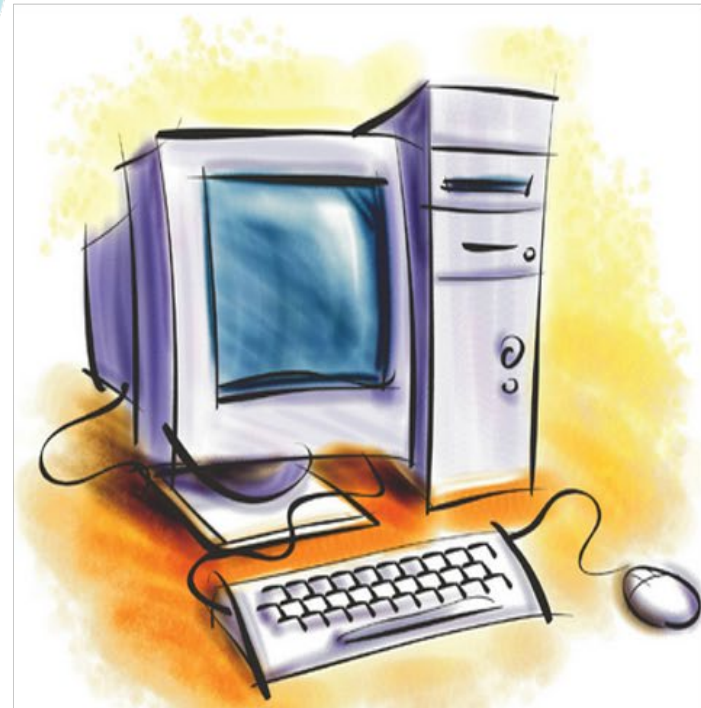
a. I like it very much. b. I like it. c. I don't like it. d. I hate it.

15. How do you feel about your life in general?

a. I like it very much. b. I like it. c. I don't like it. d. I hate it.



Georg Rasch (1901-1980)



Rasch Analysis

Rasch analysis is frequently applied to verify if an instrument shows important (psycho)metric properties.

- Stochastic ordering (fit of data to model)
- Monotonicity (ordering of response options)
- No local response dependencies or LID (no significant correlations between items)
- Unidimensionality (one latent construct)
- No differential item functioning or DIF (no sample subgroup effects)

Recommended literature

Rasch:

- T.G. Bond: Applying the Rasch Model: Fundamental Measurement in the Human Sciences. Lawrence Erlbaum Associates, Mahwah New Jersey 2007.
- D. Andrich and I. Marais: A Course in Rasch Measurement Theory: Measuring in the Educational, Social, and Health Sciences. Springer Nature, Singapore 2019.

R:

- Contributed documentation with introductions to R : <https://cran.r-project.org/>

Recommended literature

Rasch & R:

- An overview to packages for psychometric analysis are found on <https://cran.r-project.org/web/views/Psychometrics.html>
- C. Strobl: Das Rasch-Modell - Eine verständliche Einführung für Studium und Praxis. 2. erweiterte Auflage. Rainer Hampp Verlag, Muenchen 2012.
- Overview to psychometric methods including Rasch in R:
- [Modern Psychometrics with R \(Mair, 2018\)](#)
- [Using R for Item Response Theory Model Applications \(Paek & Cole, 2020\)](#)

Notes

1. Andrich D. (2004) The Rasch Model: A Characteristic of Incompatible Paradigms? Medical Care 42 (1) suppl
2. G. Rasch: Probabilistic models for some intelligence and attainment tests. Danish Institute for Educational Research, Copenhagen 1960
3. N.R. Campbell (1920). Physics: the Elements. London Cambridge University Press.
4. Merbitz C, Morris J, Grip JC. Arch Phys Med Rehabil 1989; 70:308-312