Research activity, interests and beyond

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Item Response Theory and Rasch modeling

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( TITLE-ABS-KEY ( "Item response theory" ) OR TITLE-ABS-KEY ( "Rasch" ) )
AND PUBYEAR > 1959 AND PUBYEAR < 2025 AND ( LIMIT-TO ( DOCTYPE , "ar" ) )
```

$n = 18,661$ documents (May, 17$^{\text{th}}$ 2024) on Scopus:

Some fields of application:

Some reasons for their application:

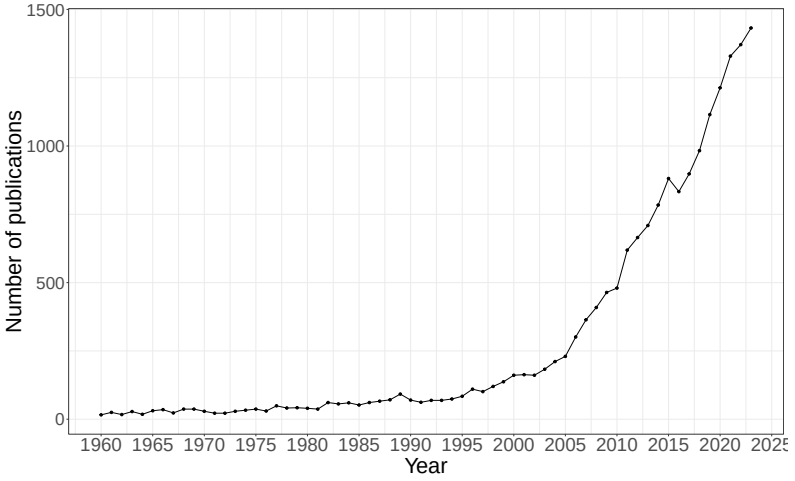
Measure validation

Measure refinement

Item selection

Computerized adaptive testing

...


Number of publications
1500
1000
500
0
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025
Year

Rasch modeling of complex data structures

A_{Bart}

A_{Lisa}

A_{Bart}

Q1

$4 + 5 = ?$

d_{q1}

Q2

$\frac{3}{2}x^2 + \frac{5}{4}x = ?$

d_{q2}

A_{Lisa}

A_{Bart}

Q1

$$4 + 5 = ?$$

$$d_{q1}$$

Q2

$$\frac{3}{2}x^2 + \frac{5}{4}x = ?$$

$$d_{q2}$$

A_{Lisa}

$$P(X_{pi} = 1) = \frac{\frac{A_p}{d_i}}{1 + \frac{A_p}{d_i}}$$

$$P(X_{pi} = 1|\theta_p, b_i) = \frac{\exp(\theta_p - b_i)}{1 + \exp(\theta_p - b_i)}$$

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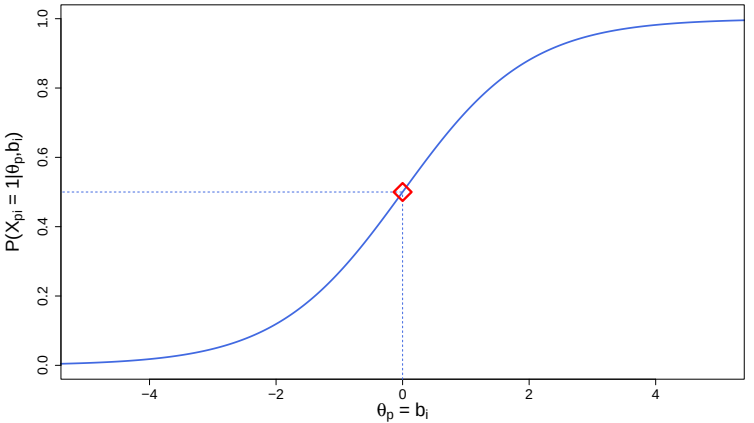
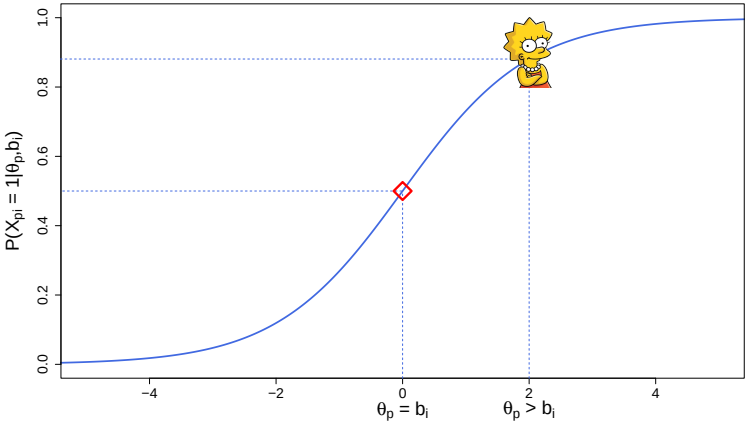


$$P(X_{pi} = 1|\theta_p, b_i) = \frac{\exp(\theta_p - b_i)}{1 + \exp(\theta_p - b_i)}$$



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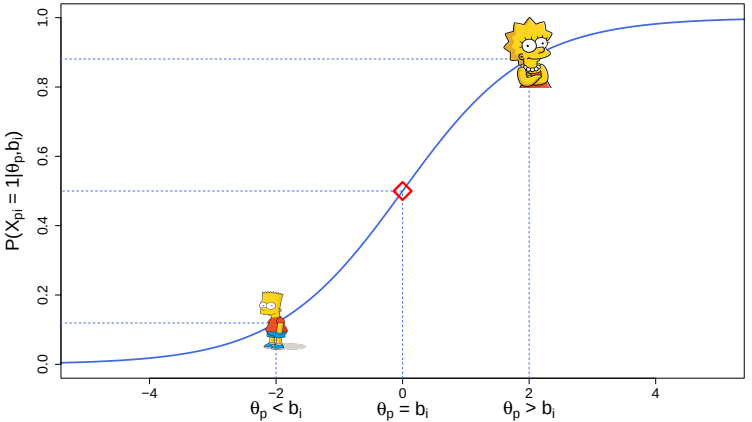
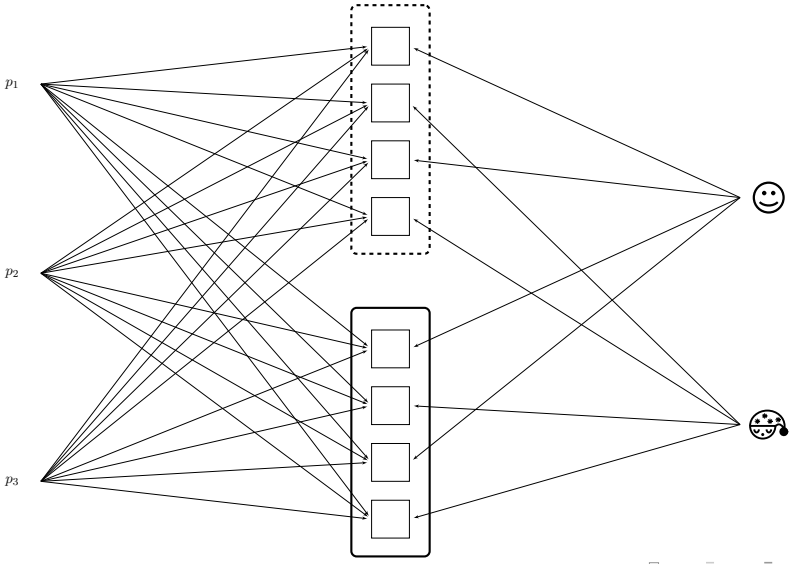
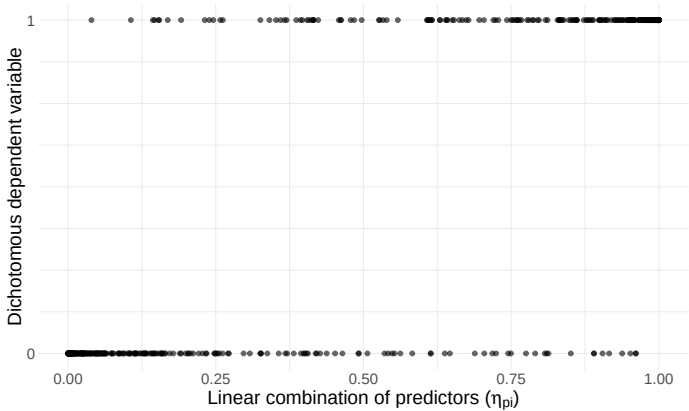



p_1
p_2
p_3

Generalized linear model (GLM) for dichotomous responses



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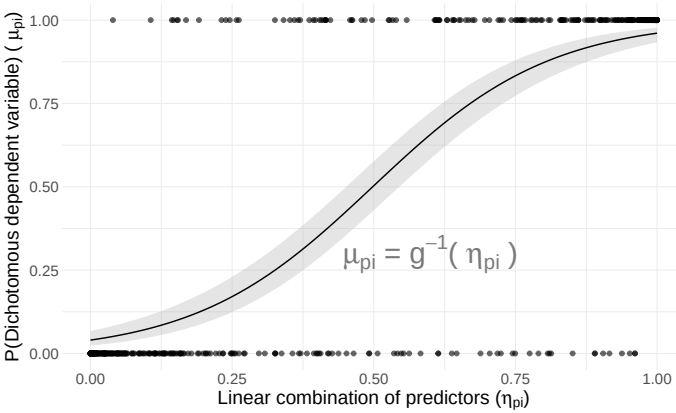


Logit link function g:

$g(\eta_{pi}) = log\left(\frac{\mu_{pi}}{1-\mu_{pi}}\right)$

Inverse g^{-1}

$g^{-1} = \frac{\exp(\eta_{pi})}{1+\exp(\eta_{pi})}$

Random effects and random factors

Linear combination of predictors in a Linear Model:

$$\eta = X\beta,$$

where β indicates the coefficients of the fixed intercept and slope(s), and X is the model-matrix.
Linear combination of predictors in a Linear Mixed-Effects Model (LMM):

$$\eta = X\beta + Zd,$$

where Z is the matrix and d is the vector of the random effects (not parameters!)

Best Linear Unbiased Predictors

Future lines and developments

Application to data from experiments typically used in different fields of study, such:

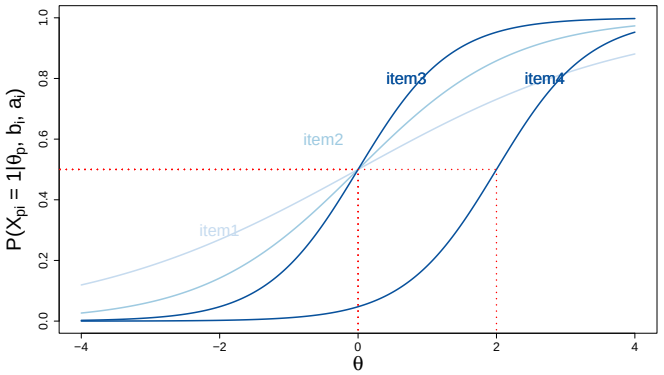
- Go/No-Go in addiction studies
- SNARC effect in cognitive psychology
- ...

Integration between the information obtained from the accuracy responses and the response times

Item Response Theory and short test forms development

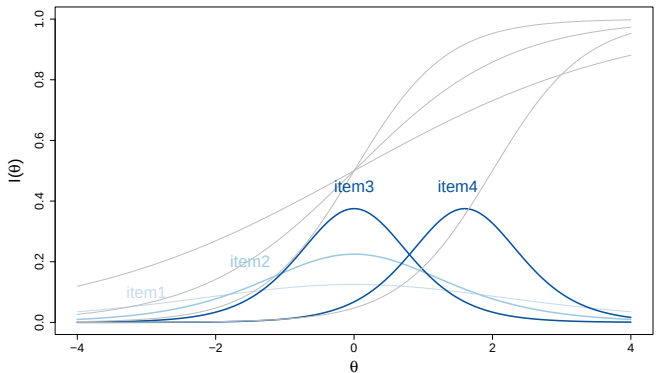
2-Parameter Logistic Model

Item Response Function: $P(x_{pi} = 1|\theta_p, b_i, a_i) = \frac{\exp[a_i(\theta_p - b_i)]}{1+\exp[a_i(\theta_p - b_i)]}$



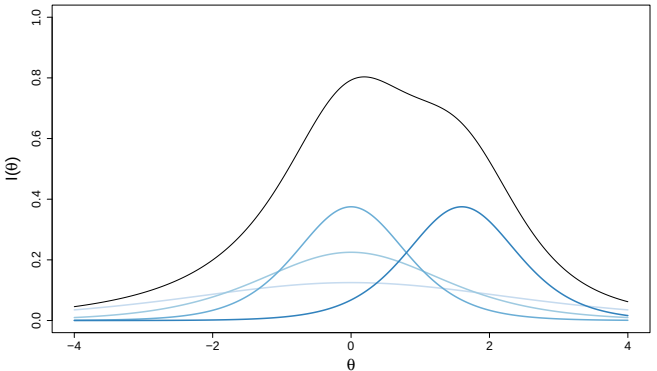
2-Parameter Logistic Model

Item Information Function: $I_i(\theta) = a_i^2 P_i(\theta, b_i, a_i)[1 - P_i(\theta, b_i, a_i)]$



2-Parameter Logistic Model

Test Information Function: $I(\theta) = \sum_{i=1}^{I} I_i(\theta)$



θ-target procedure

Selected items $\rightarrow$ items with highest *IIF*s with respect to θ targets (θ')

e.g.: 3-item short form from 10-item full-length test

item	θ'_1 -2.67	θ'_2 0.01	θ'_3 2.67
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

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item	θ'_1 -2.67	θ'_2 0.01	θ'_3 2.67
1	0.04	0.12	0.08
2	0.09	0.33	0.03
3	0.01	0.01	0.02
4	0.73	0.06	0.01
5	0.04	0.03	0.02
6	0.01	0.06	0.59
7	0.05	0.06	0.03
8	0.01	0.04	0.69
9	0.03	0.05	0.04
10	0.02	0.03	0.02

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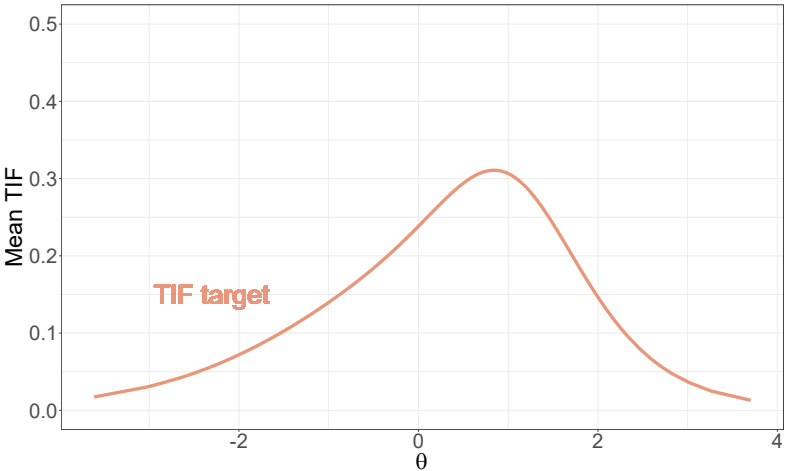
The other way around



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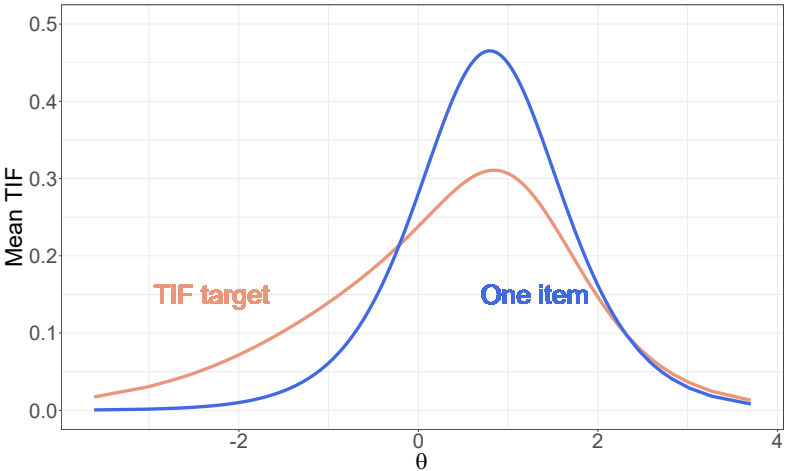

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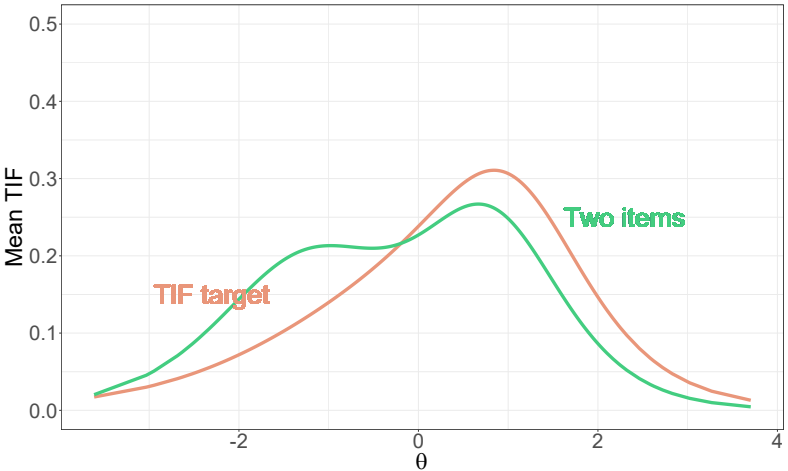

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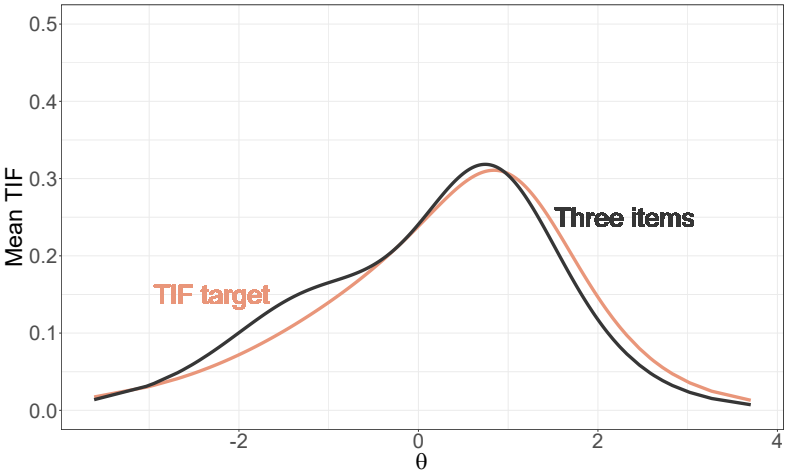


Future lines and directions

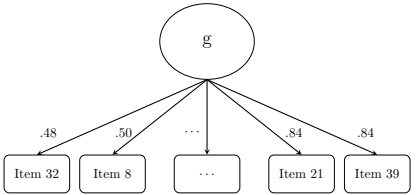
- Development of short test forms for the diagnosis of clinically relevant constructs (e.g., addiction) → Focused on specific regions of the latent trait
- Extension to multidimensionl/bifactor latent structures (e.g., content balancing) and to polytomous data

Measurement theory

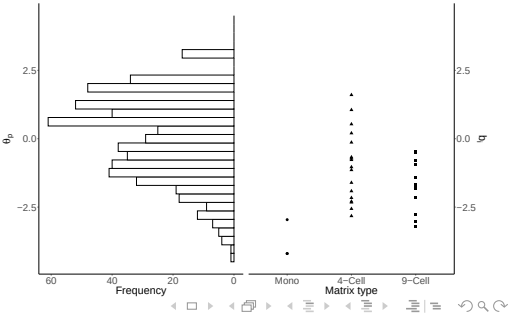
Measuring fluid intelligence

Raven-like measure for the assessment of fluid intelligence in children and adults: From stimulus generation to measure validation under three different approaches

Classical Test Theory
Factorial solution



Rasch modeling
Wright map



The meaningfulness of Psychological Measures

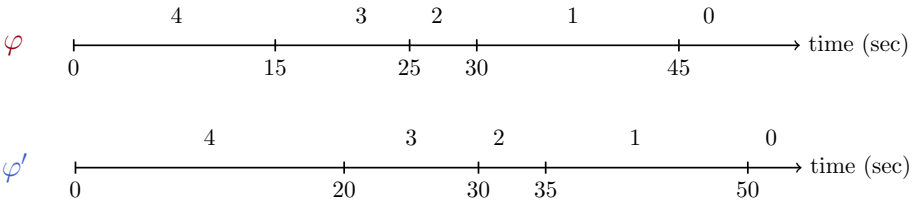
The ratio between the measures of a and b is constant and independent of the measurement unit:

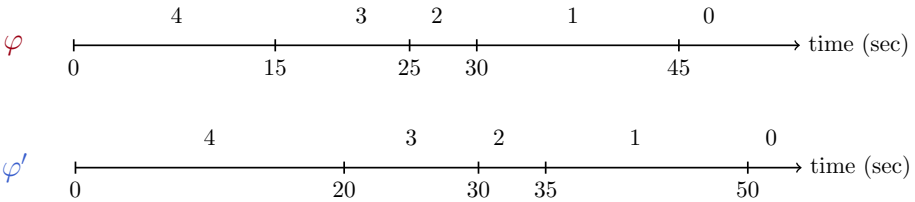
$$\frac{\varphi(a)}{\varphi(b)} = \frac{\varphi'(a)}{\varphi'(b)},$$

where φ and φ' are two different scales of measurement of the same variable.

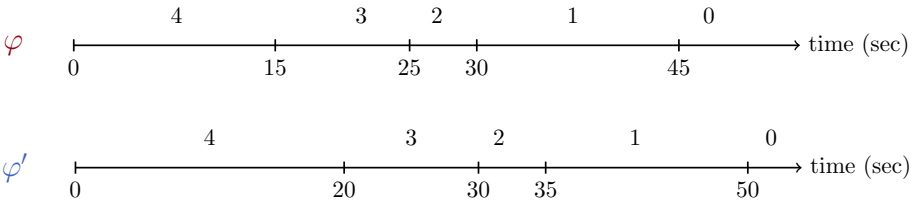
Meaningful comparisons

The comparison between a and b is meaningful if it is invariant under all the unit transformations.


φ
4
3
2
1
0
time (sec)
0
15
25
30
45
φ′
4
3
2
1
0
time (sec)
0
20
30
35
50



Item	t_A	t_B	φ_A	φ_B	φ'_A	φ'_B
1	14	17	4	3	4	4
2	26	19	2	3	3	4
3	31	18	1	3	2	4
4	47	33	0	1	1	2
5	17	47	3	0	4	1
Sum scores			10	10	14	15



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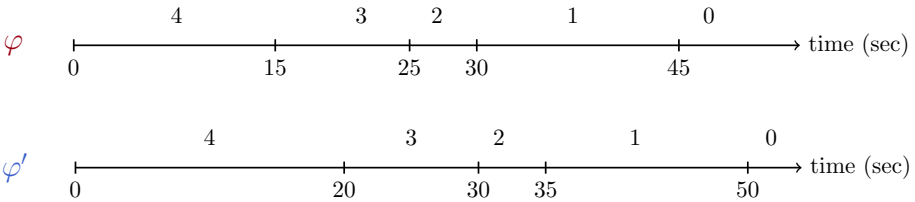

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Sum scores			10	10	14	15

Teaching Activity

From theory...

Psychometrics
Statistics, data analysis, and experiment design in Social Sciences
Measurement Theory and Measurement models in Psychology
Rasch modeling and Item Response Theory

...to practice

`R` for beginne`R`s
RMarkdown in an Open Science perspective
Developing web applications with `shiny`
Implementing experiments in Inquisit

Thank you!