

# **A Principled Way of Assessing Visualization Literacy**

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Immediate motivation:

- **detect low-visualization literacy participants before conducting online studies.**

Requirements:

- **short, reliable, and easy to administer tests.**

*This presentation.*

- I** — What is visualization literacy?
- II** — Item response theory.
- III** — A principled way of assessing visualization literacy.
- IV** — Conclusion

**I — What is visualization literacy?**

## **Practical definition for *visualization literacy.***

We define **visualization literacy** (VL) as “the ability to confidently use a given data visualization to translate questions specified in the data domain into visual queries in the visual domain, as well as interpreting visual patterns in the visual domain as properties in the data domain.”

*What is visualization literacy?*

*Stimulus*

*Gateway skill*

*Comprehension*

text

textual  
literacy

literary  
comprehension

visualization

visualization  
literacy

data comprehension

Perception

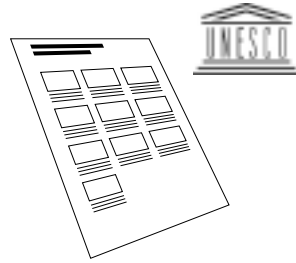
Activation of initial  
understanding

Extraction and  
integration



***How might it be assessed?***

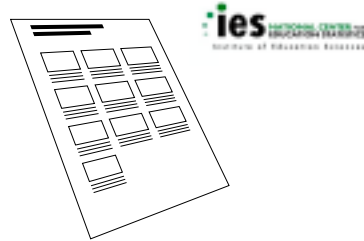
*How might it be assessed?*



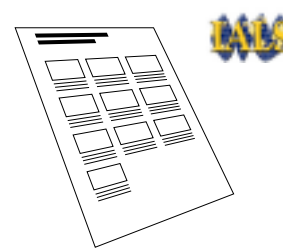
Literacy Assessment and Monitoring Programme (LAMP)



Programme for International Student Assessment (PISA)

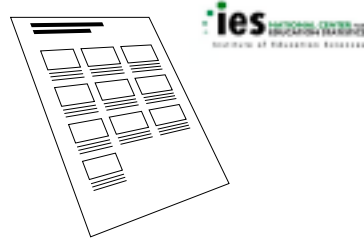


Adult Literacy and Lifeskills Survey (ALL)

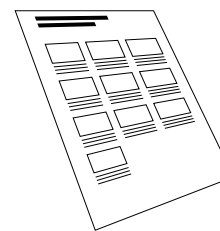


International Adult Literacy Survey (IALS)

Standard tests.



Fluency Addition to NAAL (FAN) and The Adult Literacy Supplemental Assessment (ALSA).

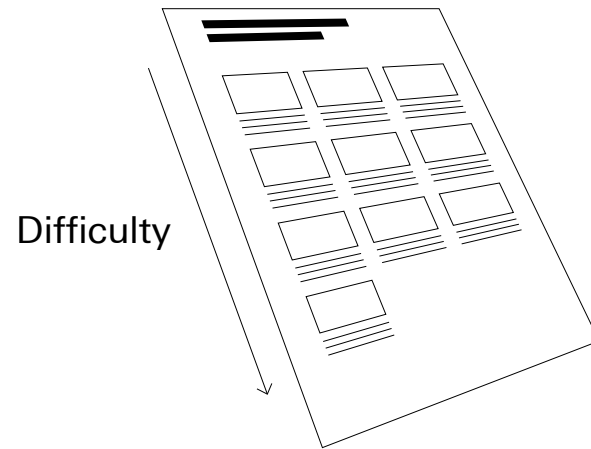


Miller Word Identification Assessment (MWIA)—for whole-word dyslexia.

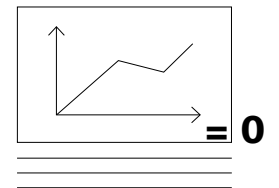
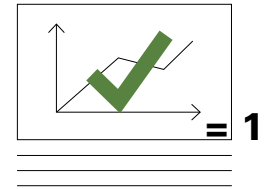
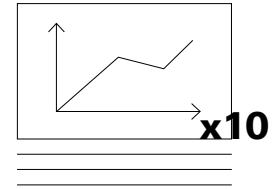
Fallback tests.

*Imagine...*

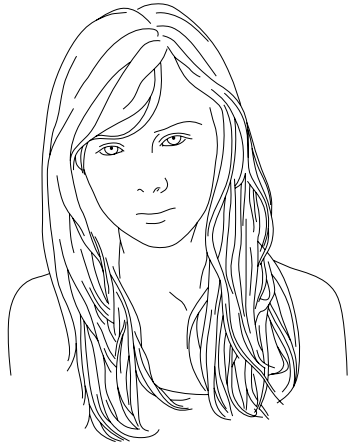
*How might it be assessed?*



Standard  
VL test



*How might it be assessed?*



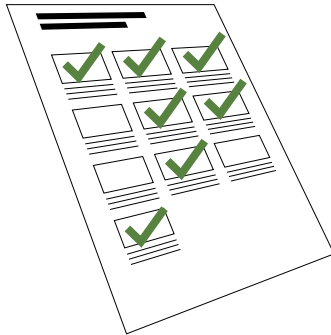
**Jenny**



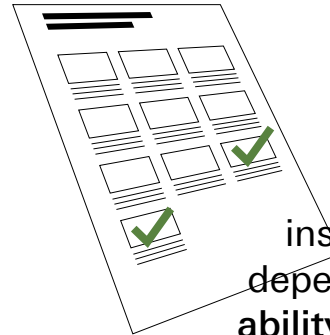
**Chris**



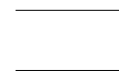
**Rob**



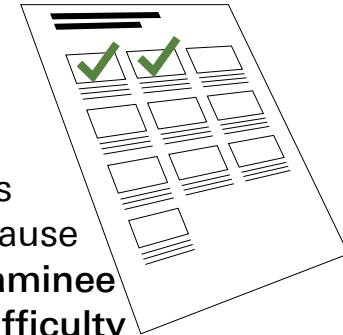
Standard  
VL test



Standard  
VL test

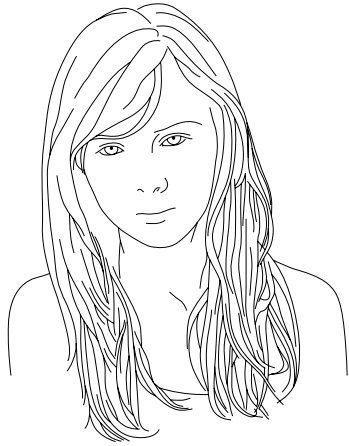


raw score is  
insufficient because  
dependant on examinee  
ability and item difficulty

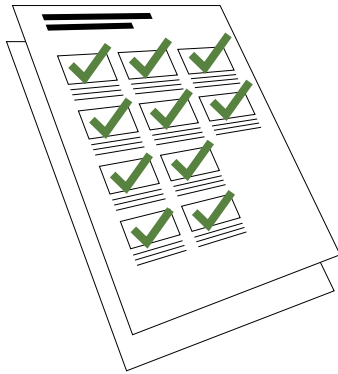


Standard  
VL test

*How might it be assessed?*



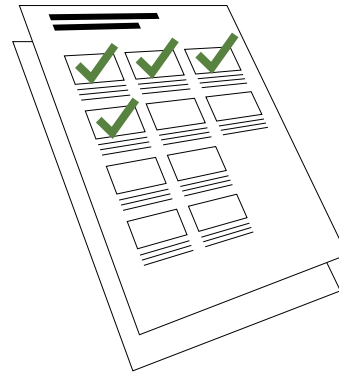
**Jenny**



Fallback  
VL test



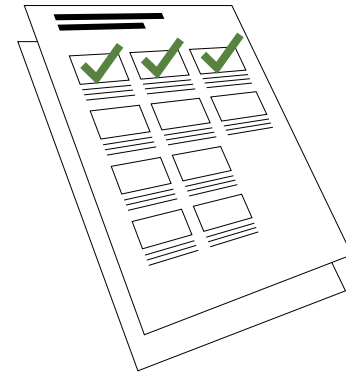
**Chris**



Fallback  
VL test



**Rob**



Fallback  
VL test

*How might it be assessed?*

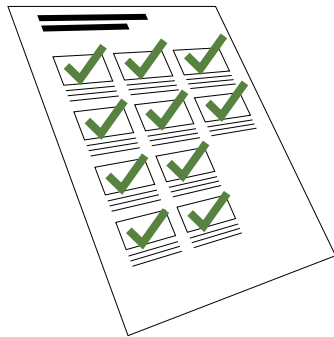
Important attributes:

- reveal an examinee's **ability** to 'read' visualizations,
- know | the items' **difficulty**,  
| the items' **discrimination** power,
- detect the probability of examinees **guessing** answers.

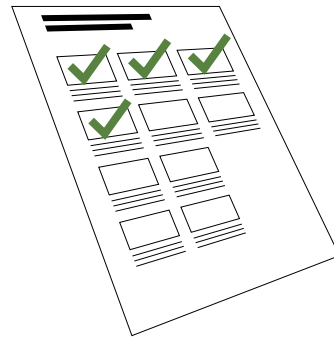
## **II — Item response theory.**

# Item response theory (IRT) model

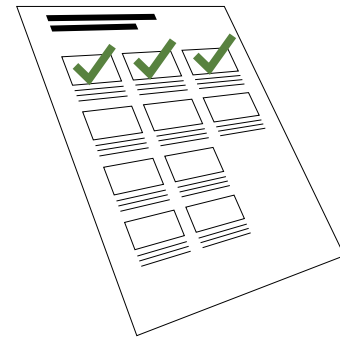
*Item response theory.*



[1, 1, 1, 1, 1, 1, 1, 1, 1, 1]



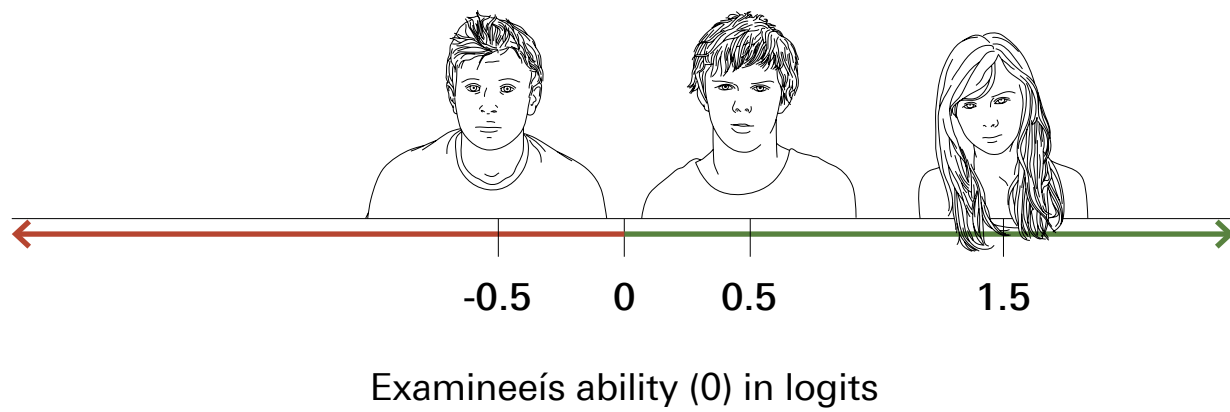
[1, 1, 1, 1, 0, 0, 0, 0, 0, 0]



[1, 1, 1, 0, 0, 0, 0, 0, 0, 0]

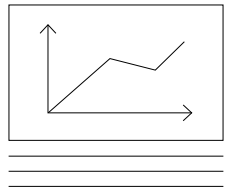
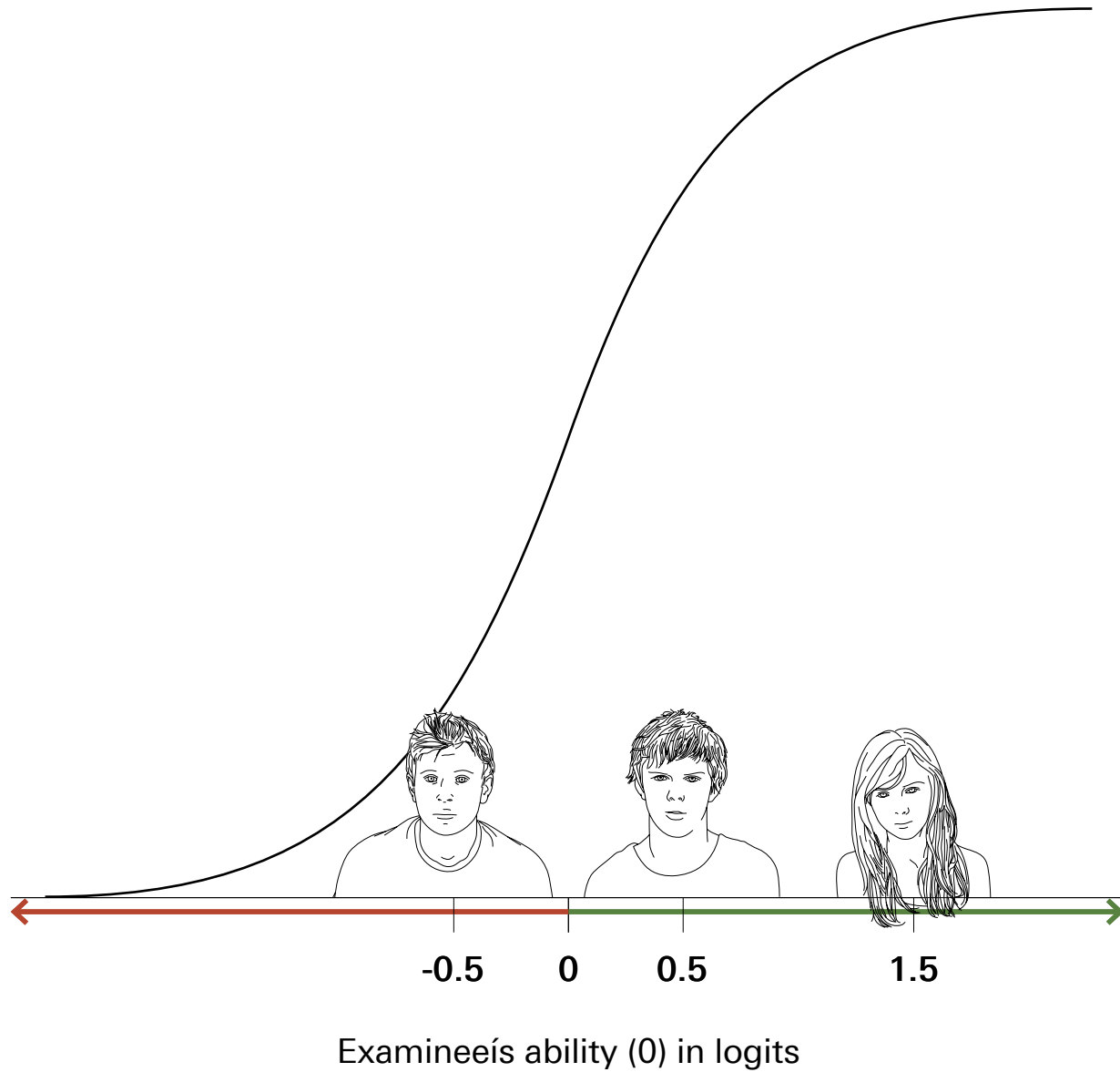


*Item response theory.*



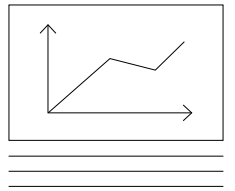
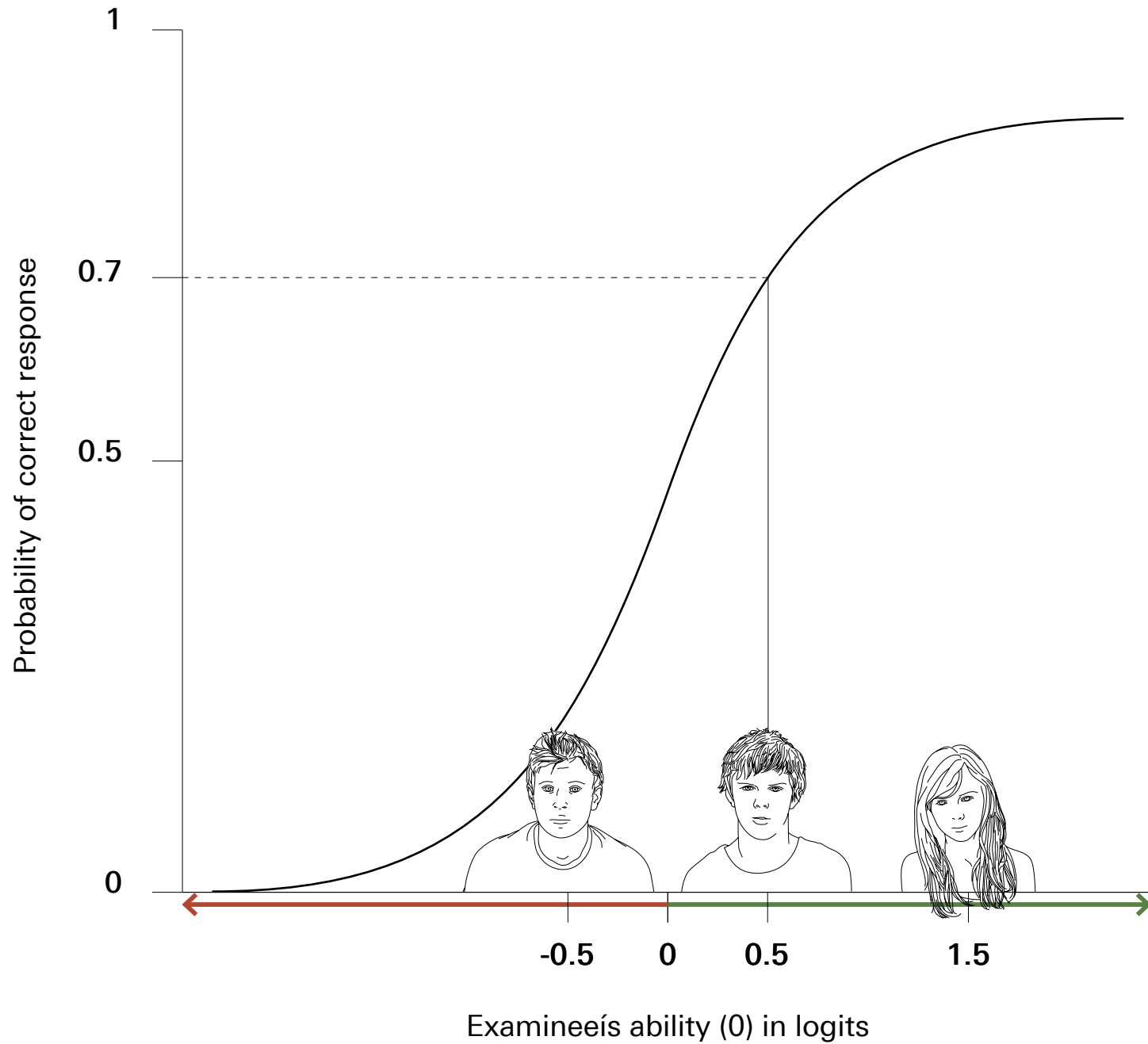
# Item characteristic curve

*Item response theory.*



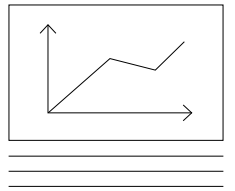
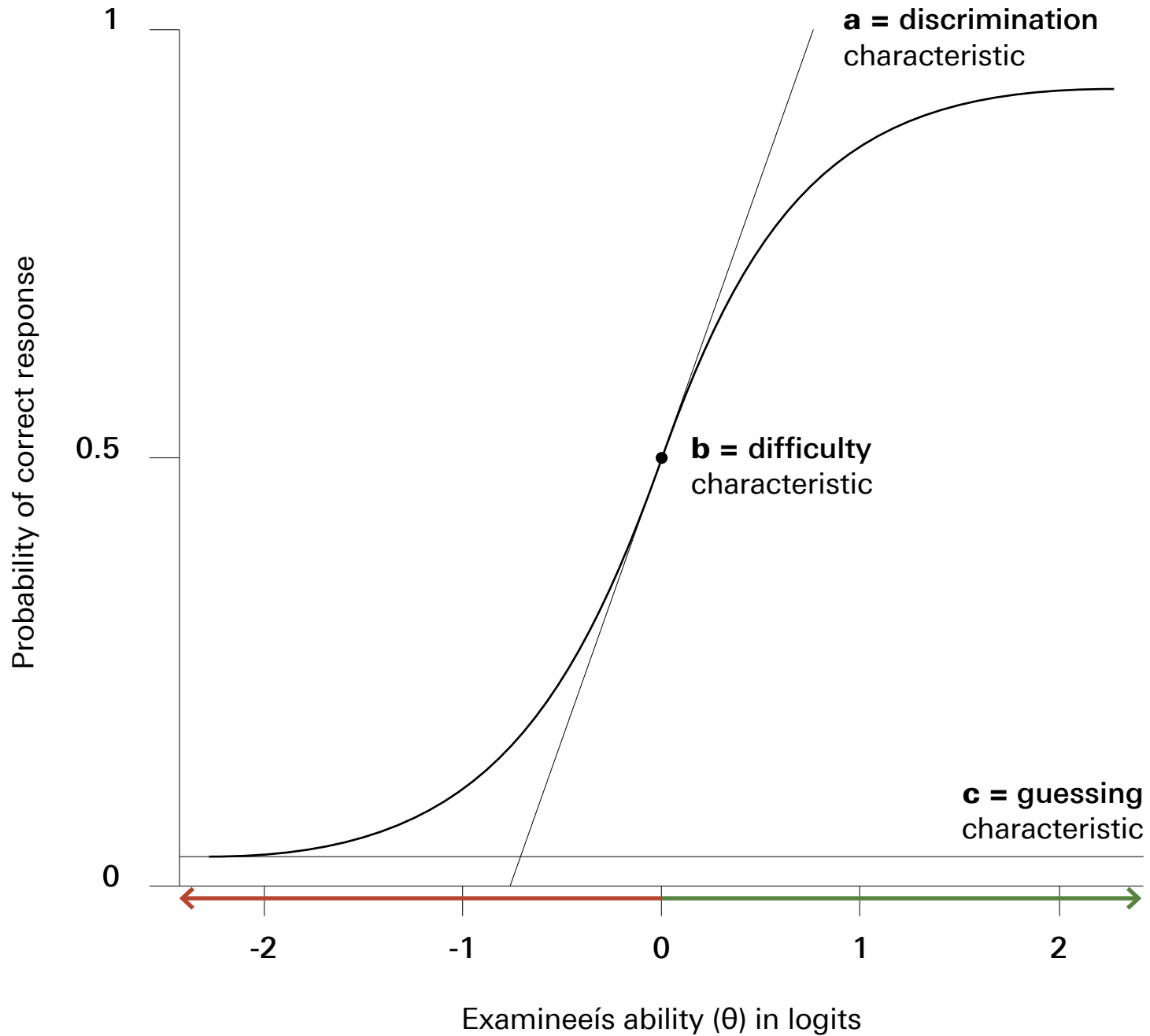
# Item characteristic curve

*Item response theory.*



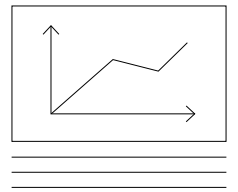
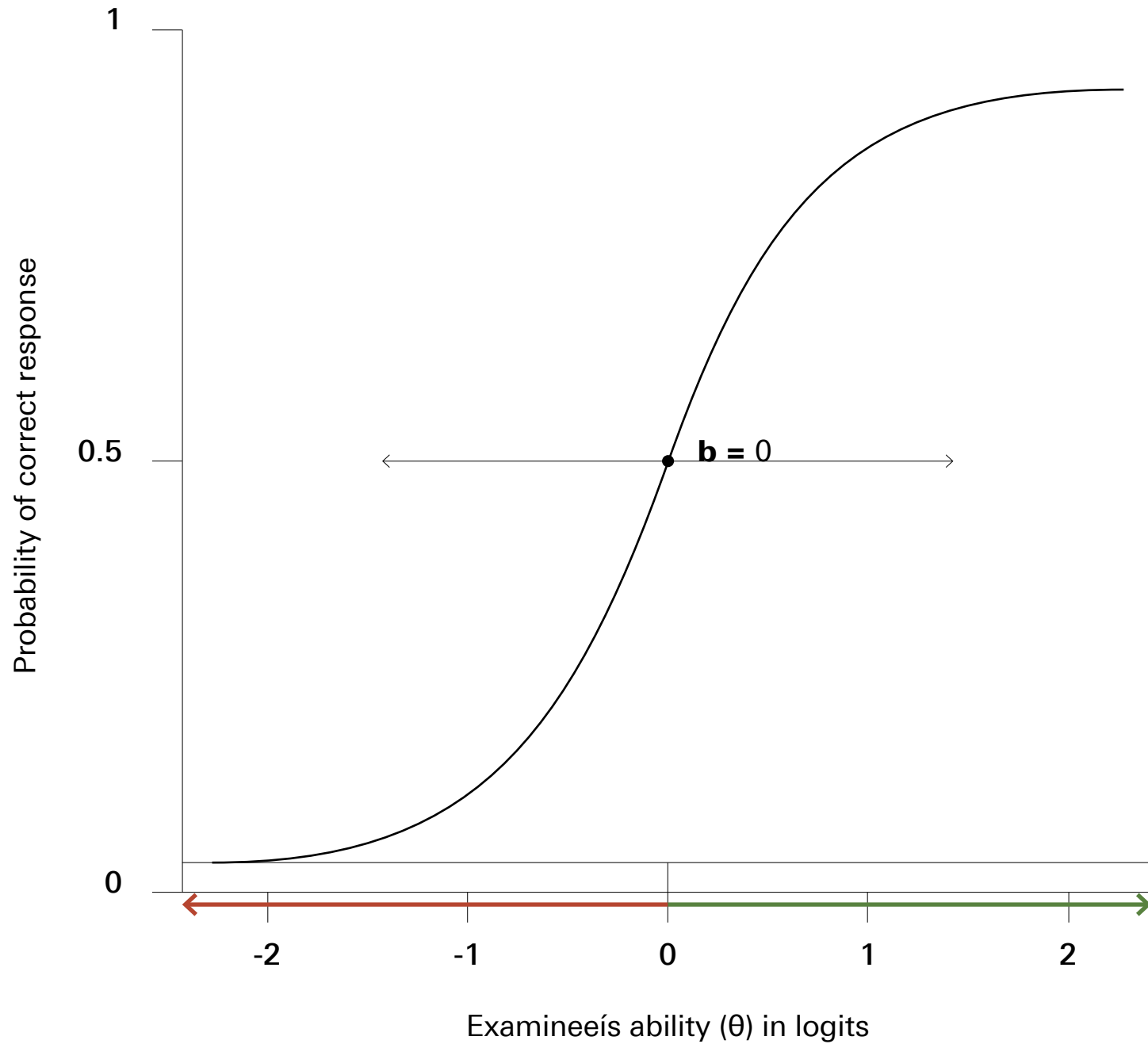
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*Item response theory.*



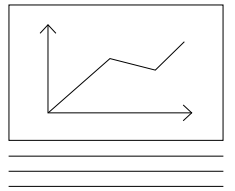
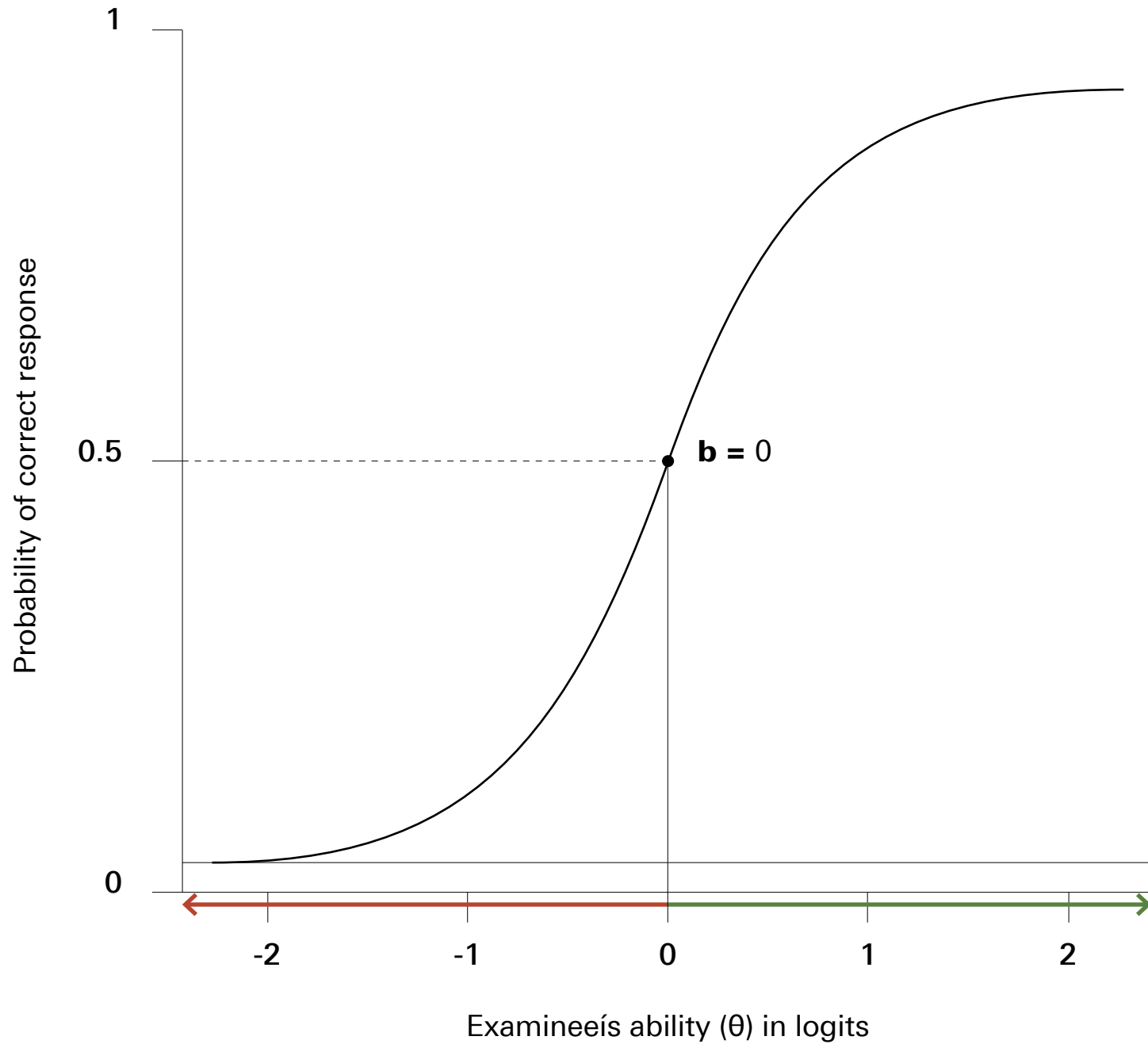
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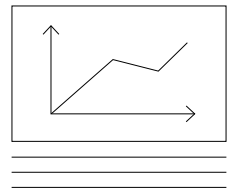
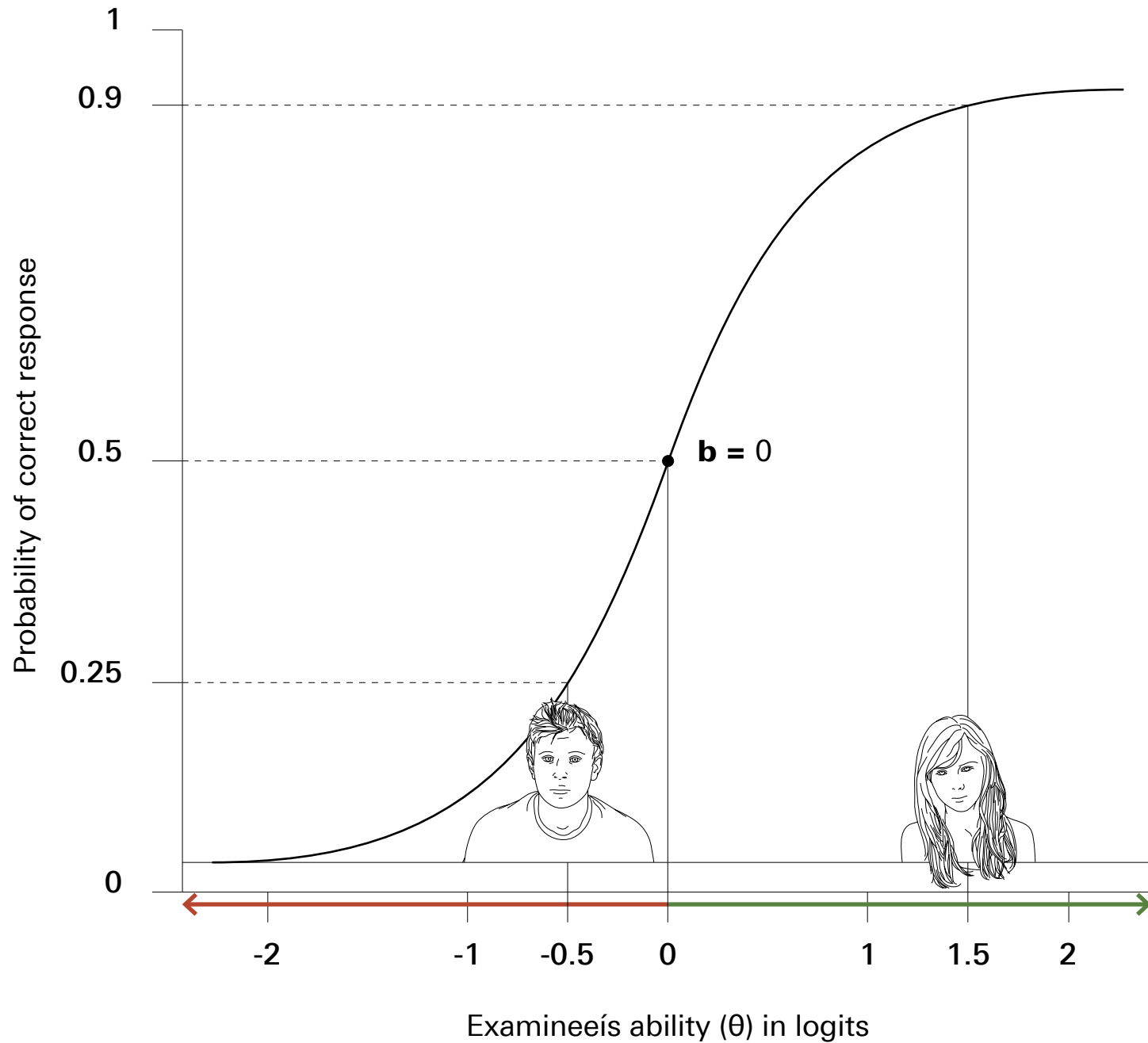
# Item characteristic curve

*Item response theory.*



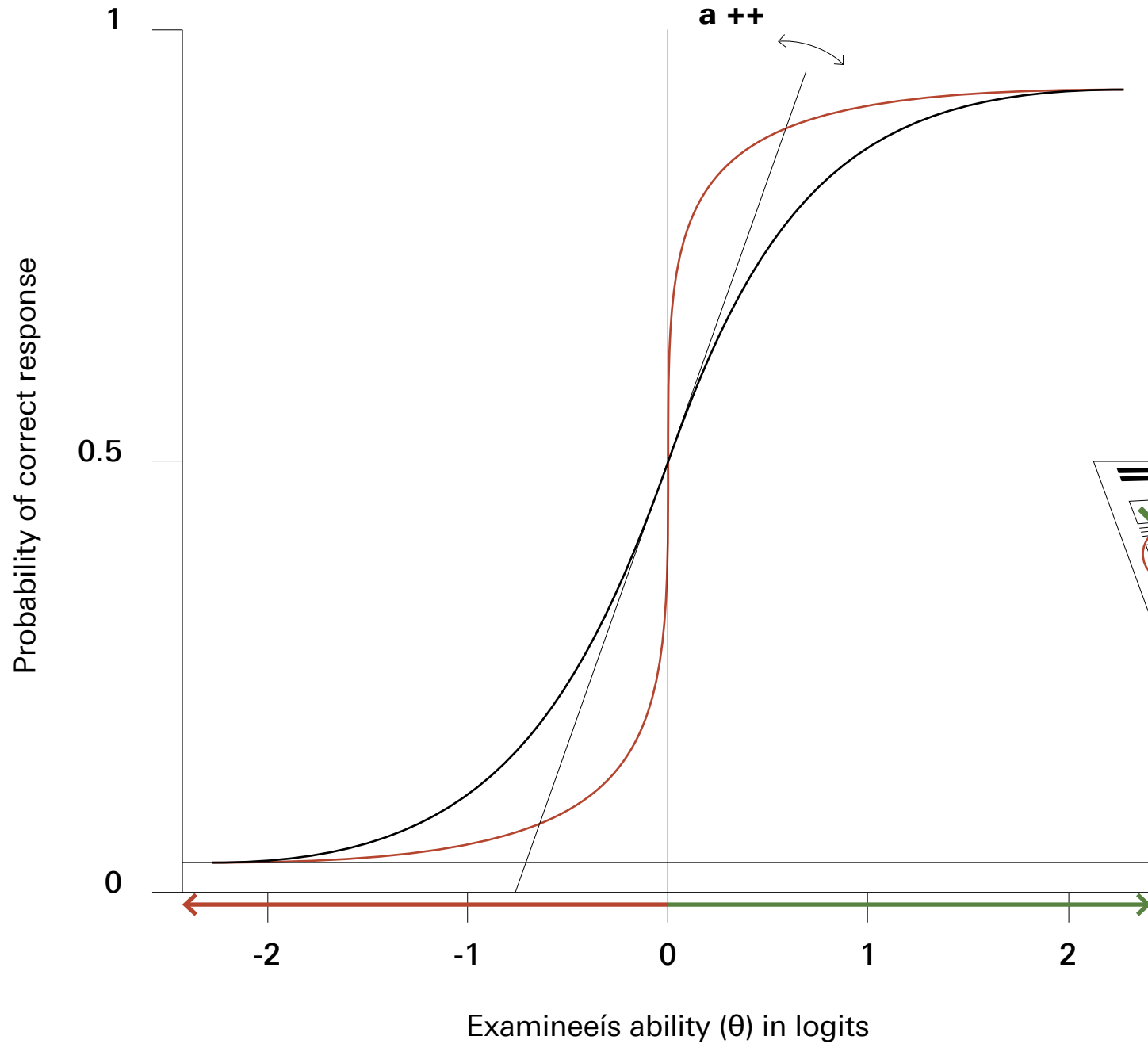
# Item characteristic curve

*Item response theory.*



# Item characteristic curve

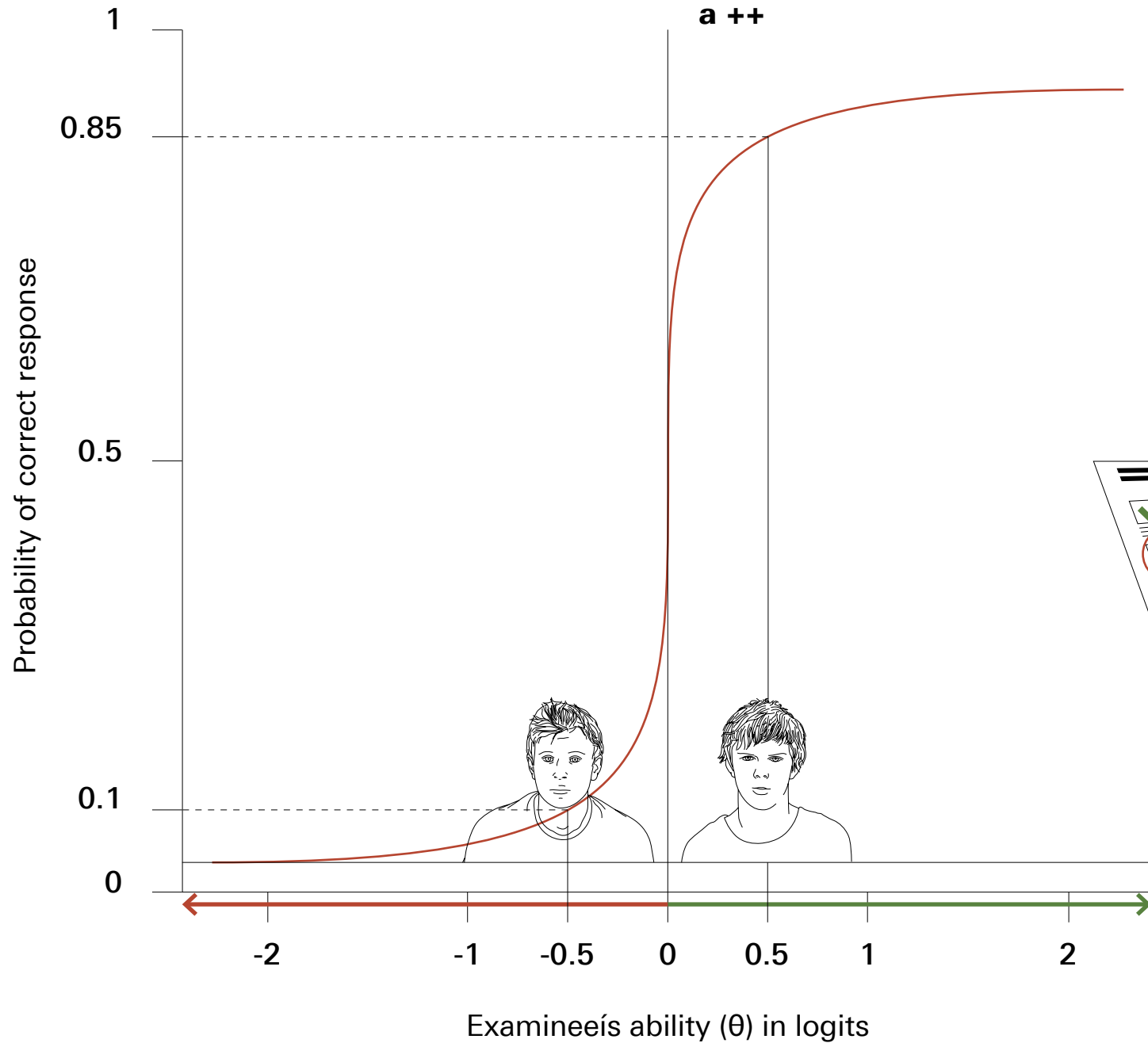
*Item response theory.*





# Item characteristic curve

*Item response theory.*



**III — A principled way of  
assessing visualization  
literacy.**

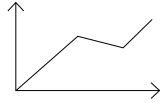
Our method consists of two phases:

- 1. a design phase: create, administer and calibrate tests, and**
- 2. an assessment phase: retrieve examinees' visualization literacy scores.**

# *A test-item parametric design space.*



*A test-item parametric design space.*



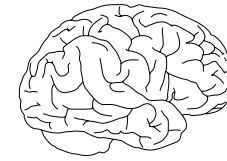
## Stimuli

- **number of samples**
- **complexity**  
or **variation**  
in the data
- **layout** (the graphical framework and the scales used)
- **distraction** (focus on one sample/ dimension while several are displayed)



## Tasks

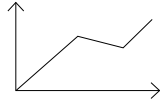
- **extrema**  
(min/max)
- **variation** (*e.g.*, trend detection)
- **intersection**
- **average**
- **comparison**



## Questions

- **perception** (non-congruent)
- **high-congruency**
- **low-congruency**

*A test-item parametric design space.*



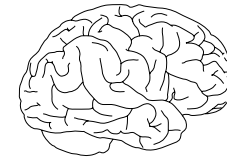
## Stimuli

- **number of samples**
- **complexity or variation in the data**
- **layout** (the graphical framework and the scales used)
- **distraction** (focus on one sample/ dimension while several are displayed)



## Tasks

- **extrema** (min/max)
- **variation** (*e.g.*, trend detection)
- **intersection**
- **average**
- **comparison**



## Questions

- **perception** (non-congruent)
- **high-congruency**
- **low-congruency**

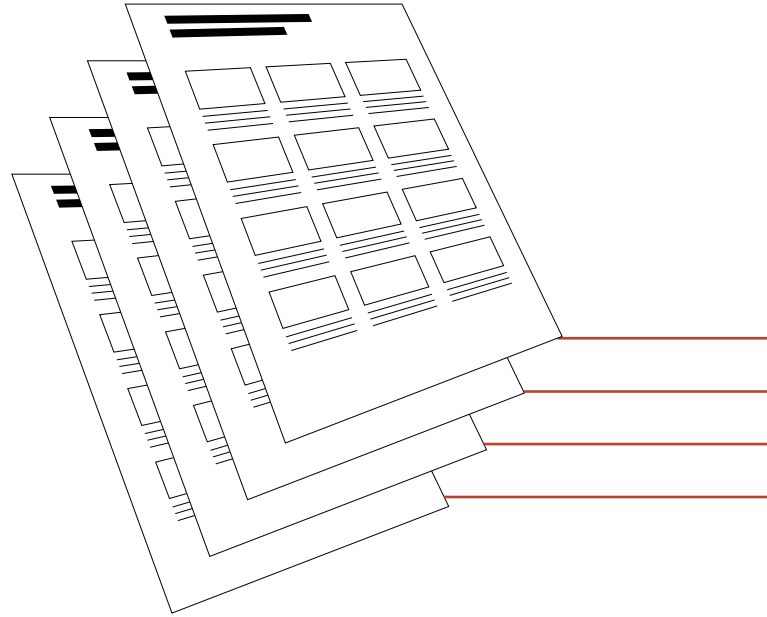
## **Practical definition for *congruency*.**

**Congruent questions** refer to semantic aspects of the data.

The **level of congruence** is defined by the ‘replaceability’ of the data-related terms in the question by perceptual terms.

*A principled way of assessing visualization literacy.*

Create...



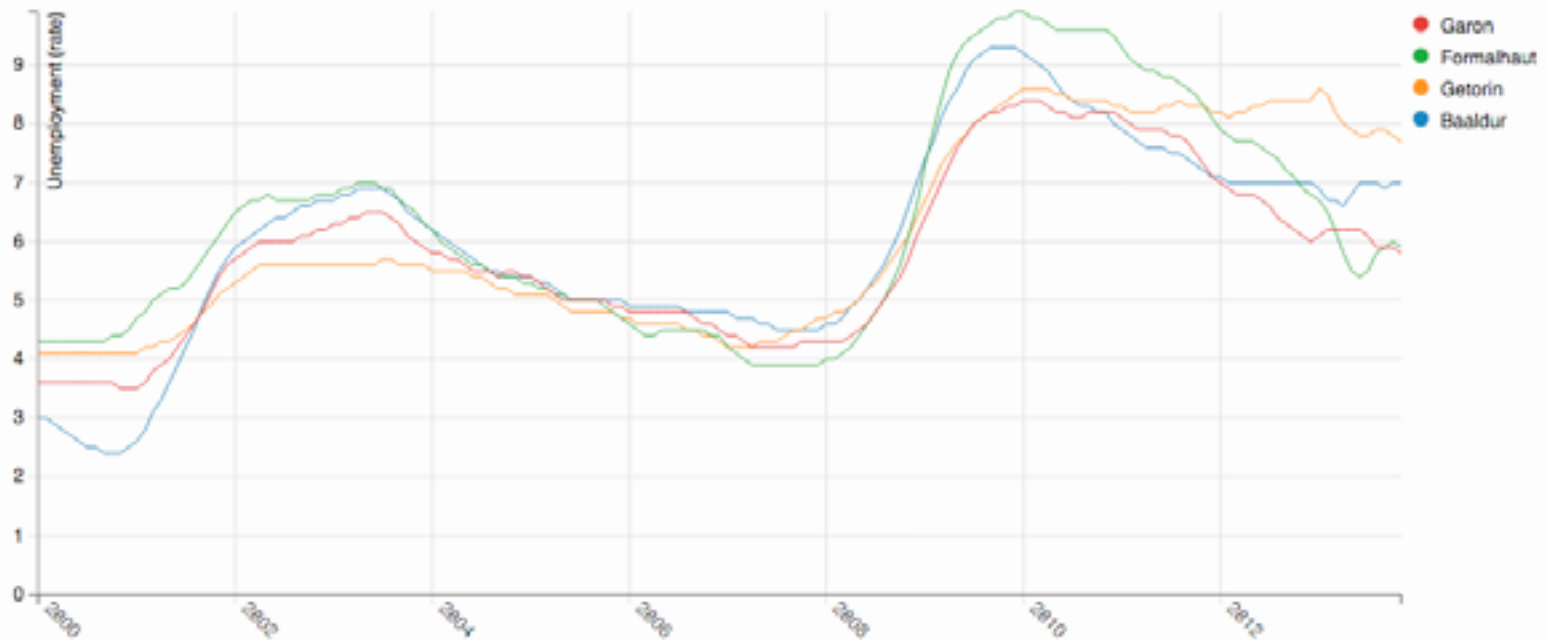
- Line Graph Test 1
- Line Graph Test 2
- Bar Chart Test
- Scatterplot Test



*A principled way of assessing visualization literacy.*

**Question:** Even though there has been some variation, has the unemployment trend generally increased on planet **Garon** since the beginning of this time period?

**Evolution of Unemployment Rate on 4 Planets**



Yes No

Timer: 10 seconds

[26/73]

*A principled way of assessing visualization literacy.*

*Administer...*



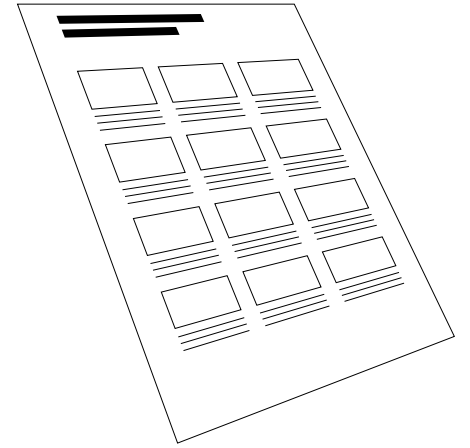
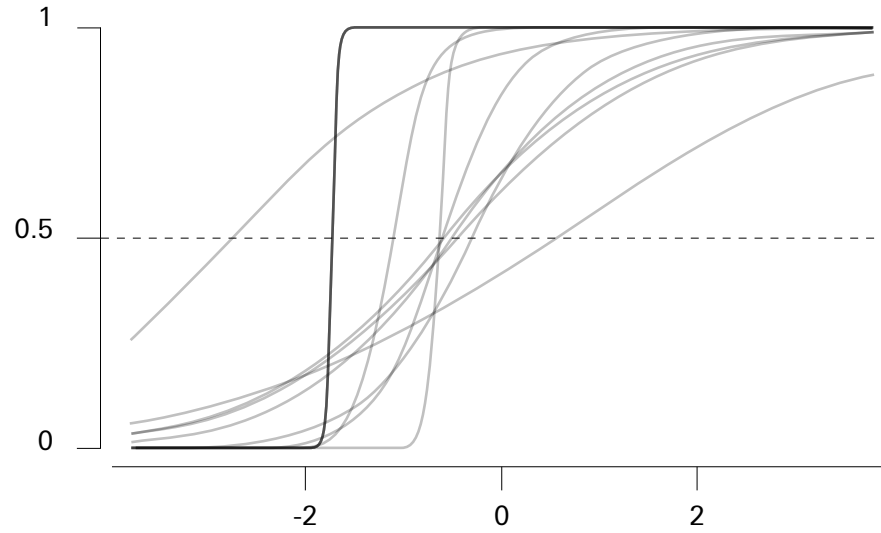
Procedure:

1. check that the **simplest variant of IRT** fits the data,
2. find the **best variant of the model**, and
3. assess the **usefulness of each item**.

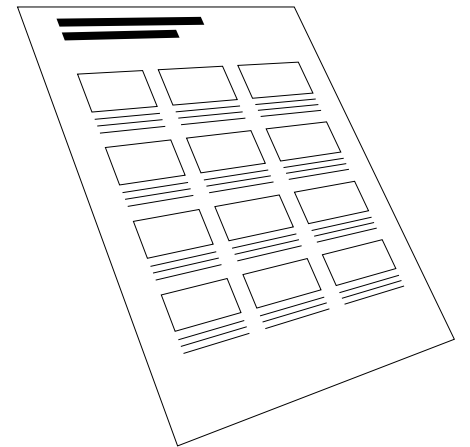
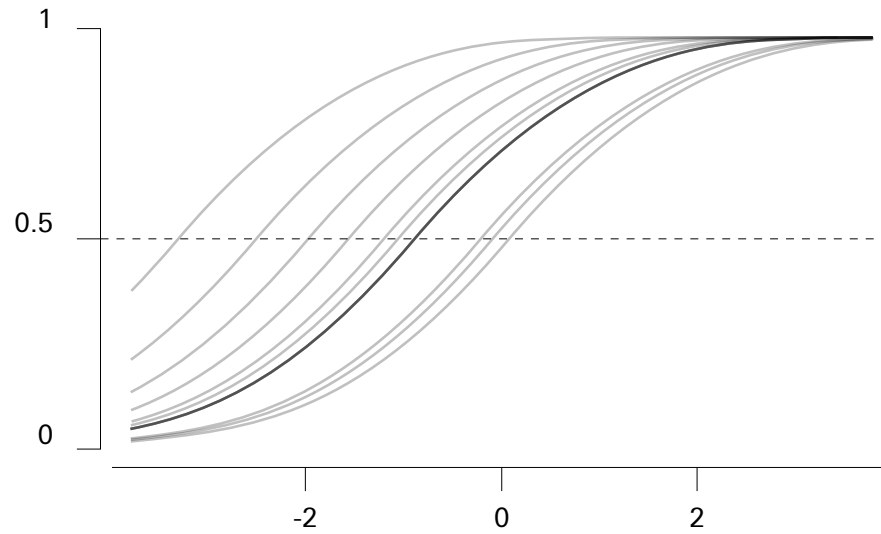
*Calibrate.*

*A principled way of assessing visualization literacy.*

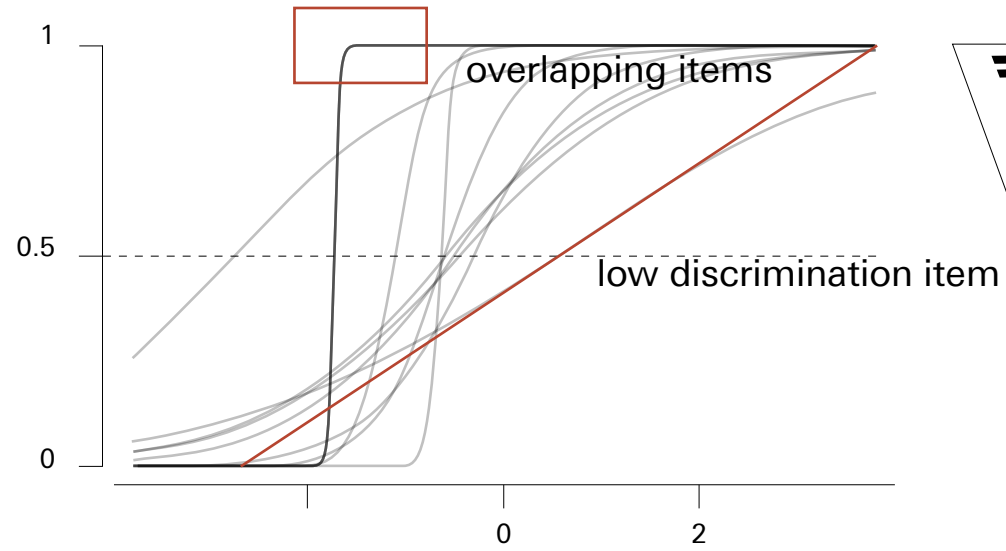
*Item characteristics curves for the Line Graph Test 1.*



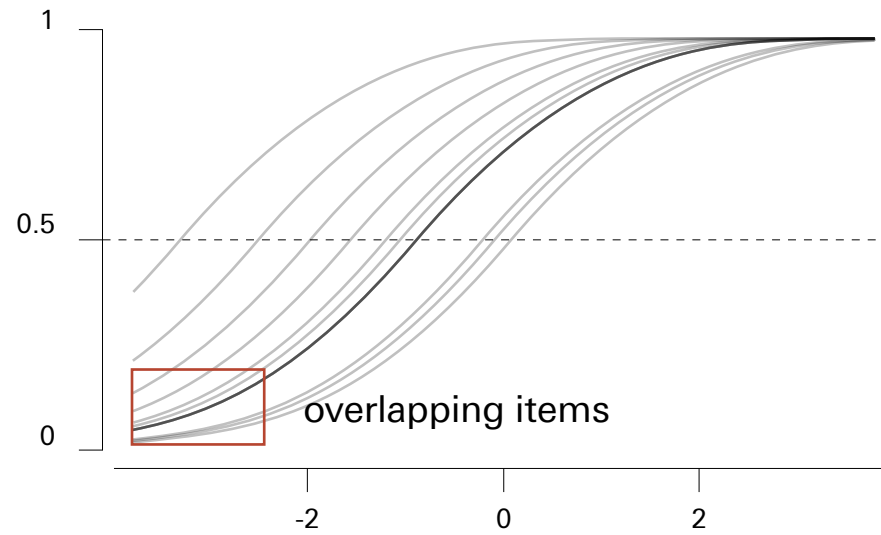
*Item characteristics curves for the Line Graph Test 2.*



*Item characteristics curves for the Line Graph Test 1.*



*Item characteristics curves for the Line Graph Test 2.*



Our method consists of two phases:

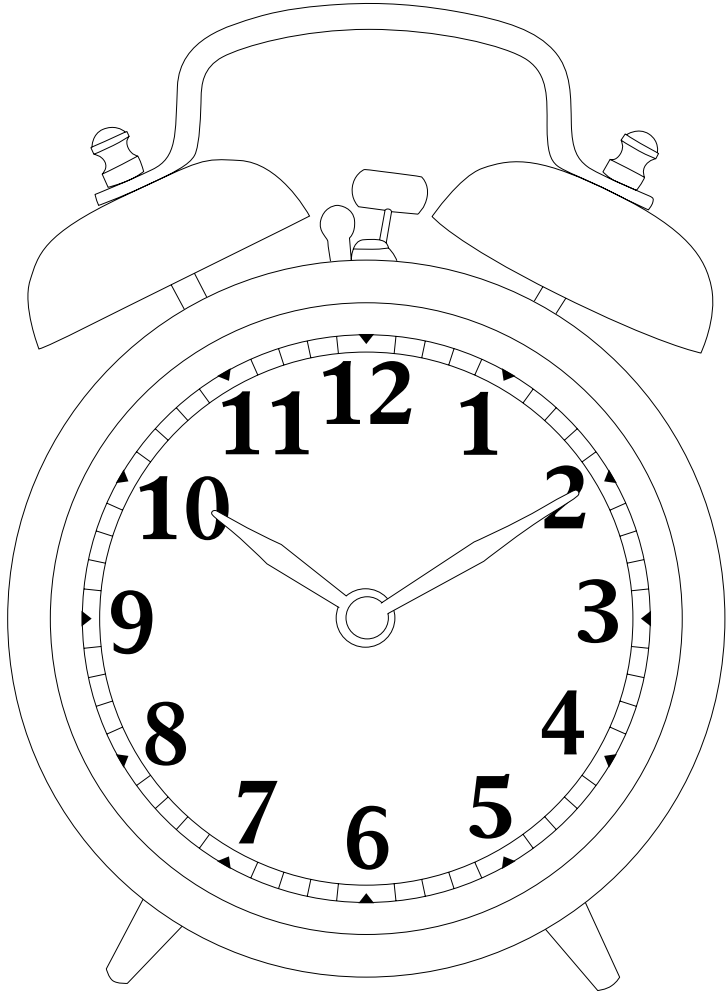
**1. a design phase: create, administer and calibrate tests, and**

**2. an assessment phase: retrieve examinees' visualization literacy scores.**

*A principled way of assessing visualization literacy.*

Test	Different scores	Score range	Examinees above average	Mean
Line Graph 1	27	[-1.85, 1]	40.7%	-0.27
Line Graph 2	33	[-1.83, 1.19]	39.4%	-0.17
Bar Chart	21	[-1.67, 0.99]	42.8%	-0.39
Scatterplot	23	[-1.72, 0.72]	43.5%	[-0.14] (median)

*A principled way of assessing visualization literacy.*



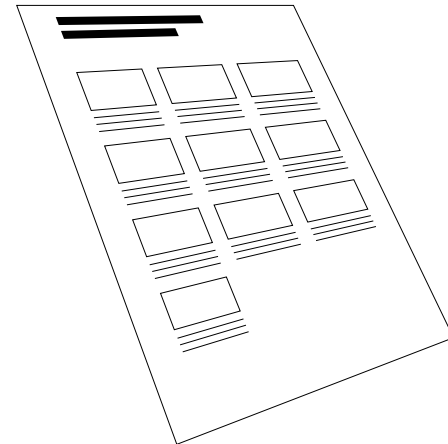


*A principled way of assessing visualization literacy.*

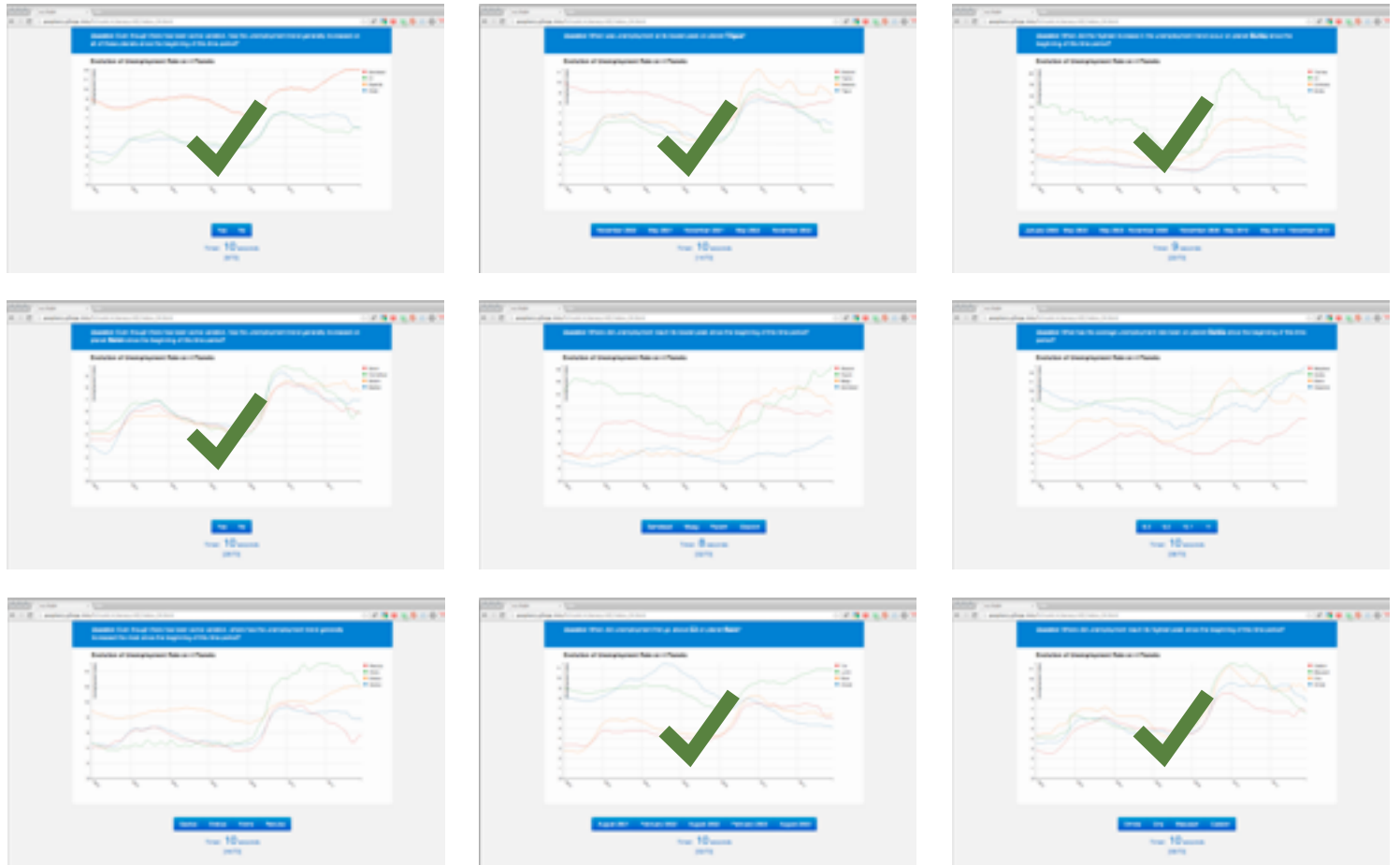
<b>Item 1</b>	<b>Item 2</b>	<b>Item n</b>	<b>Score</b> (logits)
0	0	0	s1
1	0	0	s2
0	1	0	s3
0	0	1	s4
0	1	1	s5
1	1	0	s6
1	0	1	s7
1	1	1	s8

*A principled way of assessing visualization literacy.*

<b>Item 1</b>	<b>Item 2</b>	<b>Item n</b>	<b>Score (logits)</b>
0	0	0	s1
1	0	0	s2
0	1	0	s3
0	0	1	s4
0	1	1	s5
1	1	0	s6
1	0	1	s7
1	1	1	s8



*A principled way of assessing visualization literacy.*



= **Score** (logits)

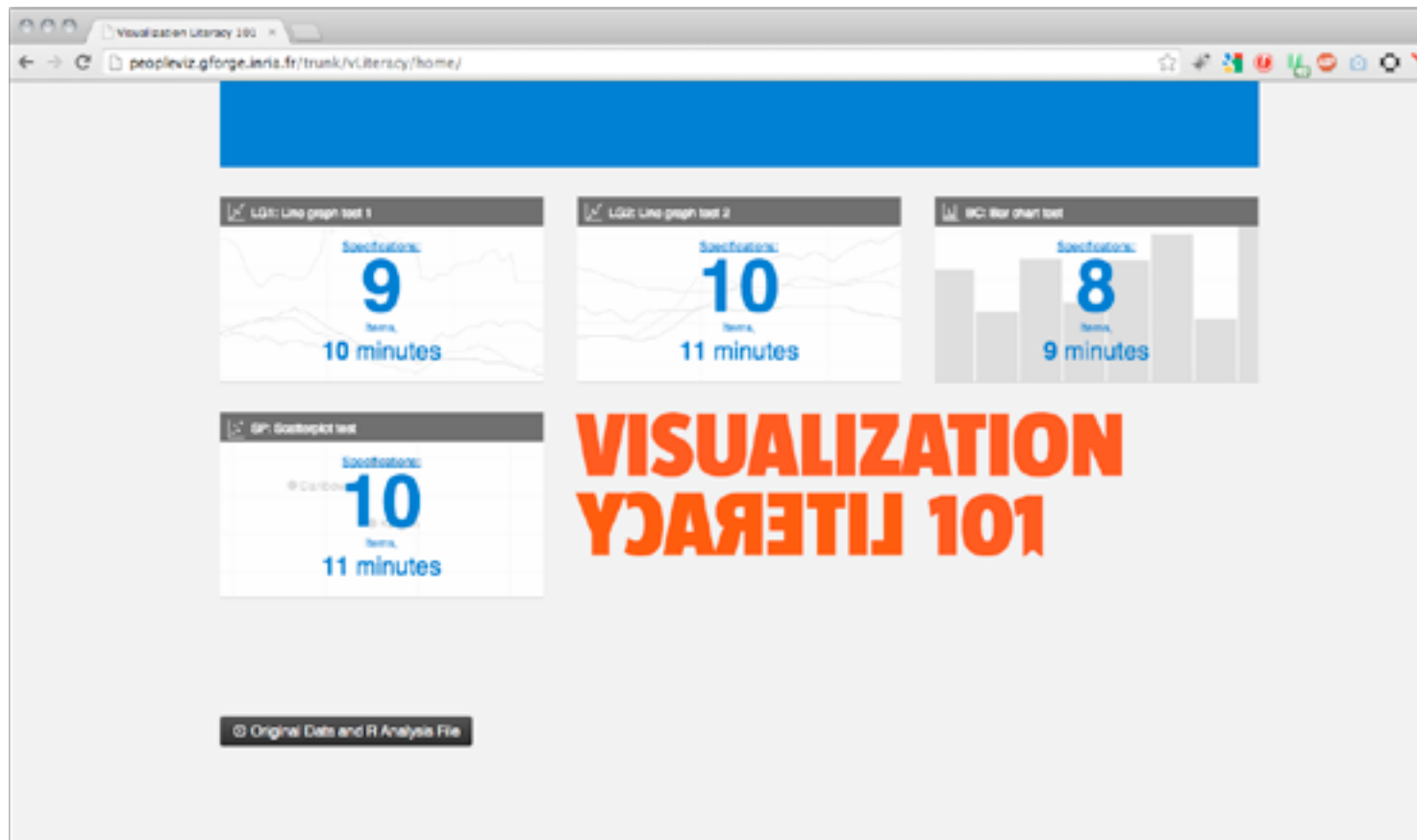
## **IV — Conclusion.**

***Conclusion.***

This presentation:

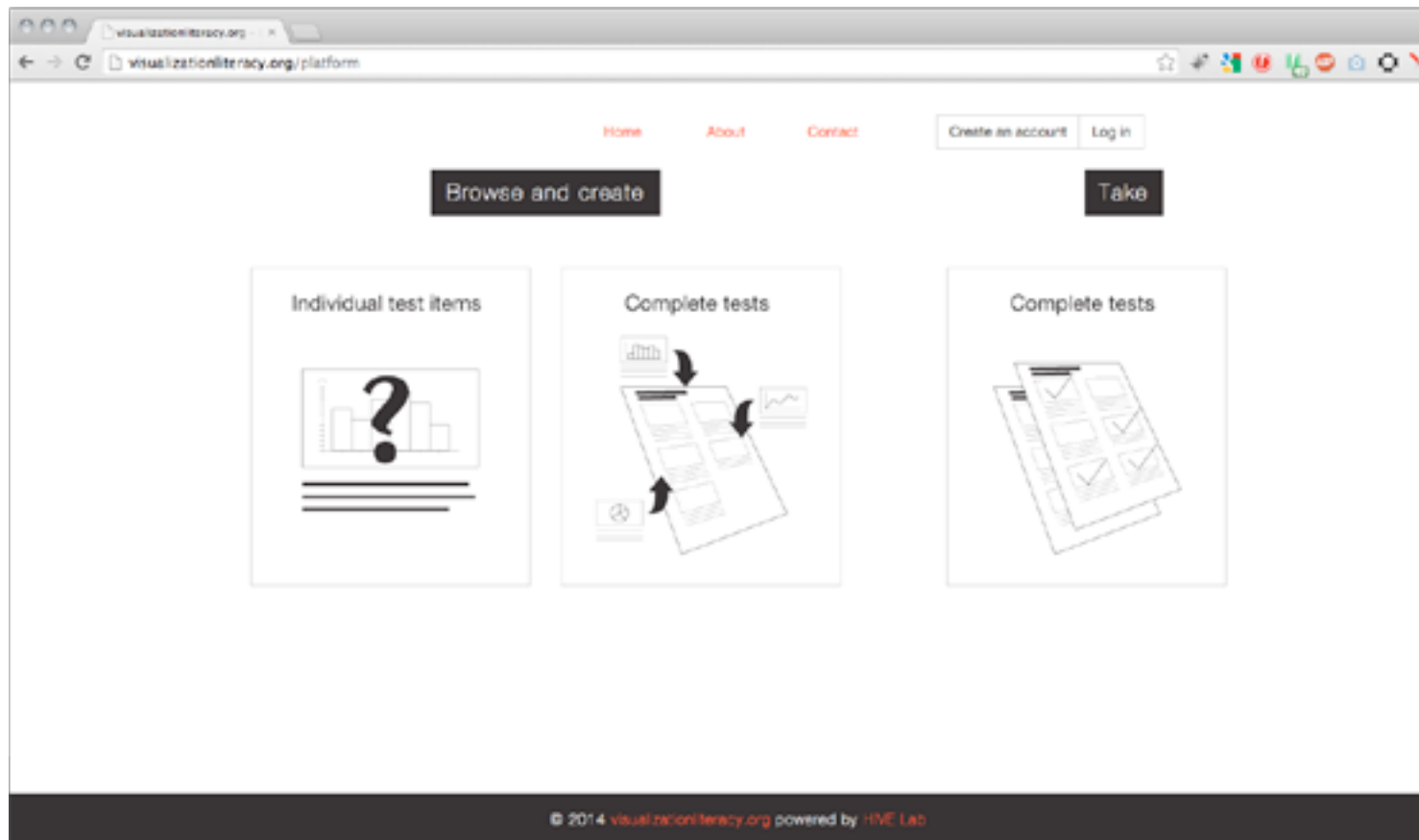
- a **practical definition** of visualization literacy,
- a **test-item parametric design space**, and
- a **principled way of assessing visualization literacy**:
  - › *design phase*
  - › *assessment phase.*

*Conclusion.*



<http://tiny.cc/vLiteracy>

*Conclusion.*



<http://visualizationliteracy.org/platform/>