E-411 PRMA

LECTURE 9 & 10 - ITEM RESPONSE THEORY

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ITEM ANALYSIS

- Many different ways to analyze items
- Can focus on
  - Difficulty of item
  - Reliability of item
  - Validity of item
  - Discrimination of item

ISSUES IN TEST DEVELOPMENT

Guessing

Bias in favor of one group - differential item functioning

Test length and duration of testing session

ALTERNATIVES TO ITEM ANALYSIS

Think Alouds

Expert Panels

Interviews

Qualitative Methods

TEST REVISION

- On what basis should we revise our items?
- Too easy or too hard items?
- Items with similar difficulty that are measuring the same concept?
- Items with negative point-biserial correlations?
- Items that on a second/third read through seem unrelated to the construct?
- Items with low factor loadings?
- Based on IRT?

STANDARDIZATION

- We settle on our revisions
- Administer revised version to new sample
- This becomes our comparsion group, our standardization sample

REVISING OLD TESTS

- Tests need to be revised when the domain has significantly changed
- Content of the items is not understood or changed
- Test norms are no longer adequate
- Theory underlying the domain has changed
- Reliability and validity of the instrument can be improved

CROSS- AND CO-VALIDATION

- Cross-validation - revalidation of a test on a seperate, independent sample of testtakers
- Item validities should shrink during this process (validity shrinkage)
- Co-validation - test validation conducted on two or more tests with the same sample of testtakers
- Creating norms, co-norming
- Cheaper, reduces sampling error by norming on the same sample

TODAY

Item Response Theory

REVIEW

Classical Test Theory

$$X = T + E$$

$$\sigma_X^2 = \sigma_T^2 + \sigma_E^2$$

$$\sigma_{\text{SEM}} = \sigma\sqrt{1 - r_{xx}}$$

CRITIQUES OF CTT

- Person are measured on number correct
- Score dependent on number of items on a test and their difficulty
- Scores are limited to fixed values
- Scores are interpretable on a within-group normative basis
- SEM is group dependent and constant for a group
- Item and person fit evaluation difficult
- Test development different depending on type of test

ITEM RESPONSE THEORY RATIONALE

- In an nutshell, IRT is able to address all of these criticisms
- BUT, makes stronger assumptions and requires a larger sample size

WHAT IS ITEM RESPONSE THEORY?

A measurement perspective

A series of non-linear models

Links manifest variables with latent variables

Latent characteristics of individuals and items are predictors of observed responses

Not a "how" or "why" theory

GENERALIZED ANXIETY DISORDER

- Anxiety could be loosely defined as feelings that range from general uneasienss to incapcitating attacks of terror
- Is anxiety latent and is it continuous, categorical, or both?
  - Categorical - Individuals can be placed into a high anxiety latent class and a low anxiety latent class
  - Continuous - Individuals fall along an anxiety continuum
  - Both - Given a latent class (e.g. the high anxiety latent class), within this class there is a continuum of even greater anxiety.

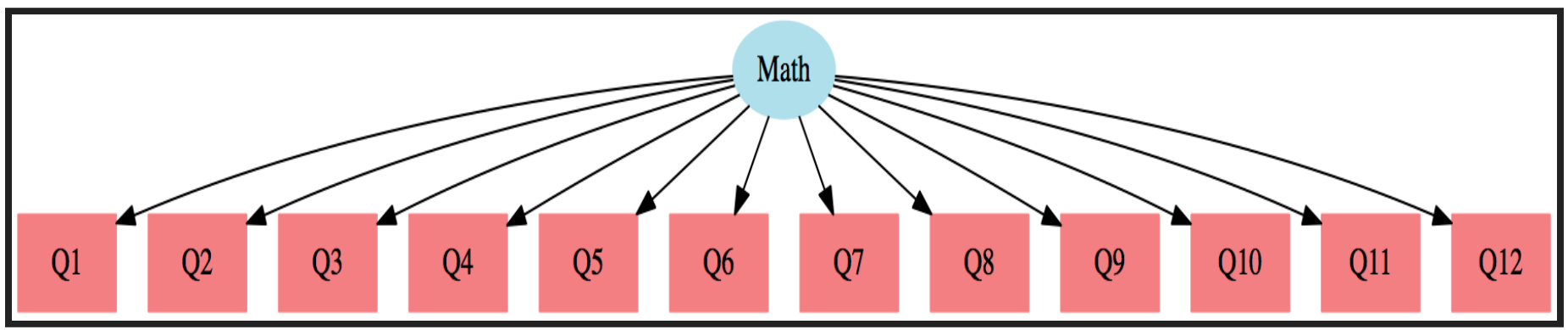
HOW TO MEASURE GENERALIZED ANXIETY?

- Used observed (i.e. **manifest variables**) that provide a proxy of generalized anxiety
- These provide our **operationalized definition** of generalized anxiety
- But how do we put these observed measures onto the generalized anxiety scale?

PROPERTIES OF IRT

1. Manifest variables differentiate among persons at different locations on the latent scale
2. Items are characterized by location and ability to discriminate among persons
3. Items and persons are on the same scale
4. Parameters estimated in a sample are linearly transformable to estimates of those parameters from another sample
5. Yields scores that are independent of number of items, item difficulty, and the individuals it is measured on, and are placed on a real-number scale

ASSUMPTIONS OF IRT



Response of a person to an item can be modeled with the a specific item reponse function

ITEM PARAMETERS

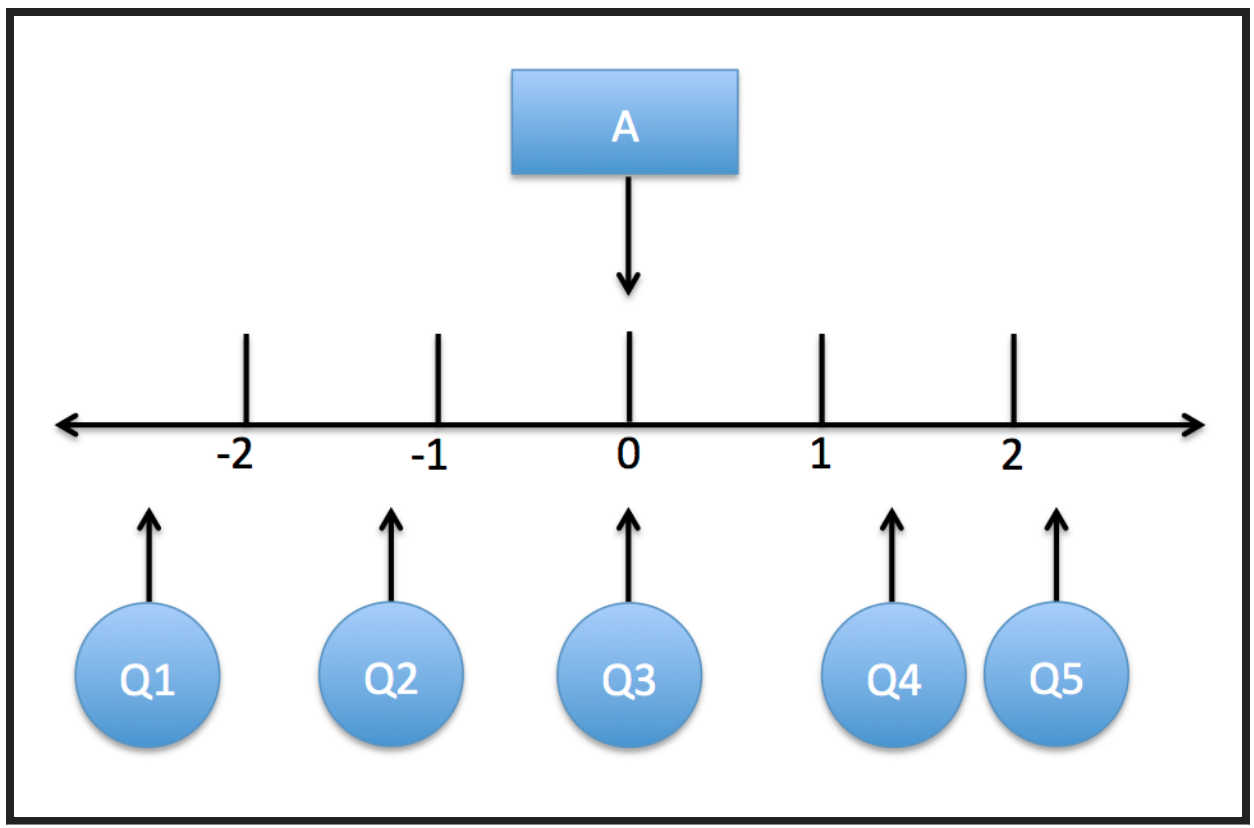
IRT: Item parameters estimated in one sample from a population are linearly transformable to estimates of those parameters on another sample from the same population. This makes it possible to create large pools of items that have been **linked** by this transformation process onto a common scale.

Unlike CTT, **equating occurs automatically** as a result of linking, without assumption of score distributions. This makes it possible to compare on a common scale persons measured in different groups and with different items.

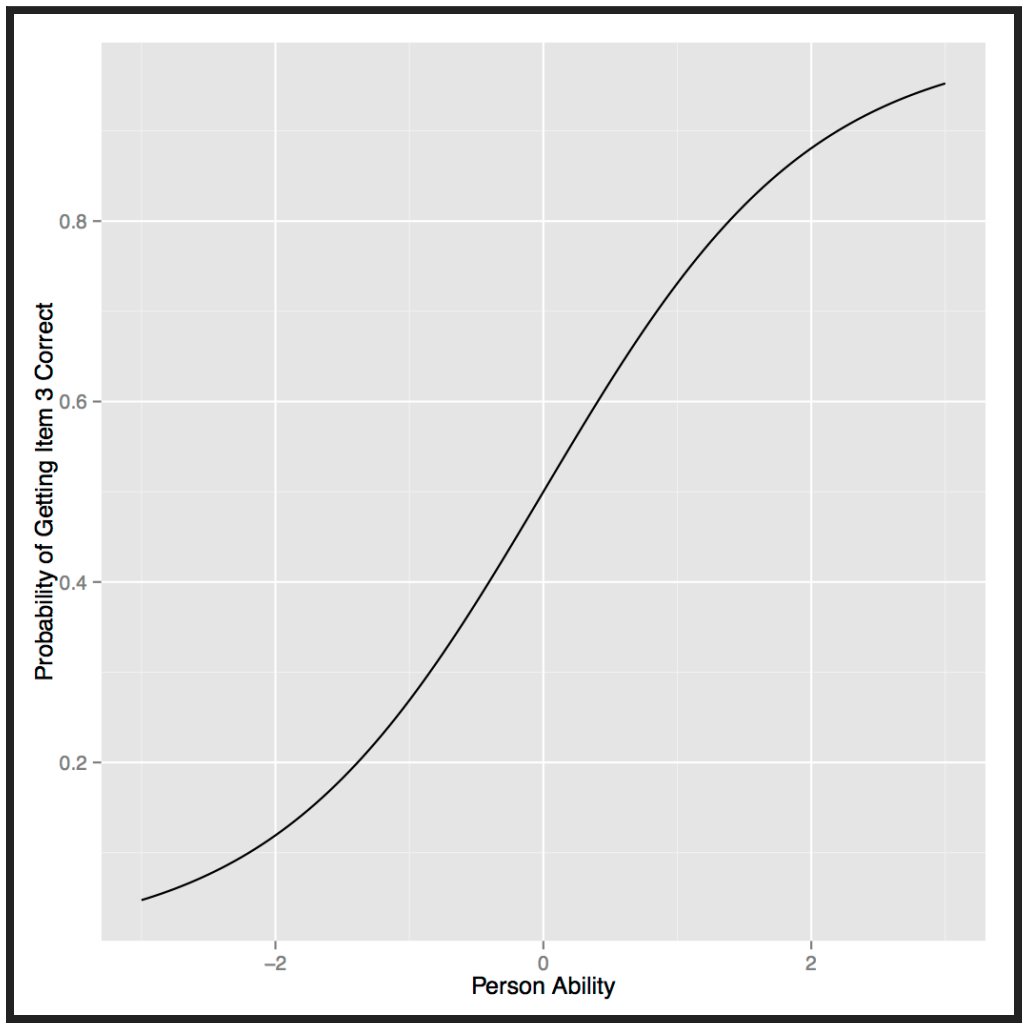
OTHER TRAITS OF IRT

- Use test information function for designing a test
- Has methods for examing item fit for identifying items that misfit
- Has methods for examing person fit for identifying persons that misfit
- Adaptive testing can be implemented (e.g. CAT)
- IRT is a family of models for various response types and could be used with multidimensional data.

IRT CONCEPTUALLY



ITEM RESPONSE FUNCTION (IRF)



THE RASCH MODEL

The logistic model

$$p(x = 1|z) = \frac{e^z}{1-e^z}$$

The logistic regression model

$$p(x = 1|g) = \frac{e^{\beta_0+\beta_1 g}}{1-e^{\beta_0+\beta_1 g}}$$

The Rasch model

$$p(x_j = 1|\theta, b_j) = \frac{e^{\theta-b_j}}{1-e^{\theta-b_j}}$$

So, the Rasch model is just the logistic regression model in disguise

WHAT DOES $\theta - b_j$ MEAN

```
rasch <- function(person, item) {
exp(person - item\) (1 + exp(person - item))
}
rasch(person = 1, item = 1.5)
# [1] 0.3775407

rasch(person = 1, item = 1)
# [1] 0.5
```

https://lundinn.shinyapps.io/rasch

shinyapps.io

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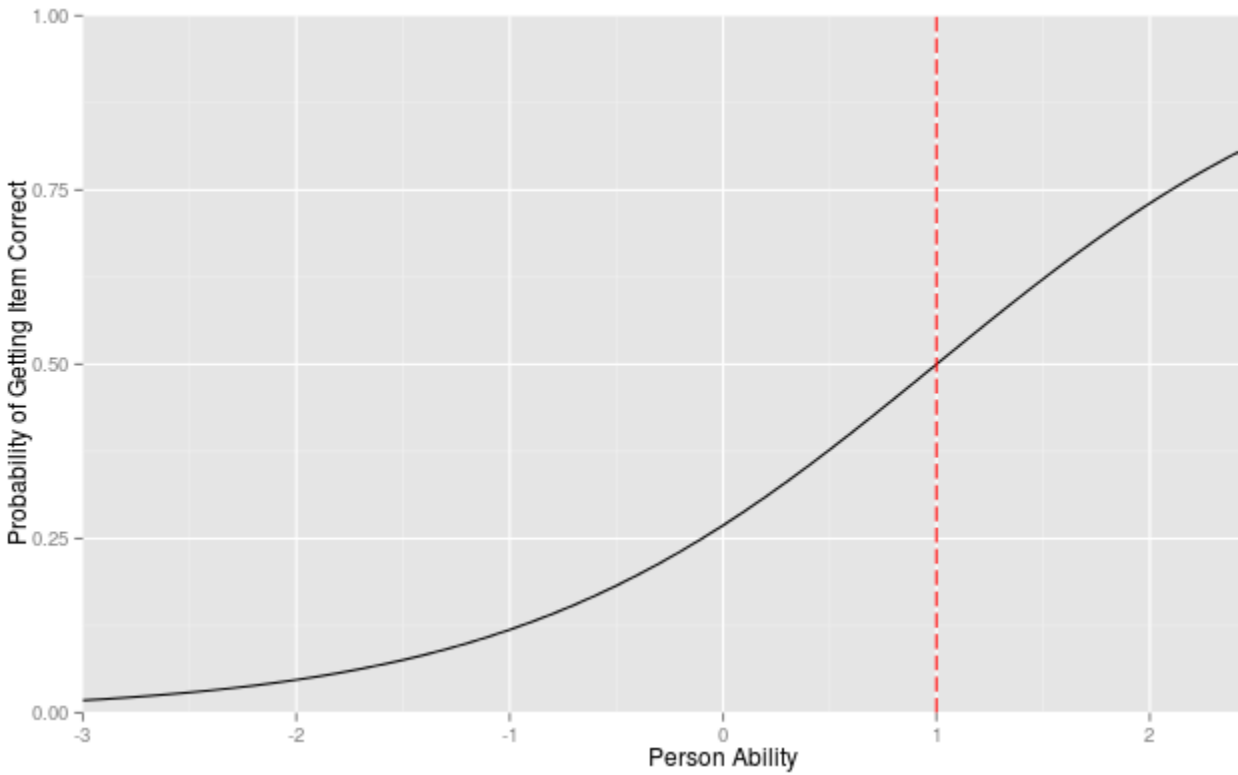
Rasch Model

Item Difficulty

-3 1 3

-3 -2 -1 0 1 2 3



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2PL IRT model

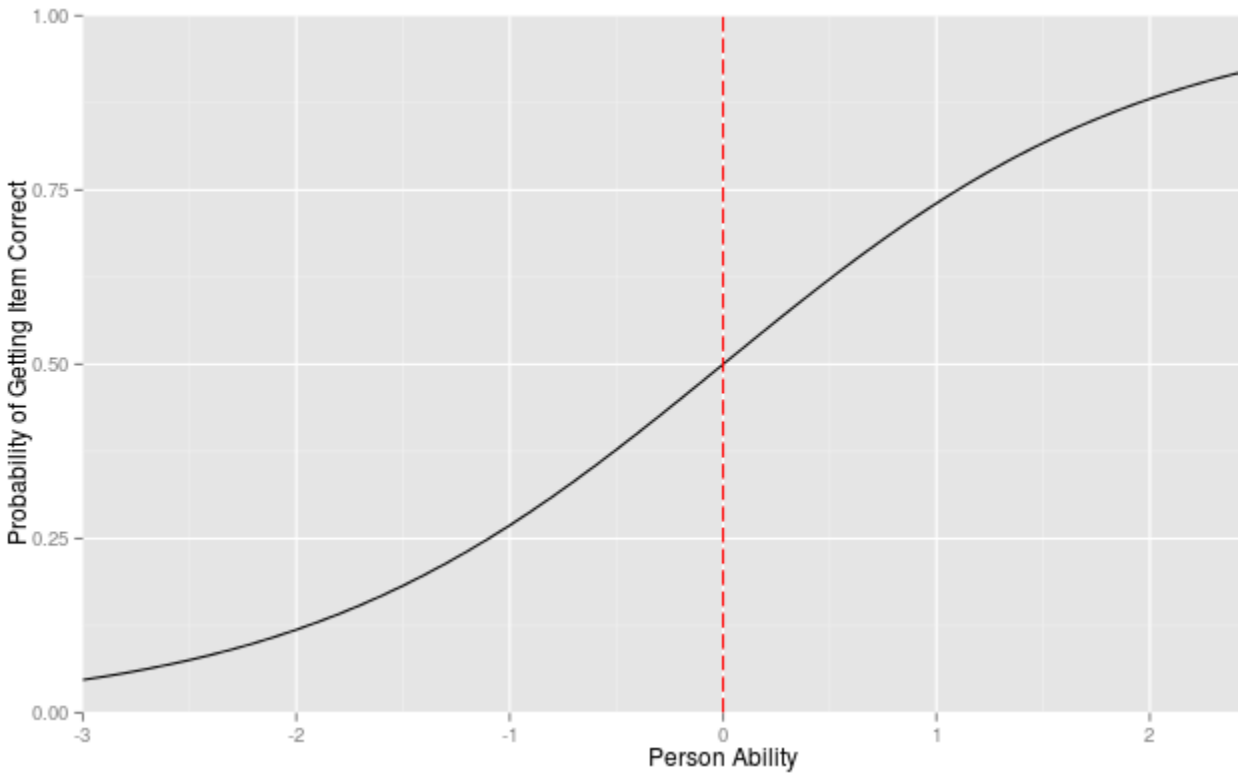
Item Difficulty

0

Item Discrimination

-3 1 3

-3 -2 -1 0 1 2 3



https://lundinn.shinyapps.io/threepl

shinyapps.io

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3PL IRT model

Item Difficulty

0

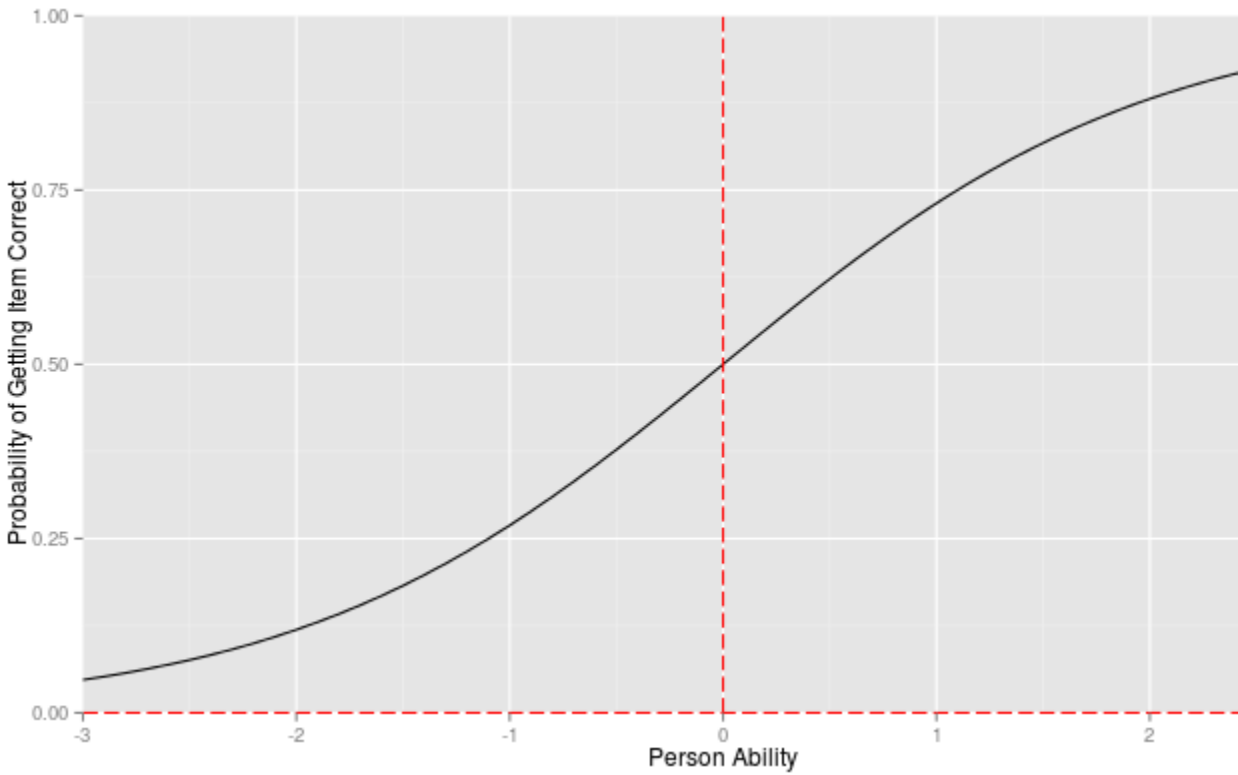
Item Discrimination

1

Guessing

0 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1



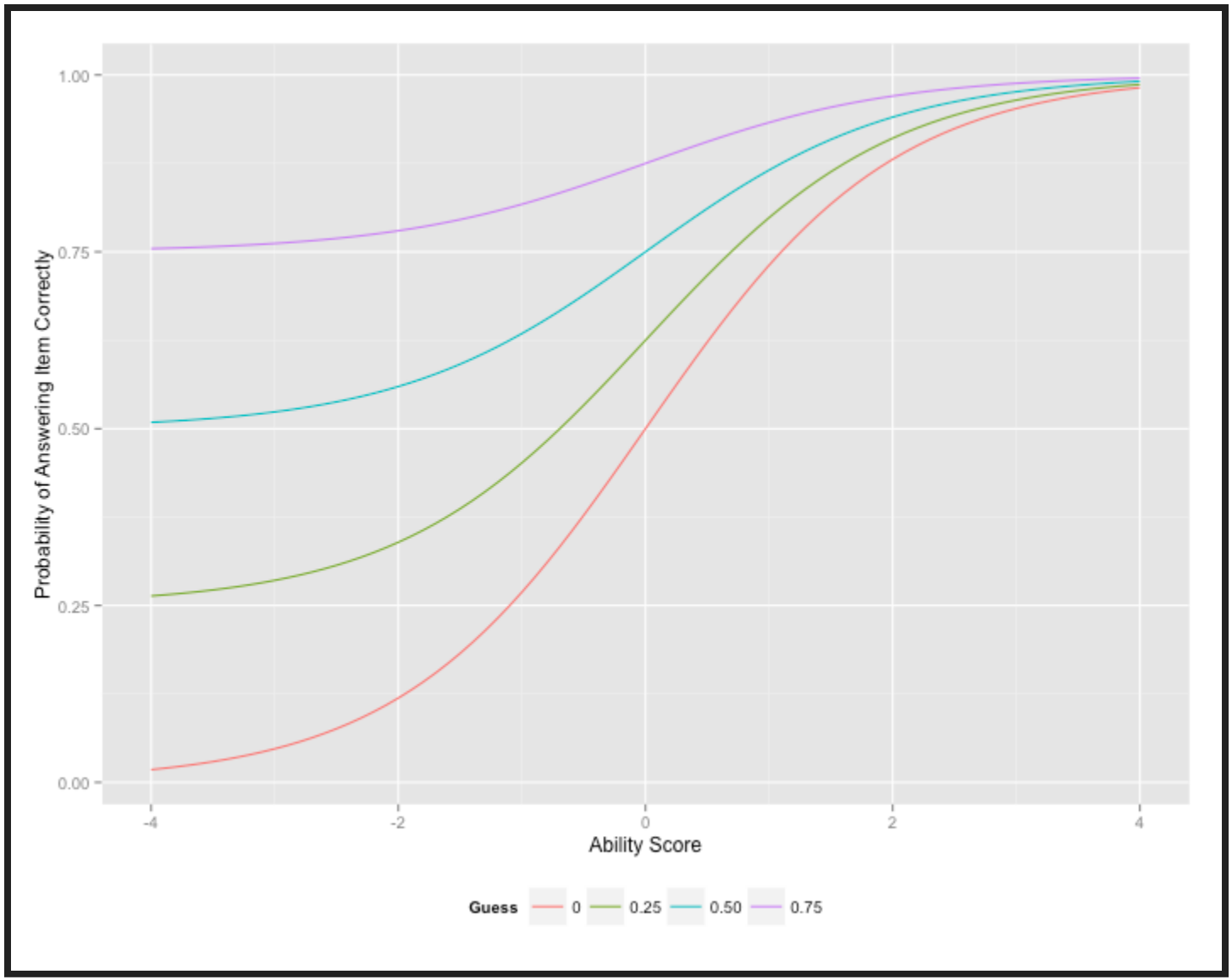
GETTING ITEM CORRECT RECAP

For the 1-PL and the Rasch, the probability of getting an item correct is a function of the distance an item is located from a person.

For the 2-PL, this is also a function of how well the item differentiates among people at different locations.

For the 3-PL, include item difficulty, item discrimination, and guessing

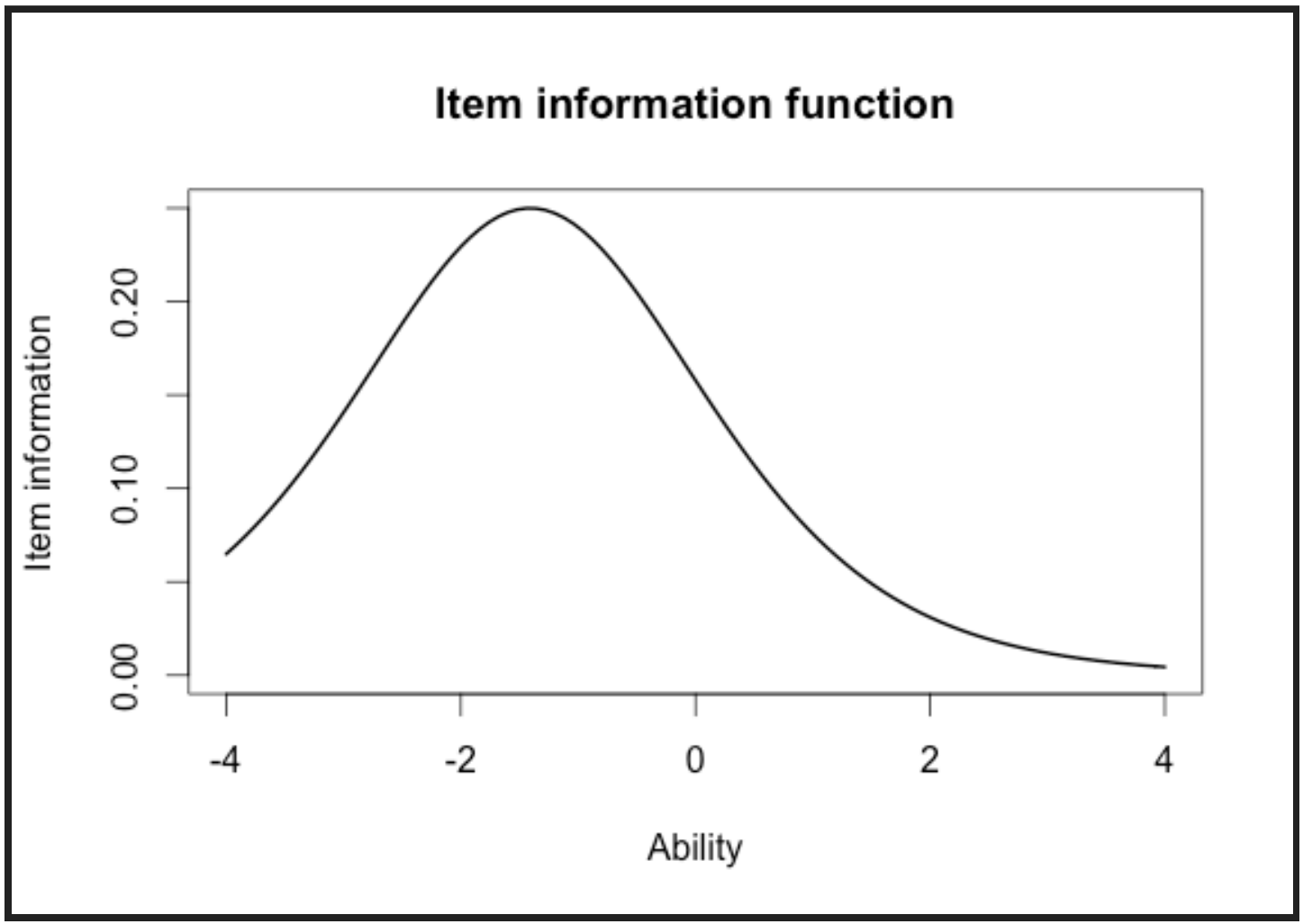
GUESSING PARAMETER



STANDARD ERROR OF ESTIMATE AND INFORMATION

- Similar to the SEM, the standard error of estimate (SEE) allows us to quantify uncertainty about score of a person within IRT
- Information is the inverse of the SEE and tells us how precise our estimates
- We can use this to select items and develop tests!
- See can also create 95% confidence intervals with this information

ITEM INFORMATION FUNCTION



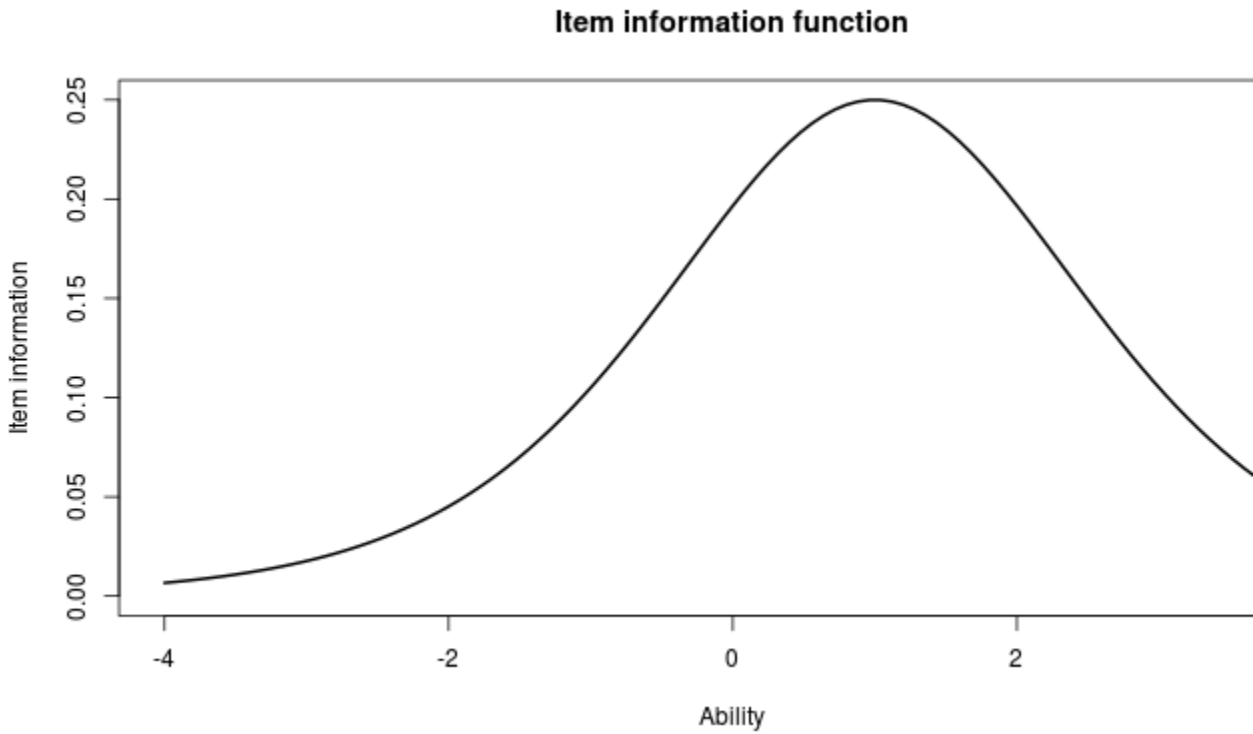
http://130.208.71.121:3838/rasch_information/

Rasch Information

Item Difficulty

-3 1 3

-3 -2 -1 0 1 2 3



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2PL IRT information

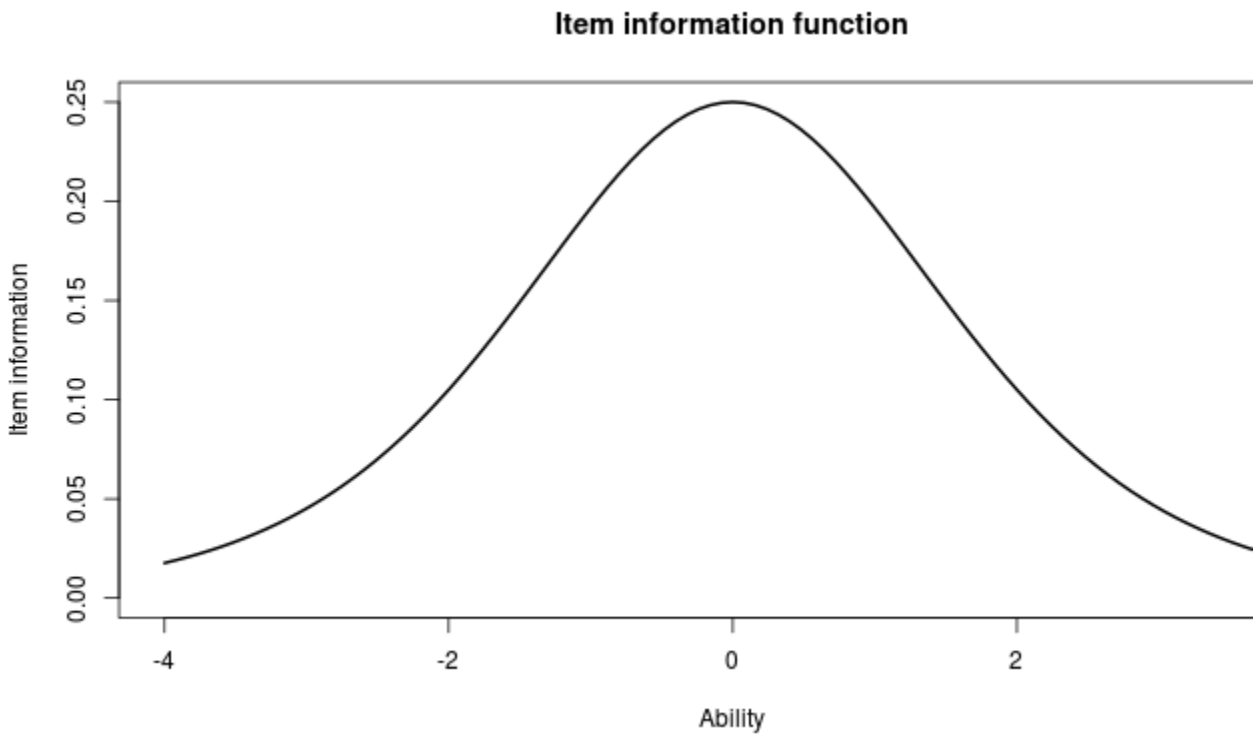
Item Difficulty

0

Item Discrimination

1 3

1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3



http://130.208.71.121:3838/threepl_information/

3PL IRT model

Item Difficulty

0

Item Discrimination

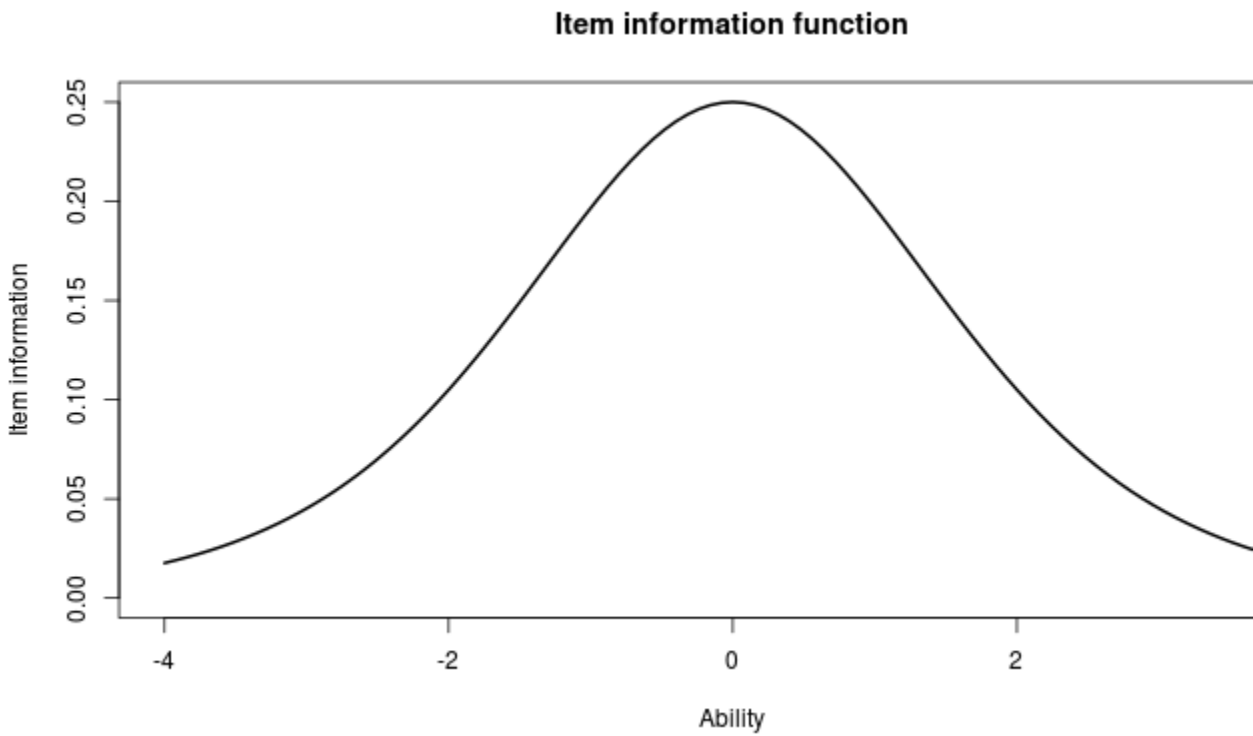
1 3

1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3

Guessing

0 1

0 0.25 0.5 0.75 1



TEST INFORMATION FUNCTION