

**CHAPTER 6**  
**The Information Function**

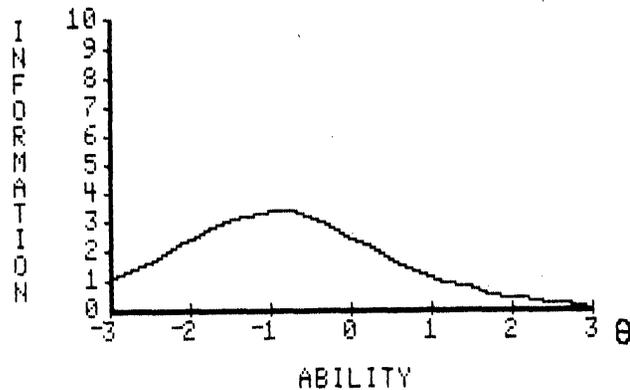
## CHAPTER 6

### The Information Function

When you speak of having information, it implies that you know something about a particular object or topic. In statistics and psychometrics, the term *information* conveys a similar, but somewhat more technical, meaning. The statistical meaning of information is credited to Sir R.A. Fisher, who defined information as the reciprocal of the precision with which a parameter could be estimated. Thus, if you could estimate a parameter with precision, you would know more about the value of the parameter than if you had estimated it with less precision. Statistically, the precision with which a parameter is estimated is measured by the variability of the estimates around the value of the parameter. Hence, a measure of precision is the variance of the estimators, which is denoted by  $\sigma^2$ . The amount of information, denoted by  $I$ , is given by the formula:

$$I = \frac{1}{\sigma^2} \quad [6-1]$$

In item response theory, our interest is in estimating the value of the ability parameter for an examinee. The ability parameter is denoted by  $\theta$ , and  $\hat{\theta}$  is an estimator of  $\theta$ . In the previous chapter, the standard deviation of the ability estimates about the examinee's ability parameter was computed. If this term is squared, it becomes a variance and is a measure of the precision with which a given ability level can be estimated. From equation 6-1, the amount of information at a given ability level is the reciprocal of this variance. If the amount of information is large, it means that an examinee whose true ability is at that level can be estimated with precision; i.e., all the estimates will be reasonably close to the true value. If the amount of information is small, it means that the ability cannot be estimated with precision and the estimates will be widely scattered about the true ability. Using the appropriate formula, the amount of information can be computed for each ability level on the ability scale from negative infinity to positive infinity. Because ability is a continuous variable, information will also be a continuous variable. If the amount of information is plotted against ability, the result is a graph of the information function such as that shown below.



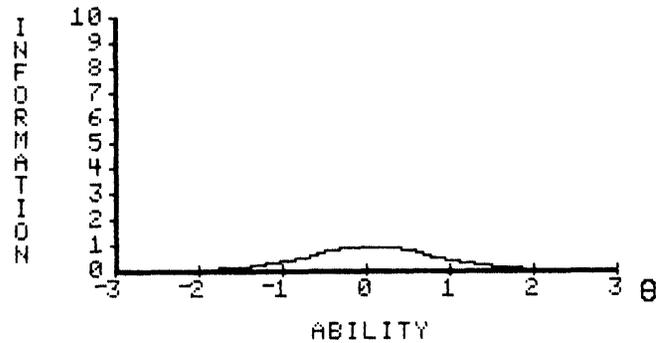
**FIGURE 6-1.** An information function

Inspection of Figure 6-1 shows that the amount of information has a maximum at an ability level of  $-1.0$  and is about 3 for the ability range of  $-2 < \theta < = \theta$ . Within this range, ability is estimated with some precision. Outside this range, the amount of information decreases rapidly, and the corresponding ability levels are not estimated very well. Thus, the information function tells us how well each ability level is being estimated. It is important for the reader to recognize that the information function does not depend upon the distribution of examinees over the ability scale. In this regard, it is like the item characteristic curve and the test characteristic curve. In a general-purpose test, the ideal information function would be a horizontal line at some large value of  $I$  and all ability levels would be estimated with the same precision. Unfortunately, such an information function is hard to achieve. The typical information function looks somewhat like that shown in Figure 6-1, and different ability levels are estimated with differing degrees of precision. This becomes of considerable importance to both the test constructor and the test consumer since it means that the precision with which an examinee's ability is estimated depends upon where the examinee's ability is located on the ability scale.

### Item Information Function

Since it depends upon the individual items composing a test, item response theory is what is known as an itemized theory. Under the theory, each item of the test measures the underlying latent trait. As a result, the amount of

information, based upon a single item, can be computed at any ability level and is denoted by  $I_i(\theta)$ , where  $i$  indexes the item. Because only a single item is involved, the amount of information at any point on the ability scale is going to be rather small. If the amount of item information is plotted against ability, the result is a graph of the item information function such as that shown below.



**FIGURE 6-2.** An item information function

An item measures ability with greatest precision at the ability level corresponding to the item's difficulty parameter. The amount of item information decreases as the ability level departs from the item difficulty and approaches zero at the extremes of the ability scale.

### Test Information Function

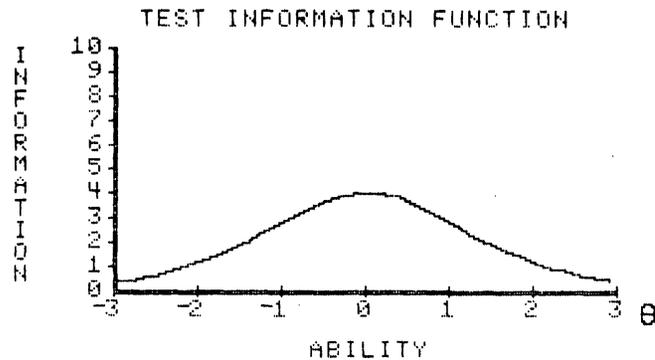
Since a test is used to estimate the ability of an examinee, the amount of information yielded by the test at any ability level can also be obtained. A test is a set of items; therefore, the test information at a given ability level is simply the sum of the item informations at that level. Consequently, the test information function is defined as:

$$I(\theta) = \sum_{i=1}^N I_i(\theta) \quad [6-2]$$

where:  $I(\theta)$  is the amount of test information at an ability level of  $\theta$ ,

$I_i(\theta)$  is the amount of information for item  $i$  at ability level  $\theta$ ,  
 $N$  is the number of items in the test.

The general level of the test information function will be much higher than that for a single item information function. Thus, a test measures ability more precisely than does a single item. An important feature of the definition of test information given in equation 6-2 is that the more items in the test, the greater the amount of information. Thus, in general, longer tests will measure an examinee's ability with greater precision than will shorter tests. Plotting the amount of test information against ability yields a graph of the test information function such as that shown below for a ten-item test.



**FIGURE 6-3.** A test information function

The maximum value of the test information function in Figure 6-3 is modest and, in this example, the amount of information decreases rather steadily as the ability level differs from that corresponding to the maximum. Thus, ability is estimated with some precision near the center of the ability scale. However, as the ability level approaches the extremes of the scale, the amount of test information decreases significantly.

The test information function is an extremely useful feature of item response theory. It basically tells you how well the test is doing in estimating ability over the whole range of ability scores. While the ideal test information function often may be a horizontal line, it may not be the best for a specific purpose. For example, if you were interested in constructing a test to award scholarships, this ideal might not be optimal. In this situation, you would like

to measure ability with considerable precision at ability levels near the ability used to separate those who will receive the scholarship from those who do not. The best test information function in this case would have a peak at the cutoff score. Other specialized uses of tests could require other forms of the test information function.

While an information function can be obtained for each item in a test, this is rarely done. The amount of information yielded by each item is rather small, and we typically do not attempt to estimate an examinee's ability with a single item. Consequently, the amount of test information at an ability level and the test information function are of primary interest. Since the test information is obtained by summing the item informations at a given ability level, the amount of information is defined at the item level. The mathematical definition of the amount of item information depends upon the particular item characteristic curve model employed. Therefore, it is necessary to examine these definitions under each model.

## Definition of Item Information

### Two-Parameter Item Characteristic Curve Model

Under a two-parameter model, the item information function is defined as:

$$I_i(\theta) = a_i^2 P_i(\theta) Q_i(\theta) \quad [6-3]$$

where:  $a_i$  is the discrimination parameter for item  $i$ :

$$P_i(\theta) = 1 / (1 + \text{EXP}(-a_i(\theta - b_i))),$$

$$Q_i(\theta) = 1 - P_i(\theta),$$

$\theta$  is the ability level of interest.

To illustrate the use of equation 6-3, the amount of item information will be computed at seven ability levels for an item having parameter values of  $b = 1.0$  and  $a = 1.5$ .

$\theta$	$L$	$\text{EXP}(-L)$	$P_i(\theta)$	$Q_i(\theta)$	$P_i(\theta)Q_i(\theta)$	$a^2$	$I_i(\theta)$
-3	-6	403.43	.00	1.00	.00	2.25	.00
-2	-4.5	90.02	.01	.99	.01	2.25	.02
-1	-3.0	20.09	.05	.95	.05	2.25	.11
0	-1.5	4.48	.18	.82	.15	2.25	.34
1	0.0	1.00	.50	.50	.25	2.25	.56
2	1.5	.22	.82	.18	.15	2.25	.34
3	3.0	.05	.95	.05	.05	2.25	.11

**Table 6-1.** Calculation of item information under a two-parameter model,  $b = 1.0$ ,  $a = 1.5$

This item information function increases rather smoothly as ability increases and reaches a maximum value of .56 at an ability of 1.0. After this point, it decreases. The obtained item information function is symmetrical about the value of the item's difficulty parameter. Such symmetry holds for all item information functions under one- and two-parameter models. When only a single item is involved and the discrimination parameter has a moderate value, the magnitude of the amount of item information is quite small.

### One-Parameter Item Characteristic Curve Model

Under a one-parameter (Rasch) model, the item information is defined as:

$$I_i(\theta) = P_i(\theta) Q_i(\theta) \quad [6-4]$$

This is exactly the same as that under a two-parameter model when the value of the discrimination parameter is set to 1. To illustrate the use of equation 6-4, the amount of item information will be calculated for an item having a difficulty parameter of 1.0.

$\theta$	$L$	$EXP(-L)$	$P_i(\theta)$	$Q_i(\theta)$	$P_i(\theta)Q_i(\theta)$	$a^2$	$I_i(\theta)$
-3	-4.0	45.60	.02	.98	.02	1	.02
-2	-3.0	20.09	.05	.95	.05	1	.05
-1	-2.0	7.39	.12	.88	.11	1	.11
0	-1.0	2.72	.27	.73	.20	1	.20
1	0.0	1.00	.50	.50	.25	1	.25
2	1.0	.37	.73	.27	.20	1	.20
3	2.0	.14	.88	.12	.11	1	.11

**Table 6-2.** Calculation of the item information under the Rasch model,  $b = 1.0$

The general level of the amount of information yielded by this item is somewhat lower than that of the previous example. This is a reflection of the value of the item discrimination parameter being smaller than that of the

previous item. Again, the item information function is symmetric about the value of the difficulty parameter.

### Three-Parameter Item Characteristic Curve Model

In Chapter 2, it was mentioned that the three-parameter model does not possess the nice mathematical properties of the logistic function. The loss of these properties becomes apparent in the complexity of the equation given below for the amount of item information under this model.

$$I_i(\theta) = a^2 \left[ \frac{Q_i(\theta)}{P_i(\theta)} \right] \left[ \frac{P_i(\theta) - c^2}{(1 - c^2)} \right] \quad [6-5]$$

where:  $P_i(\theta) = c + (1 - c) (1/(1 + EXP(-L)))$  and  $L = a(\theta - b)$   
 $Q_i = 1.0 - P_i(\theta)$ .

To illustrate the use of these formulas, the computations will be shown for an item having parameter values of  $b = 1.0$ ,  $a = 1.5$ ,  $c = .2$ . The values of  $b$  and  $a$  are the same as those for the preceding two-parameter example. The computations will be performed in detail at an ability level of  $\theta = 0.0$ .

$$L = 1.5 (0 - 1) = -1.5$$

$$EXP(-L) = 4.482$$

$$1/(1 + EXP(-L)) = .182$$

$$P_i(\theta) = c + (1 - c) (1/(1 + EXP(-L))) = .2 + .8 (.182) = .346$$

$$Q_i(\theta) = 1 - .346 = .654$$

$$Q_i(\theta)/P_i(\theta) = .654/.346 = 1.890$$

$$(P_i(\theta) - c)^2 = (.346 - .2)^2 = (.146)^2 = .021$$

$$(1 - c)^2 = (1 - .2)^2 = (.8)^2 = .64$$

$$a^2 = (1.5)^2 = 2.25$$

Then:

$$I_i(\theta) = (2.25) (1.890) (.021)/(.64) = .142$$

Clearly, this is more complicated than the computations for the previous two models, which are, in fact, logistic models. The amount of item information computations for this item at seven ability levels is shown below.

$\theta$	$L$	$P_i(\theta)$	$Q_i(\theta)$	$P_i(\theta)Q_i(\theta)$	$(P_i(\theta) - c)$	$I_i(\theta)$
-3	-6.0	.20	.80	3.950	.000	.000
-2	-4.5	.21	.79	3.785	.000	.001
-1	-3.0	.24	.76	3.202	.001	.016
0	-1.5	.35	.65	1.890	.021	.142
1	0.0	.60	.40	.667	.160	.375
2	1.5	.85	.15	.171	.428	.257
3	3.0	.96	.04	.040	.481	.082

**Table 6-3.** Calculations for the amount of item information under a three-parameter model,  $b = 1.0$ ,  $a = 1.5$ ,  $c = .2$

The shape of this information function is very similar to that for the preceding two-parameter example in which  $b = 1.0$  and  $a = 1.5$ . However, the general level of the values for the amount of information is lower. For example, at an ability level of  $\theta = 0$ , the item information was .142 under a three-parameter model and .34 under a two-parameter model having the same values of  $b$  and  $a$ . In addition, the maximum of the information function did not occur at an ability level corresponding to the value of the difficulty parameter. The maximum occurred at an ability level slightly higher than the value of  $b$ . Because of the presence of the terms  $(1 - c)$  and  $(P_i(\theta) - c)$  in equation 6-5, the amount of information under a three-parameter model will be less than under a two-parameter model having the same values of  $b$  and  $a$ . When they share common values of  $a$  and  $b$ , the information functions will be the same when  $c$

$= 0$ . When  $c > 0$ , the three-parameter model will always yield less information. Thus, the item information function under a two-parameter model defines the upper bound for the amount of information under a three-parameter model. This is reasonable, because getting the item correct by guessing should not enhance the precision with which an ability level is estimated.

## Computing a Test Information Function

Equation 6-2 defined the test information as the sum of the amount of item informations at a given ability level. Now that the procedures for calculating the amount of item information have been shown for the three item characteristic curve models, the test information function for a test can be computed. To illustrate this process, a five-item test will be used. The item parameters under a two-parameter model are as follows:

Item	b	a
1	-1.0	2.0
2	-0.5	1.5
3	-0.0	1.5
4	0.5	1.5
5	1.0	2.0

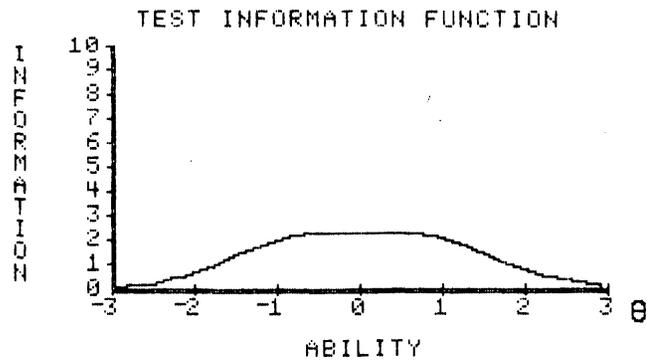
The amount of item information and the test information will be computed for the same seven ability levels used in the previous examples.

$\theta$	Item Information					Test
	1	2	3	4	5	Information
-	.071	.051	.024	.012	.001	.159
-	.420	.194	.102	.051	.010	.777
-	1.000	.490	.336	.194	.071	2.091
0	.420	.490	.563	.490	.420	2.383
1	.071	.194	.336	.490	1.000	2.091
2	.010	.051	.102	.194	.420	.777
3	.001	.012	.024	.051	.071	.159

**Table 6-4.** Calculations for a test information function based upon five items

Each of the item information functions was symmetric about the value of the item's difficulty parameter. The five item discriminations had a symmetrical distribution around a value of 1.5. The five item difficulties had a symmetrical distribution about an ability level of zero. Because of this, the test information function also was symmetric about an ability of zero. The graph of this test information function is shown in Figure 6-4.

The graph of the test information function shows that the amount of information was relatively flat over the range  $\theta = -1$  to  $\theta = +1$ ; outside of this range, the amount of information decreased rather rapidly. However, in Table 6-4, the values of the test information varied over the whole ability scale. The apparent flat section of the plotted test information function is due to the coarseness of the information scale in the graph.



**FIGURE 6-4.** Test information function for the five items of Table 6-4

### Interpreting the Test Information Function

$$SE(\theta) = \frac{1}{\sqrt{I(\theta)}}$$

While the shape of the  
desired test information  
function depends upon the  
purpose for which a test is

designed, some general interpretations can be made. A test information function that is peaked at some point on the ability scale measures ability with unequal precision along the ability scale. Such a test would be best for estimating the ability of examinees whose abilities fall near the peak of the test information function. In some tests, the test information function is rather flat over some region of the ability scale. Such tests estimate some range of ability scores with nearly equal precision and outside this range with less precision. Thus, the test would be a desirable one for those examinees whose ability falls in the given range. When interpreting a test information function, it is important to keep in mind the reciprocal relationship between the amount of information and the variability of the ability estimates. To translate the amount of information into a standard error of estimation, one need only take the reciprocal of the square root of the amount of test information.

[6-6]

For example, in Figure 6-4, the maximum amount of test information was 2.383 at an ability level of 0.0. This translates into a standard error of .65, which means roughly that 68 percent of the estimates of this ability level fall between -.65 and +.65. Thus, this ability level is estimated with a modest amount of precision.

### Computer Session for Chapter 6

The purpose of this computer session is to enable you to develop a sense of how the form of the test information function depends upon the parameters of the items constituting the test. You will establish the parameter values for the items in a small test, then the computer will display the test information function on the screen. You can try different item characteristic curve models to determine how the choice of model affects the shape of the test

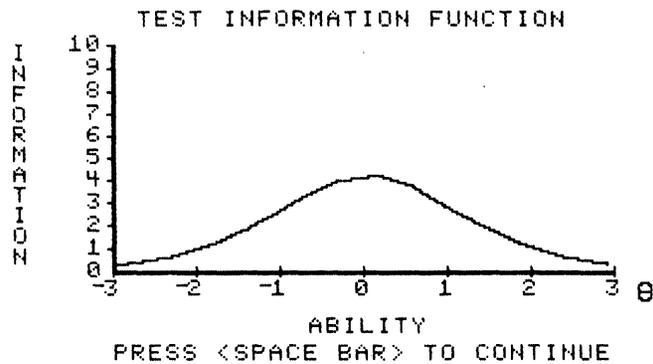
information function. Under each model, different mixes of item parameter values can be used and the resultant test information function obtained. You should reach the point where you can predict the form of the test information function from the values of the item parameters.

### Procedures for an Example Case

- a. Follow the start-up procedures described in the Introduction.
- b. Use the mouse to highlight the TEST CHARACTERISTIC CURVE session and click on [CONTINUE]. The TEST SPECIFICATION screen will appear.
- c. Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- d. In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on TWO PARAMETER.
- e. In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- f. Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- g. Click on [ENTER PARAMETERS] and then set the following item parameter values:

$b = -.4,$	$a = 1.0$
$b = -.3,$	$a = 1.5$
$b = -.2,$	$a = 1.2$
$b = -.1,$	$a = 1.3$
$b = 0,$	$a = 1.0$
$b = 0,$	$a = 1.6$
$b = .1,$	$a = 1.6$
$b = .2,$	$a = 1.4$
$b = .3,$	$a = 1.1$
$b = .4,$	$a = 1.7$

- a. When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- b. Click on [CONTINUE]. The test characteristic curve shown below will appear on the screen.



**FIGURE 6-5.** Test information function

- j. The test information function is symmetric about an ability level of 0.0, reflecting the distribution of the item difficulties around zero. The maximum value of the amount of test information is approximately 4.2, which yields a standard error of estimate of .49. Within the range of ability from -1.0 to +1.0, the amount of test information is greater than 2.5, and the standard error of estimate is less than .63 in this range. Outside of this range, the amount of information is smaller, and at an ability level of -2.0 or +2.0, it is only about 1.0. At these points, the standard error of estimate is 1.0. Since this test has only ten items, the general level of the test information function is at a modest value, and the precision reflects this.
- k. Click on [CONTINUE]. The SELECT OPTION FROM LIST screen will appear.

1. If you click on MODIFY EXISTING TEST, the ITEM PARAMETERS screen will appear and you can edit any of the values. If you click on CREATE NEW TEST, the TEST SPECIFICATION screen will appear. Click on CREATE NEW TEST.

## Exercises

### a. Using a two-parameter model

#### Exercise 1

- (1) The TEST SPECIFICATION screen will appear.
- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on TWO PARAMETER.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then set all the item difficulty parameters to  $b = 0.0$  and use various values of  $a$  that are all greater than 1.0 but less than 1.7.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.

- (10) Click on CREATE NEW TEST.

### Exercise 2

- (11) The TEST SPECIFICATION screen will appear.
- (12) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (13) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on TWO PARAMETER.
- (14) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (15) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (16) Click on [ENTER PARAMETERS] and then set all the item difficulty parameters to  $b = 0.0$  and use various values of  $a$  that are all less than 1.0.
- (17) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (18) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (19) The test information function will be symmetric about zero, but will have a much lower overall level than the previous test information function.
- (20) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (21) Click on CREATE NEW TEST.

### Exercise 3

- (1) The TEST SPECIFICATION screen will appear.
- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on TWO PARAMETER.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then set all the item difficulty parameters to  $b = 0.0$  and use various values of  $a$  that are all greater than 1.7. The maximum value you can use is 2.0.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) The test information function will have a maximum greater than that of all of the previous examples, thus illustrating the dependence of the amount of information upon the values of the discrimination parameter.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

#### **Exercise 4**

- (1) The TEST SPECIFICATION screen will appear.

- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 5$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on TWO PARAMETER.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then set the item parameters to values of your choice.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) The general level of the test information function will be much lower than the corresponding example. Depending on how you chose the values of  $b$  and  $a$ , the shape of the curve could be quite similar to the previous case.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

## **b. Using a Rasch model**

### **Exercise 1**

- (1) The TEST SPECIFICATION screen will appear.

- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on RASCH.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then set all the item difficulty parameters to some common value other than zero.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) The test information curve will be centered on this common value. The general level of the amount of information will be modest because the Rasch model fixes the discrimination parameter at 1.0.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

### **Exercise 2**

- (1) The TEST SPECIFICATION screen will appear.
- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .

- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on RASCH.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then set the item difficulty parameters to some values that are equally spaced over the full range of ability from -3 to +3.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) The test information function will be rather flat, and the general amount of information will be rather low.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

### c. Using a three-parameter model

#### Exercise 1

- (1) The TEST SPECIFICATION screen will appear.
- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on THREE PARAMETER.

- (4) In the SELECT ITEM PARAMETER CREATION METHOD list, click on USER INPUT OF ITEM PARAMETER VALUES.
- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then select values of  $b$  and  $a$  that vary in value. Set the value of  $c = .1$  for all items. Write down the values of  $b$  and  $a$  so they can be used again.
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) Take note of the shape and general level of the obtained test information function.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

### **Exercise 2**

- (1) The TEST SPECIFICATION screen will appear.
- (2) Click on [NUMBER OF ITEMS] and set the number of items in the test to  $N = 10$ .
- (3) In the SELECT ITEM CHARACTERISTIC CURVE MODEL list, click on THREE PARAMETER.
- (4) In the SELECT ITEM PARAMETER CREATION METHOD, list click on USER INPUT OF ITEM PARAMETER VALUES.

- (5) Respond to the question SETTINGS OK? by clicking on the YES button. The ITEM PARAMETERS screen will appear.
- (6) Click on [ENTER PARAMETERS] and then use the same values of  $b$  and  $a$  that were used in the previous problem, but set all the values of  $c = .35$ .
- (7) When you are satisfied with the parameter values, respond to the message PARAMETER VALUES OK? by clicking on the YES button.
- (8) Click on [CONTINUE] and the test information function curve will appear on the screen.
- (9) The resulting test information function will have a shape similar to that of the previous problem. However, the general level of the amount of test information will be less than that of the previous example. This illustrates the effect of guessing upon the precision with which ability is estimated.
- (10) Click on [CONTINUE] and the SELECT OPTION FROM LIST screen will appear.
- (11) Click on CREATE NEW TEST.

#### d. Exploratory exercises

1. Use a model of your choice and select values of the item parameters such that the test information function approximates a horizontal line. Use a ten-item test.
2. Experiment a bit with different item characteristic curve models, parameter values, and number of items. To make things easier, let the computer select the values of the item parameters by responding to the message SELECT ITEM PARAMETER CREATION METHOD by clicking on COMPUTER GENERATED ITEM PARAMETER VALUES.

It will be helpful to make rough sketches of the test information functions displayed and notes to indicate the nature of the mix of item parameter values. The goal is to be able to predict what the form of the test information function will be from the values of the item parameters.

## Things To Notice

1. The general level of the test information function depends upon:
  - a. The number of items in the test.
  - b. The average value of the discrimination parameters of the test items.
  - c. Both of the above hold for all three item characteristic curve models.
2. The shape of the test information function depends upon:
  - a. The distribution of the item difficulties over the ability scale.
  - b. The distribution and the average value of the discrimination parameters of the test items.
3. When the item difficulties are clustered closely around a given value, the test information function is peaked at that point on the ability scale. The maximum amount of information depends upon the values of the discrimination parameters.
4. When the item difficulties are widely distributed over the ability scale, the test information function tends to be flatter than when the difficulties are tightly clustered.
5. Values of  $a < 1.0$  result in a low general level of the amount of test information.
6. Values of  $a > 1.7$  result in a high general level of the amount of test information.
7. Under a three-parameter model, values of the guessing parameter  $c$  greater than zero lower the amount of test information at the low-ability levels. In addition, large values of  $c$  reduce the general level of the amount of test information.
8. It is difficult to approximate a horizontal test information function. To do so, the values of  $b$  must be spread widely over the ability scale, and the

values of  $a$  must be in the moderate to low range and have a U-shaped distribution.