DIFAS 5.0

Differential item functioning analysis system

User's Manual

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CHAPTER 1

Getting Started with DIFAS

DIFAS is a Windows based program that performs a variety of functions related to assessing the presence of differential item functioning (DIF) in items, differential test functioning (DTF) across all items of a test or scale, and differential step functioning (DSF) for ordinal polytomous items. DIFAS is exclusively point-and-click, and is aimed at providing users with the capability of conducting sophisticated DIF and DTF analyses in a user-friendly environment.

Although a multitude of parametric and nonparametric DIF detection procedures exist, DIFAS performs only nonparametric DIF analyses. The DIF procedures that DIFAS runs for dichotomously scored items include:

Mantel-Haenszel chi-square
Mantel-Haenszel common log-odds ratio and estimated standard error
Standardized Mantel-Haenszel common log-odds ratio
Breslow-Day test of trend in odds ratio heterogeneity
ETS classification scheme

The DIF procedures that DIFAS runs for polytomously scored items include:

Mantel's chi-square
Lui-Agresti cumulative common log-odds ratio and estimated standard error
Standardized Lui-Agresti cumulative common log-odds ratio
Cox's noncentrality parameter estimator and estimated standard error
Standardized Cox's noncentrality parameter estimator

The DTF procedures that DIFAS runs consists of estimates of the variance in the DIF effect across the items of the test or scale.

The DSF procedures that DIFAS runs consists of estimates of the step-level common log-odds ratios using the cumulative and adjacent categories dichotomization scheme.

All of the procedures described above are discussed in greater detail in Chapter 3.

In addition, DIFAS can compute: (a) item-level descriptive statistics, (b) frequencies for the reference and focal groups at each level of the stratifying variable, and (c) the mean of each item conditional on 10 intervals of the stratifying variable.

System Requirements

The following hardware and software is required for running DIFAS:

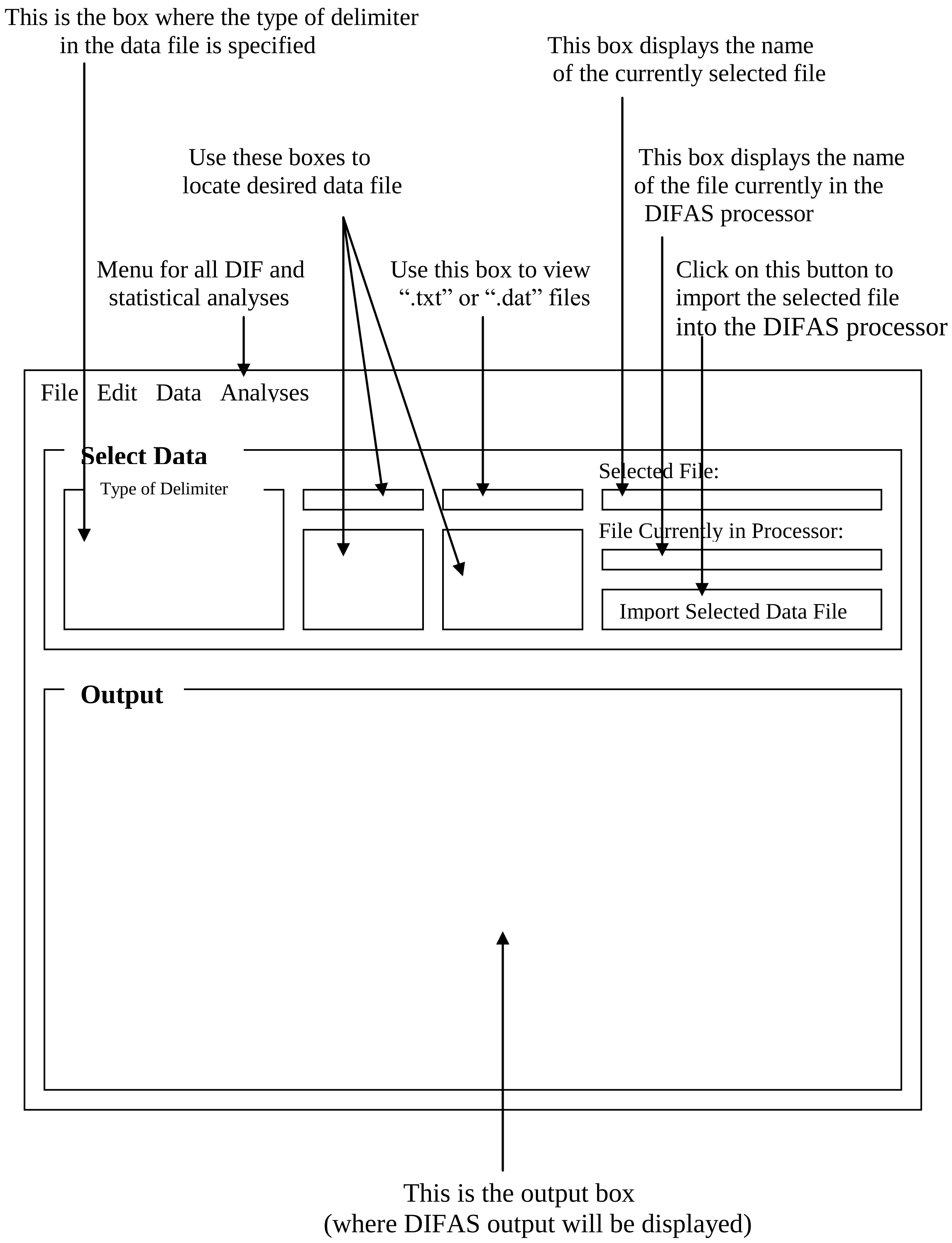
- Microsoft Windows 95 or later, or Microsoft Windows NT 3.51 or later
- 24 MB RAM for Windows 95 or later, 32 MB RAM for Microsoft NT or later
- Pentium 90MHz or higher

Running DIFAS

To run DIFAS, double click on the program icon (DIFAS.exe). The program itself is contained in a single file that is about 0.22 megabytes (220 kilobytes), and thus can be copied on a single floppy disk.

A Diagram of the DIFAS Main Window

The DIFAS Main Window has the following components:



Conducting Analyses Using DIFAS

Conducting analyses using DIFAS consists of three primary steps:

Step 1: Import the data to be analyzed. Select the appropriate file to be imported (the file must have either a ".txt" or a ".dat" extension) using the top portion of the Main Window of DIFAS. Imported files must be delimited as space-delimited, comma-delimited, or tab-delimited.

Step 2: Select the appropriate analysis from the Analyses drop-down menu.

Step 3: Examine the output of the results of analyses in the output box of the Main Window of DIFAS. DIFAS adds the output of subsequent analyses sequentially to the output displayed in the output box. The output can be annotated, edited, or saved as a text file upon request.

CHAPTER 2

Importing Data

The first step in running DIF analyses using DIFAS is to import the desired data file into DIFAS. DIFAS can accommodate data sets containing up to 1000 variables. There is no theoretical limit that DIFAS places on the number of cases contained in the data file – the limiting factor would be the memory capabilities of the computer running DIFAS. DIFAS can only read in text and data files that have the extension ".txt" or ".dat". Because it will often be the case that the data of interest is being maintained in either a statistical software package (e.g., SPSS) or a data management package (e.g., Excel), you may have to save the data file of interest in a format that DIFAS can read. There are some simple steps that can be taken to properly format the data file so that DIFAS can read its contents, as outlined in the following section.

Preparing the Data for Import

Before importing the desired data file into DIFAS, it is critical that the data be formatted properly. With respect to the values of the data, DIFAS has the following constraints:

1. DATA MUST BE NUMERIC. All data must be numeric. If any nonnumeric (e.g., text) entries exist, DIFAS will not be able to input the data, and an error message will appear informing you of that.

2. ITEM RESPONSES MUST BE CODED 0, 1, 2,…, 9. All response data for items to be analyzed for DIF must have values that set 0 equal to the lowest possible response on the item, and all other responses consist of integer values sequentially greater than 0 (e.g., 1, 2, 3,…9). Thus, for multiple-choice item formats, the responses must be coded as 0 (incorrect) and 1 (correct). For polytomous item formats, the responses must be coded as 0, 1, 2, …, *k*. Note that the highest possible item-level response category that DIFAS will permit is 9. To summarize, for all item formats (dichotomous and polytomous), the lowest response option must be coded 0, and each successively higher response option is coded according to integers successively greater than 0. Any integer value greater than 9 can also be included in the data, but the DIF analyses conducted by DIFAS will only read item-level responses between 0 and 9 - any value greater than 9 would be removed from DIF analyses.

3. ALL DATA MUST BE INTEGER. DIFAS assumes that all data entered is integer. Thus not only is it important for item responses to be integer in nature (as stated in #2 above), but any other variables concerning groups or external ability estimates should also consists of integer values. Non-integer values can be read in by DIFAS, but only the truncated values are used in analyses. An important consequence of this is that any external measure of ability that is to be used for stratifying must be integer. As a result, ability estimates that are initially in decimal form, should be transformed to an integer form (as discussed below) prior to importing the data into DIFAS.

4. MISSING VALUES MUST BE DENOTED BY ".". Missing values are permitted by DIFAS, but must be indicated by the period symbol "." or the absence of any value between two delimiters. For example, the line: 0,0,.,1 indicates four responses where the third response is missing. Alternatively, the line: 0,0,,1 could also be used to indicate four responses where the third response is missing. Note that DIFAS will not recognize a space as a missing value because a space is used as a delimiter in space-delimited files.

5. DATA BEGINS ON FIRST LINE OF FILE. When reading in data, DIFAS assumes that the data begins in the first line of the file being read in. Thus, a first line containing variable names is not permitted when importing data. For example, a space-delimited data set containing responses of three individuals on five items might look like:

```
1 0 1 1 0
1 1 1 1 1
0 0 0 1 0
```

The same data in comma-delimited form would look like:

```
1,0,1,1,0
1,1,1,1,1
0,0,0,1,0
```

And the same data in tab-delimited form would look like:

```
1	0	1	1	0
1	1	1	1	1
0	0	0	1	0
```

DIFAS labels variables as Var1, Var2, etc., and so it is often useful to have a listing of the variable ordering and/or column numbers at your fingertips when using DIFAS.

6. EXTERNAL ABILITY ESTIMATE CAN BE INCLUDED. Because DIF analyses are predicated upon examination of a relationship between a grouping variable and item performance conditional on an estimate of ability, DIFAS must be instructed as to the nature and location of the estimate of ability. By default, DIFAS uses the sum of the responses to the items included in the DIF analysis (the summated test score) as an internal measure of ability. If the summated test score is the desired measure of ability, then no other estimate of ability need be included in data file. If, however, the measure of ability is other than the summated test score (i.e., there is an external measure of ability), then the external measure of ability must be included in the data file prior to importing the data into DIFAS. Note, however, that DIFAS assumes all data is integer in nature, and so if the measure of ability contains decimals, then the ability measure would need to be transformed to eliminate the decimals. For example, if the ability measure consists of a standard normal variable, then the user can multiply the standard variable by 1000 (if 3 decimal places are desired) and truncate the resulting variable accordingly to remove any resulting decimal places. Negative values should not pose a problem, provided they are integer in value. Any transformations must be conducted prior to importing the data into DIFAS.

7. DATA FILE MUST HAVE ".txt" OR ".dat" EXTENSION. DIFAS is designed to read in only text (*.txt) or data (*.dat) files. Text files are typically maintained in a program such as Notepad.

8. DATA FILES MUST BE SPACE-, COMMA-, OR TAB-DELIMITED. DIFAS is designed to read in files for which the columns (variables or items) of the data file are delimited using either a space, comma, or tab. If the data is being maintained in a data management program (such as Excel) or a statistical software package (such as SPSS or SAS), the data must be converted to a delimited text file. Here are some guidelines for creating a delimited text file from several of the more common data management and statistical programs.

> ***SPSS*** – When the desired data file is in SPSS, save the data file as a tab-delimited (*.dat) file, and make certain that you **deselect** the check box labeled "Write variable names to spreadsheet". If this check box is not deselected, the variables names will be written to the first line of the data file, and DIFAS cannot read in non-numeric values. The resulting file is a tab-delimited file having the extension ".dat", which can be accessed by DIFAS.

> ***Excel*** - When the desired data file is in Excel, save the data file as a text (tab-delimited) file. The resulting file is a text tab-delimited file having the extension ".txt", which can be accessed by DIFAS. Note that there cannot be any variable names in the first row, as DIFAS can read in only numeric values, and assumes all entries are data and are to be included in the analyses.

Importing the Data

To import a data file, use the top portion of the main window of DIFAS to select the desired file. When selecting the desired file, follow these steps:

STEP 1: SPECIFY DELIMITER USED IN DATA FILE. Specify the delimiter used in the file (space, comma, or tab), as listed by the options on upper left portion of the Main Window. By default, DIFAS sets the delimiter to "space", but you may have to change this to comma or tab. Not changing delimiter appropriately will cause DIFAS to not recognize the data when importing.

STEP 2: SPECIFY FILE TYPE. Specify whether the file has the extension ".txt" or ".dat" using the drop-down list box. By default, DIFAS sets the file type to ".txt". Note, however, that if you are importing a file created from SPSS, you may have to select the ".dat" extension.

STEP 3: LOCATE DESIRED DATA FILE. Using the drive list box and the directory list box in the top portion of the Main Window, locate and select the desired file. Clicking on the desired file will cause the file's name to appear in the "Selected File:" box in the upper right side of the Main Window.

STEP 4: CLICK IMPORT BUTTON. To import the data of the selected file to DIFAS, click the button marked "Import Selected Data File" in the upper right portion of the Main Window. If DIFAS recognizes every element of the file as being valid (i.e., numeric), then the box labeled "File Currently in Processor: " will list the file name, and a message will appear in the output box specifying the file that was imported, and the number of cases and variables in the file. An example of such a message is as follows:

```
Opened the text file: C:\playdata\dif2.txt
Number of Cases: 400
Number of Variables: 12
```

If an invalid element exists (such as a non-numeric entry), then DIFAS will provide a message box stating so, and listing the row and column of the file that had the invalid value.

Here are some guidelines to follow when opening files created by common statistical and data management programs.

1. ENSURE THAT THE CORRECT DELIMITER IS SELECTED. A common error that occurs in importing data into DIFAS is that the proper delimiter is not selected (in the upper left portion of the Main Window), and as a result DIFAS treats the incorrect delimiter as text which causes an error.

2. IMPORTING DATA FROM *SPSS* FILES. Data from SPSS can be saved as a tab-delimited ".dat" file. In this case, the resulting ".dat" file will contain the variable names in the first row of the data file. These names must be deleted from the file to be imported into DIFAS because DIFAS would mistake the first line as being data. Simply delete the fist line of the ".dat" file and save. Next, ensure that the type of delimiter in DIFAS is set to tab-delimited. Failing to do so will result in DIFAS displaying a message that an invalid entry was made. In addition, in order to display the *.dat files, you must change the extension option in the top portion of DIFAS from "Text (*.txt)" to "Data (*.dat)".

3. IMPORTING DATA FROM *EXCEL* FILES. Data from Excel can be saved as tab-delimited ".txt" file. In this case, ensure that in the created ".txt" file, the first row of the file consists of data, not variable names. Next, ensure that the type of delimiter in DIFAS is set to tab-delimited. Failing to do so will result in DIFAS displaying a message that an invalid entry was made. In addition, in order to display the *.txt files, you must ensure that extension option "Text (*.txt)" is selected in the top portion of the Main Window.

Navigating the Imported Data File

Once a file has been successfully imported, you may navigate through the file, one cell at a time, using the "Navigate Data File" window contained within the Data menu. Opening this window you will find a central box that displays the contents of any selected element of the imported data file. By default, the initial element is that contained in the first row and first column of the data file. By clicking "Up", "Down", "Left", and "Right", you may view successive elements in the data file. This function permits you to ensure that the contents of the data file are as expected.

CHAPTER 3

Conducting Analyses

The analyses offered by DIFAS are located using the Analyses Menu of DIFAS. DIFAS includes several analysis windows that can be used to conduct a variety of analyses related to DIF detection. The options on the Analyses Menu are as follows:

- → Descriptives
- → Frequencies
- → Nonparametric DIF Tests
    - -Dichotomous Models
    - -Polytomous Models
- → Differential Test Functioning
    - -Dichotomous Models
    - -Polytomous Models
- → Differential Step Functioning
    - -Cumulative
    - -Adjacent Categories

Descriptives

The Descriptives Window of the Analyses Menu computes the mean, standard deviation, minimum, maximum, and number of valid cases for each variable selected. To obtain the descriptive statistics, select the variables of interest by left-clicking in the check box associated of the desired variables, and then click the OK button. An example of the output generated by the descriptives function is given by:

```
DESCRIPTIVES
-------------------------------------------------------------
Name              Mean         SD        Min        Max         N
-------------------------------------------------------------
Var 1              1.5      0.501          1          2       400
Var 2            0.522        0.5          0          1       400
Var 3            0.507      0.501          0          1       400
Var 4              0.5      0.501          0          1       400
Var 5            0.438      0.497          0          1       400
Var 6            0.522        0.5          0          1       400
Var 7             0.47        0.5          0          1       400
Var 8            0.488        0.5          0          1       400
Var 9            0.482        0.5          0          1       400
Var 10           0.472        0.5          0          1       400
Var 11           0.502      0.501          0          1       400
-------------------------------------------------------------
```

The use of the descriptives function may prove useful in obtaining general information about the variables held in the DIFAS processor.

Note that by default, the "Range of Items" option is selected (in the Descriptives Window). In this mode, a range of variables can be selected by first selecting the lower variable of the range and then the upper variable of the range. For example, to select variables 2 through 10, first select variable 2 and then select variable 10. This will cause all variables between 2 and 10 to be selected. To turn off the "Range of Items" option, click on the "Individual Items" option.

Frequencies

The Frequencies Window of the Analyses Menu computes the frequency, percentage of the total sample, percentage of the sample having valid data, and the cumulative percentage of each outcome for each variable selected. In addition, the Frequencies function computes the number of cases having valid (present) values and the number of cases having missing values. To obtain the frequencies output, select the variables of interest by left-clicking in the check box associated of the desired variables, and then click the OK button. An example of the output generated by the frequencies function is given by:

```
FREQUENCIES AND PERCENTAGES FOR: Var 1
-------------------------------------------------
Value           Freq   % Total    % Pres     Cum %
-------------------------------------------------
1                200        50        50        50
2                200        50        50       100

Present          400       100
Missing            0         0
Total            400       100
-------------------------------------------------
```

The use of the frequencies function may prove useful in obtaining general information about the variables held in the DIFAS processor.

Note that by default, the "Range of Items" option is selected (in the Frequencies Window). In this mode, a range of variables can be selected by first selecting the lower variable of the range and then the upper variable of the range. For example, to select variables 2 through 10, first select variable 2 and then select variable 10. This will cause all variables between 2 and 10 to be selected. To turn off the "Range of Items" option, click on the "Individual Items" option.

DIF Analyses for Dichotomous Items

The Dichotomous Models Window conducts DIF analyses for dichotomous items by computing the following statistics: the Mantel-Haenszel chi-square, the Mantel-Haenszel log-odds ratio, the estimated standard error of the Mantel-Haenszel log-odds ratio, the standardized Mantel-Haenszel log-odds ratio, the Breslow-Day chi-square test of trend in odds ratio heterogeneity, the Combined Decision Rule classification scheme, and the ETS classification scheme. These procedures are described later in this section.

The Dichotomous Models Window contains three lists of the variables contained in the imported data file. The first list, called “Select Items”, is used to designate the items to be included in the DIF analysis. The second list, called “Select Groups”, is used to designate the variable containing the grouping information. The third list, called “Select Stratifying”, is used to designate the variable used to stratify the individuals according to an estimate of ability. Note that by default, DIFAS assumes that the stratification variable is the summated test score of the items selected for the DIF analysis, as noted by the selection of the “Stratify by Sum” option at the bottom of the “Select Stratifying” list. However, the user may select any variable contained in the imported data file to use as the stratifying variable.

To run DIF analyses for dichotomous items, follow these steps:

1. In the “Select Items” list (the list at the far left of the Dichotomous Models Window), select the items to be studied for DIF. Note that by default, the “Range of Items” option is selected. In this mode, a range of items can be selected by first selecting the lower item of the range and then the upper item of the range. For example, to select items 2 through 10, first select item 2 and then select item 10. This will cause all items between 2 and 10 to be selected. To turn off the “Range of Items” option, click on the “Individual Items” option.

2. In the “Select Groups” list (the list in the middle of the Dichotomous Models Window), select the variable designating the groups of interest. DIFAS permits only the comparison of two groups at a time. Below the variable selection box, specify the value designating reference group members, and the value designating focal group members. For example, the imported data file may use a “1” to designate reference group members and a “2” to designate focal group members. Any two numeric values may be used to designate the reference and focal groups.

3. In the “Select Stratify” list (the list at the far right of the Dichotomous Models Window), specify the stratifying (or matching) variable. If you wish the total test score obtained from the items selected to be included in the DIF analysis to serve as the stratifying variable, ensure that the option “Stratify by sum” is selected. In this case, no variable needs to be selected from the “Select Stratify” list. Note that when DIFAS computes the total test score, any individual having a missing value is assigned a missing value for the total test score, and thus is ignored in the analyses. Thus, if you wish a total test score to be computed for individuals having missing values, be sure to code all

missing values as “0” before importing the data file into DIFAS. If you wish the stratifying variable to be some other variable in the data file, click the option “Stratify by external”, and then select the external variable from the “Select Stratify” list.

4. By default, DIFAS uses a stratum size of 1. You can, however, change this size by specifying a stratum size in the box located in the lower right portion of the Dichotomous Models Window. For example, if a stratum width of 2 is desired, then the user would change the 1 to a 2 in the “Stratum Size” box.

5. DIFAS can print out the number of reference and focal group members located in each stratum of the stratifying variable. To do so, select the “Print strata n” check box in the lower right portion of the Dichotomous Models Window.

Once these three steps are completed, click on the OK button. The resulting output consists of two tables – a table containing the relevant DIF statistics, and a table containing the conditional differences in mean item score between the reference and focal groups at ten intervals across the stratifying variable continuum (the lower and upper limits of each of the ten intervals are presented at the top of each interval). An example of output for a DIF analysis of ten dichotomous items is:

DIF STATISTICS: DICHOTOMOUS ITEMS

Name	MH CHI	MH LOR	LOR SE	LOR Z	BD	CDR	ETS
Var 2	0.011	-0.052	0.233	-0.223	0.034	OK	A
Var 3	1.786	0.358	0.246	1.455	0	OK	A
Var 4	0.189	0.128	0.23	0.557	2.776	OK	A
Var 5	0	-0.031	0.236	-0.131	0.03	OK	A
Var 6	0.161	-0.13	0.25	-0.52	0.043	OK	A
Var 7	0.323	-0.162	0.238	-0.681	1.156	OK	A
Var 8	0.001	0.036	0.238	0.151	2.109	OK	A
Var 9	0.013	0.053	0.229	0.231	1.11	OK	A
Var 10	0.001	-0.025	0.252	-0.099	0.016	OK	A
Var 11	0.42	-0.194	0.25	-0.776	0.202	OK	A

CONDITIONAL DIFFERENCES: Intervals of size 1

Lower	0	1	2	3	4	5	6	7	8	9
Upper	1	2	3	4	5	6	7	8	9	10.1
Var 2	-0.07	-0.1	0.1	-0.14	0.3	-0.01	-0.07	0	-0.07	0
Var 3	0.08	0.11	0.02	0.15	-0.19	0.13	0.01	0.18	0.06	0
Var 4	0.03	-0.15	0.06	-0.28	0.08	0.22	0.09	0.14	0.03	0
Var 5	0	0	-0.12	0.12	0.08	0.01	-0.1	-0.01	0.09	0
Var 6	0.03	-0.11	0.05	0.07	-0.22	-0.09	0.09	-0.04	-0.07	0
Var 7	-0.02	0.09	0.06	0.12	-0.42	0	-0.1	-0.03	-0.04	0
Var 8	-0.02	0.05	0.03	0.17	0.36	-0.09	-0.25	-0.02	-0.07	0
Var 9	-0.03	0.08	-0.16	-0.12	0.13	0.05	0.2	-0.05	0.03	0
Var 10	0.04	0.04	0.01	-0.04	-0.06	-0.25	0.16	-0.08	0.13	0
Var 11	0.03	-0.02	-0.05	-0.05	-0.07	0.04	-0.03	-0.08	-0.07	0

Each of the DIF statistics conducted by DIFAS for dichotomous items will now be briefly described.

Mantel-Haenszel Chi-Square **(MH CHI)** – The Mantel-Haenszel chi-square statistic (Holland & Thayer, 1988; Mantel & Haenszel, 1959) is distributed as chi-square with one degree of freedom. Critical values of this statistic are 3.84 for a Type I error rate of 0.05 and 6.63 for a Type I error rate of 0.01.

Mantel-Haenszel Common Log-Odds Ratio **(MH LOR)** – The Mantel-Haenszel common log-odds ratio (Camilli & Shepard, 1994; Mantel & Haenszel, 1959) is asymptotically normally distributed. Positive values indicate DIF in favor of the reference group, and negative values indicate DIF in favor of the focal groups.

Standard Error of the Mantel-Haenszel Common Log-Odds Ratio **(LOR SE)** – The standard error of the Mantel-Haenszel common log-odds ratio. The standard error computed here is the nonsymmetric estimator presented by Robins, Breslow and Greenland (1986).

Standardized Mantel-Haenszel Log-Odds Ratio **(LOR Z)** – This is the Mantel-Haenszel log-odds ratio divided by the estimated standard error. A value greater than 2.0 or less than –2.0 may be considered evidence of the presence of DIF.

Breslow-Day Chi-Square **(BD)** – The Breslow-Day chi-square test of trend in odds ratio heterogeneity (Breslow & Day, 1980; Penfield, 2003) is distributed as chi-square with one degree of freedom. Critical values of this statistic are 3.84 for a Type I error rate of 0.05 and 6.63 for a Type I error rate of 0.01. This statistic has been shown to be effective at detecting nonuniform DIF.

Combined Decision Rule **(CDR)** – The combined decision rule (CDR) flags any item for which either the Mantel-Haenszel chi-square or the Breslow-Day chi-square statistic is significant at a Type I error rate of 0.025 (Penfield, 2003). The message OK is printed if neither statistic is significant, and the message FLAG is printed if either statistic is significant.

The ETS Categorization Scheme **(ETS)** – The ETS categorization scheme (Zieky, 1993) categorizes items as having small (A), moderate (B), and large (C) levels of DIF.

DIF Analyses for Polytomous Items

The Polytomous Models Window of the Analyses Menu conducts DIF analyses for polytomous items by computing the following statistic the Mantel chi-square, the Liu-Agresti cumulative common log-odds ratio, the estimated standard error of the Liu-Agresti cumulative common log-odds ratio, the standardized Liu-Agresti cumulative common log-odds ratio, Cox's estimator of the multivariate hypergeometric noncentrality parameter, the estimated standard error of Cox's estimator of the multivariate hypergeometric noncentrality parameter, and the standardized value of Cox's estimator. These procedures are described at the end of this section.

The Polytomous Models Window contains three lists of the variables contained in the imported data file. The first list, called "Select Items", is used to designate the items to be included in the DIF analysis. The second list, called "Select Groups", is used to designate the variable containing the grouping information. The third list, called "Select Stratifying", is used to designate the variable used to stratify the individuals according to an estimate of ability. Note that by default, DIFAS assumes that the stratification variable is the summated test score of the items selected for the DIF analysis, as noted by the selection of the "Stratify by Sum" option at the bottom of the "Select Stratifying" list. However, the user may select any variable contained in the imported data file to use as the stratifying variable.

To run DIF analyses for polytomous items, follow these steps:

1. In the "Select Items" list (the list at the far left of the Polytomous Models Window), select the items to be studied for DIF. Note that by default, the "Range of Items" option is selected. In this mode, a range of items can be selected by first selecting the lower item of the range and then the upper item of the range. For example, to select items 2 through 10, first select item 2 and then select item 10. This will cause all items between 2 and 10 to be selected. To turn off the "Range of Items" option, click on the "Individual Items" option.

2. In the "Select Groups" list (the list in the middle of the Polytomous Models Window), select the variable designating the groups of interest. DIFAS permits only the comparison of two groups at a time. Below the variable selection box, specify the value designating reference group members, and the value designating focal group members. For example, the imported data file may use a "1" to designate reference group members and a "2" to designate focal group members. Any two numeric values may be used to designate the reference and focal groups.

3. In the "Select Stratify" list (the list at the far right of the Polytomous Models Window), specify the stratifying (or matching) variable. If you wish the total test score obtained from the items selected to be included in the DIF analysis to serve as the stratifying variable, ensure that the option "Stratify by sum" is selected. In this case, no variable needs to be selected from the "Select Stratify" list. Note that when DIFAS computes the total test score, any individual having a missing value is assigned a missing value for the total test score, and thus is ignored in the analyses. Thus, if you wish a total test score to be computed for individuals having missing values, be sure to code all missing values as "0" before importing the data file into DIFAS. If you wish the stratifying variable to be some other variable in the data file, click the option "Stratify by external", and then select the external variable from the "Select Stratify" list.

Once these three steps are completed, click on the OK button. The resulting output consists of two tables – a table containing the relevant DIF statistics, and a table containing the conditional differences in mean item score between the reference and focal groups at ten intervals across the stratifying variable continuum (the lower and upper limits of each of the ten intervals are presented at the top of each interval). An example of output for a DIF analysis of ten polytomous items is:

DIF STATISTICS: POLYTOMOUS ITEMS

Name	Mantel	L-A LOR	LOR SE	LOR Z
Var 2	94.397	0.948	0.1	9.48
Var 3	0.061	0.023	0.093	0.247
Var 4	0.508	-0.067	0.094	-0.713
Var 5	0.748	-0.079	0.093	-0.849
Var 6	4.55	-0.2	0.094	-2.128
Var 7	1.61	-0.119	0.093	-1.28
Var 8	1.428	-0.112	0.093	-1.204
Var 9	1.501	-0.114	0.094	-1.213
Var 10	0.543	-0.069	0.093	-0.742
Var 11	2.797	-0.156	0.093	-1.677

CONDITIONAL DIFFERENCES: Intervals of size 3

Lower	0	3	6	9	12	15	18	21	24	27
Upper	3	6	9	12	15	18	21	24	27	30.1
Var 2	0.2	0.05	0.28	0.27	0.3	0.24	0.31	0.18	0.23	0.14
Var 3	0.11	-0.03	0.13	0.02	-0.11	0.12	-0.05	0	-0.12	-0.05
Var 4	0.05	0.12	0	0.08	-0.04	-0.14	-0.1	0.02	-0.01	-0.29
Var 5	0.04	-0.06	-0.01	-0.07	0	-0.04	0.11	-0.11	-0.06	-0.12
Var 6	-0.05	-0.05	-0.1	-0.02	-0.1	0.01	-0.09	-0.02	-0.04	-0.1
Var 7	-0.12	0.08	-0.13	-0.17	0.01	0.05	0.02	-0.01	-0.08	-0.12
Var 8	-0.1	-0.12	0.12	-0.03	0.01	-0.1	-0.06	-0.04	-0.02	-0.1
Var 9	0.04	0.06	-0.15	-0.03	-0.04	-0.06	-0.06	0.08	-0.01	-0.07
Var 10	-0.2	0.02	-0.01	-0.03	0.02	0.01	-0.02	-0.14	0.07	0.01
Var 11	0.07	0.02	-0.04	-0.06	-0.09	-0.08	0.02	-0.01	-0.04	0.04

Mantel Chi-Square **(Mantel)** - The Mantel chi-square statistic (Mantel, 1963, Zwick, Donoghue & Grima, 1993; Zwick, Thayer & Mazzeo, 1997) is distributed as chi-square with one degree of freedom. Critical values of this statistic are 3.84 for a Type I error rate of 0.05 and 6.63 for a Type I error rate of 0.01.

Liu-Agresti Cumulative Common Log-Odds Ratio **(L-A LOR)** – The Liu-Agresti cummulative common log-odds ratio (Liu & Agresti, 1996; Penfield & Algina, 2003) is asymptotically normally distributed. Positive values indicate DIF in favor of the reference group, and negative values indicate DIF in favor of the focal groups.

Standard Error of the Lui-Agresti Cumulative Common Log-Odds Ratio **(LOR SE)** – The estimated standard error of the Lui-Agresti Cumulative Common Log-Odds Ratio (Liu & Agresti, 1996).

Standardized Liu-Agresti Cummulative Common Log-Odds Ratio **(LOR Z)** – This is the Liu-Agresti cumulative common log-odds ratio divided by the estimated standard error. A value greater than 2.0 or less than –2.0 may be considered evidence of the presence of DIF.

Cox's Noncentrality Parameter Estimator **(COX'S B)** – Cox's estimator of the multivariate hypergeometric noncentrality parameter (Camilli & Congdon, 1999; Cox, 1958) is distributed approximately as standard normal. Positive values indicate DIF in favor of the reference group, and negative values indicate DIF in favor of the focal groups.

Standard Error of Cox's Noncentrality Parameter Estimator **(COX SE)** – The estimated standard error of Cox's noncentrality parameter (Camilli & Congdon, 1999).

Standardized Cox's Noncentrality Parameter **(COX Z)** – This is Cox's noncentrality parameter estimator divided by the estimated standard error. A value greater than 2.0 or less than –2.0 may be considered evidence of the presence of DIF.

Differential Test Functioning

The variance of DIF effect across the items of a test or scale has been proposed as a measure of DTF for sets of dichotomous items (Camilli & Penfield, 1997), and mixtures of dichotomous and/or polytomous items (Penfield & Algina, 2006). The variance of DIF effect across dichotomous items has been symbolized by τ^2 (tau-squared) in the literature, and the variance of DIF effect across mixtures of polytomous and dichotomous items has been symbolized by ν^2 (nu-squared) in the literature. If the test contains all dichotomous items then select "Dichotomus Models" in the Differential Test Functioning Menu option. If the test contains all polytomous items, or a mixture of polytomous and dichotomous items, then select "Polytmous Models" in the Differential Test Functioning Menu option.

To conduct DTF analyses, select the appropriate items contained in the test (i.e., the items for which the DIF effect variance is desired), select the grouping variable, and specify the stratifying variable. These steps mirror those described for DIF analyses above. DIFAS will print out the following information:

1. Weighted and unweighted estimates of the DIF effect variance

2. Standard error estimators of the weighted and unweighted estimates of the DIF effect variance

3. The ratio of each DIF effect variance estimate over its respective standard error estimator (note that the variance estimator is not normally distributed, so the interpretation of this ratio has not yet been given any guidelines in the literature).

Readers are referred to the papers by Camilli and Penfield (1997) and Penfield and Algina (2006) for more detailed information about the interpretation and computations of these estimators.

Differential Step Functioning

Differential step functioning (DSF) pertains to invariance observed at each step underlying the polytomous response variable (a polytomous item with *J* score levels will have *J* – 1 steps). Because DSF effects may vary in sign and/or magnitude across the steps, examination of DSF effects can prove useful in understanding the location of the DIF effect (i.e., which score levels are manifesting the DIF effect) and the potential causes of the DIF effect. Estimates of DSF effects can be computed within the Cumulative and Adjacent Categories Windows of the Analyses Menu. The cumulative approach yields odds ratio DSF effect estimators consistent with those modeled under the graded response model, and the adjacent categories approach yields odds ratio DSF effect estimators consistent with those modeled under the generalized partial credit model. Descriptions of these estimators can be found in Penfield (2007a, 2007b).

To conduct DSF analyses, select the appropriate items contained in the test (i.g., the items for which the DSF effects are desired), select the grouping variable, and specify the stratifying variable. These steps mirror those described for DIF analyses above. For each item, DIFAS will print out a table containing the following information for each step of each selected item:

1. A step-level log-odds ratio DSF effect estimator. This is denoted by CU-LOR using the cumulative approach and AC-LOR using the adjacent categories approach.

2. The standard error estimator of the DSF effect estimate.

3. The ratio of each DSF effect estimate over its respective standard error estimator.

4. The Liu-Agresti common log-odds ratio DIF effect estimator (an estimate of the item-level DIF effect) and it's associated standard error estimate.

A sample of the DSF output for one item is shown below. This item is showing large DSF effect for the first step.

```
DSF for Var 2
----------------------------------------
Step      CU-LOR    SE        Z
----------------------------------------
1         1.239     0.19199   6.453
2         0.401     0.15435   2.598
3         -0.23     0.21202   -1.085
----------------------------------------
L-A LOR = 0.518   LOR SE = 0.131
```

Readers are referred to the papers by Penfield (2007a, 2007b) for more detailed information about DSF and the interpretation and computations of these DSF effect estimators.

Missing Data

DIFAS allows for missing data, but the way in which it deals with missing data depends on how the stratifying variable is computed. If the total summated score is used as the stratifying variable (the default in DIFAS), then DIFAS uses a listwise deletion procedure for any case containing missing data. In this case DIFAS will remove any individual in the analysis having one or more missing responses. The reason for this is that DIFAS assumes that the total summated score is an invalid stratifying value when missing values are present. If, however, an external variable is used as the stratifying variable, then DIFAS will use the following deletion rules: (a) any individual for which the stratifying variable value is missing will be omitted from the entire analysis; and (b) individuals having a nonmissing value of the external stratifying variable, but a missing value on one or more particular items, will be removed from the DIF analysis only for the item(s) for which the response is missing.

When a substantial number of missing responses exist, the DIF analyst may find it useful to compute an external stratifying variable the controls for the impact of missing data on trait estimation. One approach is to use the mean value across just the items attempted as the stratifying variable. In this situation, the appropriate stratifying variable would need to be computed prior to importing the data into DIFAS. Also, because DIFAS only stratifies on integer values, the user would need to transform the obtained mean values to integer-level values via some form of rounding or rescaling.

CHAPTER 4

Managing Output

All output is printed in the output box on the Main Window of DIFAS. DIFAS allows you to save the contents of the output box, open a previously saved output file, or augment the contents of the output as you deem appropriate.

Properties of the Output

The output of DIFAS is completely text in nature. The font of the output is Courier 10-point. The use of the Courier font is critical so that the output is formatted in columns that are appropriately aligned. Although the output box can contain a large amount of output, the space is not infinite. As a result, you should avoid storing large amounts of output at a single time without deleting that output which is not crucial. In general, the output box should be capable of storing at least several thousand lines of output before experiencing capacity limitations.

Editing the Output

The output box is a simple text editor, and acts like most other data editor programs. You may add text at any time to the output box. For example, you may want to annotate the results providing additional information concerning the data file. Contents of the output box may be cut, copied, and pasted using either the appropriate options of the Edit Menu, or using the shortcuts Control-x, Control-c, and Control-v. Thus, you can cut contents of the output box and paste the contents into an external document. Remember, however, that if you are including the contents of the output box in an external word processing file (such as a Word or a WordPerfect file), the output will only be aligned if the font is Courier. Thus, you may need to change the font of the output after pasting the desired output into the new file. In addition, to prevent output that wraps, the font size may need to be changed in the new word processing file (10-point Courier font should be fine).

The entire contents of the output box can be erased using the Clear Output option of the Edit Menu. Using this option immediately clears all contents of the output box, and there is no way to retrieve any erased contents. Thus, this function should only be used if you are completely certain that the output is to be deleted.

Saving Output Files

To save the contents of the output box, select the Save Output option of the File Menu. A window will appear that permits you to save the file. The saved file is a text file, and has the extension ".txt". As a result, this file can be opened in any other word processing application (such as Notepad, Word, or WordPerfect). Note, however, that the output will be appropriately formatted only if the font is set to Courier in the new application.

Opening Output Files

To open the contents of the output box, select the Open Output option of the File Menu. A window will appear that permits you to open the appropriate file. DIFAS will only open text files having the ".txt" extension.

Printing Output

DIFAS does not have the capability to print. However, output may be printed by first saving the output to an external file (see Saving Output Files), opening the external file in a word processing application (such as Word, Notepad or WordPerfect), and then printing the output from the word processing application. Note, however, that the output will be appropriately formatted only if the font is set to Courier in the new application. Notepad typically uses Courier as the font by default, and thus opening the saved output in Notepad provides a simple strategy for printing DIFAS output.

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