Determining Predictors for High Achievement in Math

An Ordinal Logistic Regression Analysis

4/7/2014

Kennesaw State University

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Determining Predictors for High Achievement in Math

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This project was performed as a requirement for Applied Categorical Analysis – an elective course of the Master of Science in Applied Statistics program at Kennesaw State University. The course was taught by Herman Ray, Ph.D.

# ABSTRACT

“Data-based decisions” is quickly becoming the buzz in education. Analyzing data can help to identify solutions to problems, clarify complex issues and find ways to effectively use resources and can lead to better decisions. The use of assessment data is one specific type of data-based decision making that can be used to drive instructional improvement. Consequently, assessment and instruction are working together in many schools. The goal of this research is to eliminate as much bias as possible from the identification of students with the potential for high mathematics achievement.

To aid in predicting future success or upcoming potential difficulties for the student, mathematical models could be developed to predict future success or identify possible trouble or fertile areas that may need attention. To capture a large percentage of would-be high-achieving students, these models would also need to include teacher rating scales, classroom assessment scores, and standardized test scores from most of a district or state. These data are not available to the public, and so a preliminary model will be developed using de-identified data that was made available by David Loham of Riverside Publishing.   
  
The purpose of this longitudinal quantitative study is to determine a model using just the Cognitive Abilities Test (*cogAT*) and Iowa Tests of Basic Skills (ITBS) that can be used to predict high math achievement on the Iowa Tests of Basic Skills (ITBS). This study will explore which, if any, ITBS and/or cogAT subtests can be used to identify those potentially high achieving math students.

**Determining Predictors for High Achievement in Math**

## INTRODUCTION

“Data-based decisions” is quickly becoming the buzz in education. Analyzing data can help to identify solutions to problems, clarify complex issues and find ways to effectively use resources and can lead to better decisions. The use of assessment data is one specific type of data-based decision making that can be used to drive instructional improvement. Consequently, assessment and instruction are working together in many schools. The goal of this research is to eliminate as much bias as possible from the identification of students with the potential for high mathematics achievement.

### Definitions and Terms

The Iowa Tests of Basic Skills (ITBS) are used to provide a comprehensive assessment of student progress in major content areas. The Cognitive Abilities Test (*cogAT*) measures students’ learned reasoning abilities in the three areas most linked to academic success in school: Verbal, Quantitative and Nonverbal. Although its primary goal is to assess students’ reasoning abilities, *cogAT* can also provide predicted achievement scores when administered with The Iowa Tests.

### Purpose and Research Question

The purpose of this longitudinal quantitative study is to determine a model using the Cognitive Abilities Test (*cogAT*) and Iowa Tests of Basic Skills (ITBS) that can be used to predict the effectiveness of certain types of interventions on raising math achievement on the Iowa Tests of Basic Skills (ITBS). This study will explore the following hypotheses:

### The Sample and Preliminary Analysis

The data used in the study included ITBS and *cogAT* scores of approximately 300 students obtained from David Loham’s website. Dr. David Loham is a Professor of Educational Psychology at the University of Iowa. Lohman has worked with Dr. Elizabeth Hagen to construct the sixth and seventh editions of the Cognitive Abilities Test. Lohman’s work includes extensive research to understand how students differ in their thinking and problem-solving abilities and how these differences can guide the choice of instructional methods. Dr. Loham used this sample dataset to demonstrated methods of identifying academically talented students.

The dataset contained 300 observations with 20 variables. The variables of interest, the variable type, and their codes are listed in Figure 1.1. The sample was stratified approximately equal across three ethnic groups and genders as shown in Figure 1. The mean age in months is about 112 months (9 years 4 months) and varied from 93 (7 years 9 months) to 137 (11 years 5 months). The descriptive statistics for the other variables are also listed in Figure 1.2 and 1.3.

### Coding the Variables

The response variable was recoded as Accelerated for 96 to 99 percentiles, Advanced for 80 to 95 percentiles Average for 80 to 14, and below the 13th percentile was coded as Below Average for 13 to 0 percentile; however, the assumption of proportionality odds was violated Therefore, we rejected the null hypothesis that there was no significant difference in proportionality, and collapsed the response variable to three categories. Students with cogAT Mathematics scores (MT) in the 96 to 99 percentiles were considered to be Accelerated, 80 to 95 were considered to be Advanced, and below the 80th percentile was coded as Base. The cogAT Math frequencies are also shown in Figure 1. The less restrictive model met the Proportional Odds Assumption The Response Profile shown in Figure1.5 indicates that the probability of scoring in the Base group (MT=1) is modeled.

## METHODOLOGY

Various models were explored. However, ultimately two models were closely examined. . Figure 3 shows a slight difference in two models; one model had three predictors and the other had two. I chose the model with two predictors in favor of a more parsimonious

fit. In this case, the model with Reading and Quantitative scores as predictors (AIC 227.330) was the better choice.

### Model Selection

According to Armstrong & Sloan (1989, Amer Jrn of Epid) using continuous response rather than an ordinal can result in a loss of more than 89%, depending on the number of categories and distribution within the ordinal categories.

The initial Type 3 Analysis of Effects revealed two significant effects – continuous variables Quan and RT and one marginal effect age\_mo

FIGURE 1

| TABLE 1: CODING OF VARIABLES | | | | |
| --- | --- | --- | --- | --- |
| **Code** | **Description** | **Type** |
| **ethnicity** | Ethnicity | Categorical |
| **age\_mo** | Age in Months | Numeric |
| **RT** | ITBS Reading Total | Numeric |
| **MT** | ITBS Math Total | Numeric |
| **VER** | cogAT Reading Percentile | Numeric |
| **QUAN** | cogAT Quantitative Total | Numeric |
| **NVER** | cogAT Non-Verbal | Numeric |

| TABLE 2: FREQUENCY OF ETHNICITY BY GENDER | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Ethnicity** | | **GENDER** | | |  |
| **F** | **M** | **Total** |
| **1** | **Hispanic** | 49  16.33 | 51  17.00 | 100  33.33 | **Frequency**  **Percent** |
| **10** | **Black** | 51  17.00 | 49  16.33 | 100  33.33 | **Frequency**  **Percent** |
| **100** | **White** | 50  16.67 | 50  16.67 | 100  33.33 | **Frequency**  **Percent** |
| **Total** | | 150  50.00 | 150  50.00 | 300  100.00 | **Frequency**  **Percent** |

| TABLE 3: THE MEANS PROCEDURE | | | | |
| --- | --- | --- | --- | --- |
| **Variable** | **Mean** | **Std Dev** | **Minimum** | **Maximum** |
| **age\_mo** | 111.59 | 6.42 | 93.00 | 137.00 |
| **RT** | 177.96 | 21.32 | 130.00 | 250.00 |
| **MT** | 181.23 | 17.77 | 143.00 | 226.00 |
| **VER** | 95.14 | 16.05 | 56.00 | 148.00 |
| **QUAN** | 95.14 | 15.82 | 59.00 | 147.00 |
| **NVER** | 96.34 | 16.31 | 50.00 | 138.00 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TABLE 4: RESPONSE VARIABLE** | | | | |
| **Ordered Value** | **MT** | **z-score** | **Freq** | **Per** |
| **1** | **Below Avg** | -3 -0.741 | 88 | 29.33 |
| **2** | **Average** | -.74 - .84 | 143 | 47.67 |
| **3** | **Advanced** | .841 – 1.64 | 55 | 18.33 |
| **4** | **Accelerated** | 1.641 - 3 | 14 | 4.67 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **TABLE 5: RESPONSE PROFILE** | | | |
| **Ordered Value** | **MT** | **z-score** | **Freq** | **Perc** |
| **1** | **Base** | -3 - 0.84 | 241 | 80.33 |
| **2** | **Advanced** | 0.841 - 1.64 | 41 | 13.67 |
| **3** | **Accelerated** | 1.641 - 3 | 18 | 6.00 |

### Model Adequacy

The log likelihood ratio chi-square test with 16 degree of freedom, LT suggests that at least one logit regression coefficient of the predictors was statistically different from 0, so the model with the predictors provided a better fit than the null model with no independent variables in predicting cumulative probability for Math Achievement. (Caution is taken because the predictors are continuous). The likelihood ratio is similar to suggested that the relationship between the response variable, achievement level in Math, and the predictors, Quantitative and Reading Scores is strong. Another measure of fit, the Akaike Information Criterion or AIC, is calculated as where is the number of levels of the dependent variable and  is the number of predictors in the model. AIC is used for the comparison of models from different samples or non-nested models. Ultimately, the model with the smallest AIC is typically considered the best.

## RESULTS

The score chi-square for testing the proportional odds assumption is 3.3491, which is not significant with respect to a chi-square distribution with 2 degrees of freedom (*p*=0.1874). This indicates that the proportional odds assumption is reasonable. The larger value (1.5989) for the parameter estimate for cogAT Quantitative score indicates a stronger influence on the response as opposed to ITBS Reading Total score parameter estimate (1.2988).

ITBS Accelerated math achievement is associated with both cogAT Quantitative scores and ITBS Reading Total score. There is a significant association between ITBS Accelerated math achievement and cogAT Quantitative scores. When controlling for the confounding effect of the Reading Total score, as the Quantitative score increases by 1 point, the odds increase by 4.95 times. Similarly, for each Reading Total point increased the odds by a multiple of 3.665.

This relationship is illustrated in the Predicted Cumulative Probabilities plot in Figure 3.

The probability of falling into the Base group is extremely high. The probability of falling into the Advanced group versus the Accelerated group increases more rapidly. The Quantitative and Reading score much be much high before the probability of being in the Advanced group is affected.

has Maximum Likelihood Estimates

Therefore, the fitted model is

Both cumulative logits increase as the explanatory effects increase.

## DISCUSSION

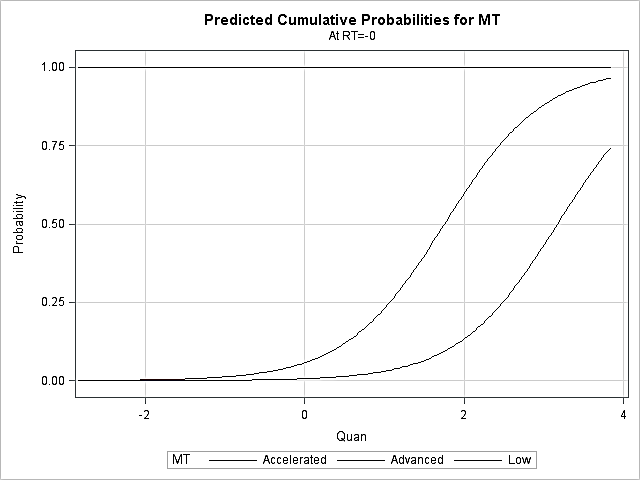
Overall, the results indicate the CogAT Quantitative score and ITBS Reading Total are significantly related to ITBS Math achievement tests, which indicates cognitive ability, and can be used to predict future academic achievement, while supporting the importance of making data‐driven decisions.

FIGURE 3

| **Table 1: Model Fit Statistics** | | |
| --- | --- | --- |
| **MT = Age\_Mo QUAN RT** | | |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 227.173 |
| **SC** | 381.439 | 245.692 |
| **-2 Log L** | 370.031 | 217.173 |

| **Table 2: Model Fit Statistics** | | |
| --- | --- | --- |
| **MT = QUAN RT** | | |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 227.330 |
| **SC** | 381.439 | 242.145 |
| **-2 Log L** | 370.031 | 219.330 |

| **Table 3: Odds Ratio Estimates** | | | | |
| --- | --- | --- | --- | --- |
| **Odds Ratio Estimates and Wald Confidence Interval** | | | | |
| **Effect** | **Unit** | **Estimate** | **95% Confidence Limits** | |
| **Quan** | 1.0000 | 4.947 | 2.956 | 8.281 |
| **RT** | 1.0000 | 3.665 | 2.230 | 6.024 |



| **Table 4: Parameter Estimates and Wald Confidence Interval** | | | | |
| --- | --- | --- | --- | --- |
| **Parameter** |  | **Estimate** | **95% Confidence Limits** | |
| **Intercept** | **Accelerated** | -5.0700 | -6.0382 | -4.1017 |
| **Intercept** | **Advanced** | -2.8024 | -3.4302 | -2.1746 |
| **Quan** |  | 1.5989 | 1.0837 | 2.1140 |
| **RT** |  | 1.2988 | 0.8018 | 1.7958 |

## APPENDICES

### Appendix A: SAS Code

ODS html close;

DM log 'OUT;CLEAR;LOG;CLEAR;' log continue ;

DM log 'next results; clear; cancel;' whostedit continue ;

ODS html newfile=none;

title 'PREDICTORS FOR ACCELERATED MATH IOWA TEST SCORE';

libname CDA ‘c:\users\cbonner\Logit’;

**RUN**;

**PROC** **IMPORT** datafile= c:\users\cbonner\Logit’\iowadat.csv'

out=CDA.iowadat2

DBMS = CSV REPLACE;

GETNAMES=Yes;

DATAROW=**2**;

**RUN**;

ODS GRAPHICS ON;

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* CALCULATE Z-SCORES FOR TEST SCORES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*;

**PROC** **STANDARD** DATA=CDA.iowadat2 MEAN=**0** STD=**1**

OUT=CDA.Ziowadat2;

VAR MT RT Ver Quan Nver ;

**RUN**;

**PROC** **FORMAT**;

value MT

-**3** - **0.84162** = 'Base'

**0.841621** - **1.644853** = 'Advanced'

**1.644854** - **3** = 'Accelerated';

**RUN**;

**PROC** **FREQ** DATA=CDA.Ziowadat2;

format MT MT.;

table MT / NOCUM;

**RUN**;

**PROC** **MEANS** DATA=CDA.Ziowadat2 MAXDEC=**2**;

format MT MT.;

**RUN**;

TITLE1 'Model 1';

TITLE2 ls=**0.4** H=**2.5** F=swiss ' MT - Ethnicity Gender AGE\_Mo Ver Quan Nver RT ';

**PROC LOGISTIC** data =CDA.Ziowadat2 descending **;**

format MT MT. ;

CLASS Ethnicity GENDER / PARAM = REF;

model MT = Ethnicity Gender AGE\_Mo Ver Quan Nver RT ;

**RUN**;

TITLE1 'Model 2';

TITLE2 ls=**0.4** H=**2.5** F=swiss ' MT - AGE\_Mo Quan rt';

**PROC LOGISTIC** data =CDA.Ziowadat2 descending **;**

format MT MT. ;

CLASS GENDER / PARAM = REF;

model MT = AGE\_Mo Quan rt;

**RUN**;

TITLE1 'Model 3';

TITLE2 ls=**0.4** H=**2.5** F=swiss ' MT - Quan NVer RT ';

**PROC LOGISTIC** data =CDA.Ziowadat2 descending **;**

format MT MT. ;

CLASS GENDER / PARAM = REF;

model MT = Quan RT ;

**RUN**;

TITLE1 'Model 4';

TITLE2 ls=**0.4** H=**2.5** F=swiss ' MT - NVer Quan RT ';

**PROC LOGISTIC** data =CDA.Ziowadat2 descending **;**

format MT MT. ;

CLASS GENDER / PARAM = REF;

model MT = NVer Quan RT;

**RUN**;

TITLE1 'Model 5';

TITLE2 ls=**0.4** H=**2.5** F=swiss ' MT - Quan ';

**PROC LOGISTIC** data =CDA.Ziowadat2 descending **;**

format MT MT. ;

CLASS GENDER / PARAM = REF;

model MT = Quan;

**RUN**;

ODS GRAPHICS ON;

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* SELECTED MODEL AND GRAPHICS

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*;

TITLE1 'Model 3: Selected ';

TITLE2 ls=**0.4** H=**2.5** F=ARIAL 'SELECTED MODEL AND GRAPHICS MT = Quan RT ';

**PROC** **LOGISTIC** data=CDA.Ziowadat2 plots(unpack)=all ;

format MT MT. ;

CLASS GENDER / PARAM = REF;

model MT = Quan RT/ clodds=wald clparm=wald;

**RUN**;

ODS GRAPHICS OFF;

### Appendix B: SAS Output

|  |
| --- |
| **PREDICTORS FOR ACCELERATED MATH IOWA TEST SCORE** |

**The FREQ Procedure**

| **MT** | **Frequency** | **Percent** |
| --- | --- | --- |
| **Low** | 241 | 80.33 |
| **Advanced** | 41 | 13.67 |
| **Accelerated** | 18 | 6.00 |

**The MEANS Procedure**

| **Variable** | **N** | **Mean** | **Std Dev** | **Minimum** | **Maximum** |
| --- | --- | --- | --- | --- | --- |
| |  | | --- | | ethnicity | | age\_mo | | RT | | MT | | Ver | | Quan | | Nver | | |  | | --- | | 300 | | 300 | | 300 | | 300 | | 300 | | 300 | | 300 | | |  | | --- | | 37.00 | | 111.59 | | -0.00 | | 0.00 | | 0.00 | | -0.00 | | 0.00 | | |  | | --- | | 44.77 | | 6.42 | | 1.00 | | 1.00 | | 1.00 | | 1.00 | | 1.00 | | |  | | --- | | 1.00 | | 93.00 | | -2.25 | | -2.15 | | -2.44 | | -2.28 | | -2.84 | | |  | | --- | | 100.00 | | 137.00 | | 3.38 | | 2.52 | | 3.29 | | 3.28 | | 2.55 | |

|  |
| --- |
| **Model 1** |
| MT - Ethnicity Gender AGE\_Mo Ver Quan Nver RT |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Class Level Information** | | | |
| --- | --- | --- | --- |
| **Class** | **Value** | **Design Variables** | |
| **ethnicity** | **1** | 1 | 0 |
|  | **10** | 0 | 1 |
|  | **100** | 0 | 0 |
| **gender** | **F** | 1 |  |
|  | **M** | 0 |  |

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 12.4417 | 8 | 0.1326 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 233.125 |
| **SC** | 381.439 | 270.162 |
| **-2 Log L** | 370.031 | 213.125 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 156.9065 | 8 | <.0001 |
| **Score** | 124.3165 | 8 | <.0001 |
| **Wald** | 72.7040 | 8 | <.0001 |

| **Type 3 Analysis of Effects** | | | |
| --- | --- | --- | --- |
| **Effect** | **DF** | **Wald Chi-Square** | **Pr > ChiSq** |
| **ethnicity** | 2 | 2.1656 | 0.3386 |
| **gender** | 1 | 0.1526 | 0.6960 |
| **age\_mo** | 1 | 3.5216 | 0.0606 |
| **Ver** | 1 | 1.2139 | 0.2706 |
| **Quan** | 1 | 24.5896 | <.0001 |
| **Nver** | 1 | 0.2899 | 0.5903 |
| **RT** | 1 | 8.2715 | 0.0040 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -13.4417 | 4.6274 | 8.4379 | 0.0037 |
| **Intercept** | **Advanced** | 1 | -11.1178 | 4.5799 | 5.8927 | 0.0152 |
| **ethnicity** | **1** | 1 | -0.00801 | 0.5274 | 0.0002 | 0.9879 |
| **ethnicity** | **10** | 1 | -0.6714 | 0.4798 | 1.9579 | 0.1617 |
| **gender** | **F** | 1 | 0.1511 | 0.3868 | 0.1526 | 0.6960 |
| **age\_mo** |  | 1 | 0.0747 | 0.0398 | 3.5216 | 0.0606 |
| **Ver** |  | 1 | 0.4015 | 0.3644 | 1.2139 | 0.2706 |
| **Quan** |  | 1 | 1.5623 | 0.3151 | 24.5896 | <.0001 |
| **Nver** |  | 1 | 0.1700 | 0.3158 | 0.2899 | 0.5903 |
| **RT** |  | 1 | 0.9588 | 0.3334 | 8.2715 | 0.0040 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **ethnicity 1 vs 100** | 0.992 | 0.353 | 2.789 |
| **ethnicity 10 vs 100** | 0.511 | 0.200 | 1.309 |
| **gender F vs M** | 1.163 | 0.545 | 2.483 |
| **age\_mo** | 1.078 | 0.997 | 1.165 |
| **Ver** | 1.494 | 0.731 | 3.052 |
| **Quan** | 4.770 | 2.572 | 8.845 |
| **Nver** | 1.185 | 0.638 | 2.201 |
| **RT** | 2.608 | 1.357 | 5.013 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 92.7 | **Somers' D** | 0.857 |
| **Percent Discordant** | 7.1 | **Gamma** | 0.858 |
| **Percent Tied** | 0.2 | **Tau-a** | 0.286 |
| **Pairs** | 14957 | **c** | 0.928 |

|  |
| --- |
| **Model 2** |
| MT - AGE\_Mo Quan rt |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 5.1796 | 3 | 0.1591 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 227.173 |
| **SC** | 381.439 | 245.692 |
| **-2 Log L** | 370.031 | 217.173 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 152.8576 | 3 | <.0001 |
| **Score** | 121.6314 | 3 | <.0001 |
| **Wald** | 74.0070 | 3 | <.0001 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -11.1408 | 4.0953 | 7.4005 | 0.0065 |
| **Intercept** | **Advanced** | 1 | -8.8476 | 4.0456 | 4.7827 | 0.0287 |
| **age\_mo** |  | 1 | 0.0542 | 0.0359 | 2.2821 | 0.1309 |
| **Quan** |  | 1 | 1.6817 | 0.2747 | 37.4890 | <.0001 |
| **RT** |  | 1 | 1.2529 | 0.2549 | 24.1584 | <.0001 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **age\_mo** | 1.056 | 0.984 | 1.133 |
| **Quan** | 5.374 | 3.137 | 9.207 |
| **RT** | 3.500 | 2.124 | 5.769 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 92.7 | **Somers' D** | 0.855 |
| **Percent Discordant** | 7.2 | **Gamma** | 0.856 |
| **Percent Tied** | 0.1 | **Tau-a** | 0.285 |
| **Pairs** | 14957 | **c** | 0.927 |

|  |
| --- |
| **Model 3** |
| MT - Quan NVer RT |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 3.3491 | 2 | 0.1874 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 227.330 |
| **SC** | 381.439 | 242.145 |
| **-2 Log L** | 370.031 | 219.330 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 150.7010 | 2 | <.0001 |
| **Score** | 116.7679 | 2 | <.0001 |
| **Wald** | 73.5996 | 2 | <.0001 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -5.0700 | 0.4940 | 105.3261 | <.0001 |
| **Intercept** | **Advanced** | 1 | -2.8024 | 0.3203 | 76.5406 | <.0001 |
| **Quan** |  | 1 | 1.5989 | 0.2628 | 37.0051 | <.0001 |
| **RT** |  | 1 | 1.2988 | 0.2536 | 26.2334 | <.0001 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **Quan** | 4.947 | 2.956 | 8.281 |
| **RT** | 3.665 | 2.230 | 6.024 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 92.5 | **Somers' D** | 0.851 |
| **Percent Discordant** | 7.4 | **Gamma** | 0.852 |
| **Percent Tied** | 0.1 | **Tau-a** | 0.284 |
| **Pairs** | 14957 | **c** | 0.925 |

|  |
| --- |
| **Model 4** |
| MT - NVer Quan RT |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 3.2995 | 3 | 0.3477 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 228.934 |
| **SC** | 381.439 | 247.452 |
| **-2 Log L** | 370.031 | 218.934 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 151.0976 | 3 | <.0001 |
| **Score** | 116.8741 | 3 | <.0001 |
| **Wald** | 73.6219 | 3 | <.0001 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -5.0886 | 0.4960 | 105.2504 | <.0001 |
| **Intercept** | **Advanced** | 1 | -2.8244 | 0.3242 | 75.8848 | <.0001 |
| **Nver** |  | 1 | 0.1946 | 0.3016 | 0.4163 | 0.5188 |
| **Quan** |  | 1 | 1.4985 | 0.3048 | 24.1700 | <.0001 |
| **RT** |  | 1 | 1.2621 | 0.2588 | 23.7840 | <.0001 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **Nver** | 1.215 | 0.673 | 2.194 |
| **Quan** | 4.475 | 2.462 | 8.133 |
| **RT** | 3.533 | 2.127 | 5.867 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 92.6 | **Somers' D** | 0.853 |
| **Percent Discordant** | 7.3 | **Gamma** | 0.854 |
| **Percent Tied** | 0.1 | **Tau-a** | 0.285 |
| **Pairs** | 14957 | **c** | 0.927 |

|  |
| --- |
| **Model 5** |
| MT - Quan |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 3.5855 | 1 | 0.0583 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 254.617 |
| **SC** | 381.439 | 265.728 |
| **-2 Log L** | 370.031 | 248.617 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 121.4140 | 1 | <.0001 |
| **Score** | 105.0538 | 1 | <.0001 |
| **Wald** | 70.8387 | 1 | <.0001 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -4.3353 | 0.4054 | 114.3641 | <.0001 |
| **Intercept** | **Advanced** | 1 | -2.3266 | 0.2536 | 84.1690 | <.0001 |
| **Quan** |  | 1 | 2.0535 | 0.2440 | 70.8387 | <.0001 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **Quan** | 7.795 | 4.832 | 12.574 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 89.8 | **Somers' D** | 0.807 |
| **Percent Discordant** | 9.1 | **Gamma** | 0.815 |
| **Percent Tied** | 1.0 | **Tau-a** | 0.269 |
| **Pairs** | 14957 | **c** | 0.903 |

|  |
| --- |
| **Model 4: Selected**  SELECTED MODEL AND GRAPHICS MT = Quan RT |

**The LOGISTIC Procedure**

| **Model Information** | |
| --- | --- |
| **Data Set** | CDA.ZIOWADAT2 |
| **Response Variable** | MT |
| **Number of Response Levels** | 3 |
| **Model** | cumulative logit |
| **Optimization Technique** | Fisher's scoring |

|  |  |
| --- | --- |
| **Number of Observations Read** | 300 |
| **Number of Observations Used** | 300 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **MT** | **Total Frequency** |
| **1** | Accelerated | 18 |
| **2** | Advanced | 41 |
| **3** | Low | 241 |

**Probabilities modeled are cumulated over the lower Ordered Values.**

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Score Test for the Proportional Odds Assumption** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 3.3491 | 2 | 0.1874 |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 374.031 | 227.330 |
| **SC** | 381.439 | 242.145 |
| **-2 Log L** | 370.031 | 219.330 |

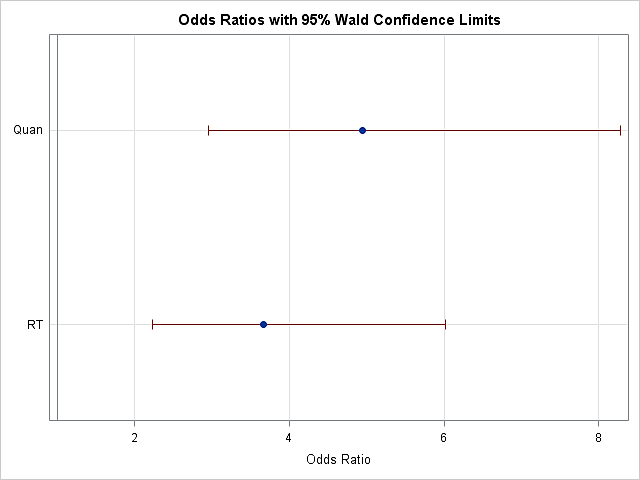
| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 150.7010 | 2 | <.0001 |
| **Score** | 116.7679 | 2 | <.0001 |
| **Wald** | 73.5996 | 2 | <.0001 |

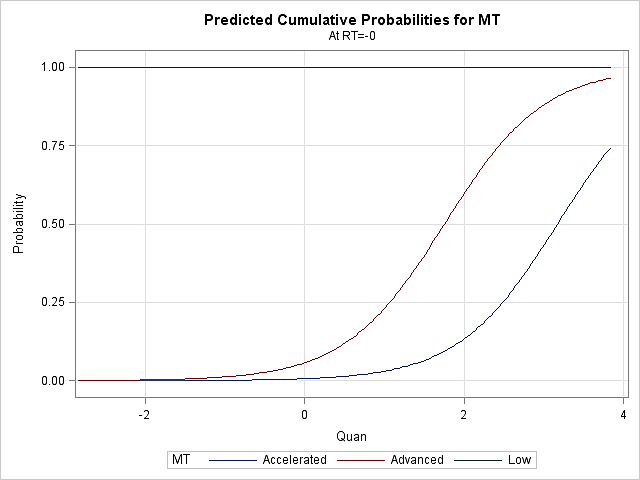
| **Analysis of Maximum Likelihood Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | **Accelerated** | 1 | -5.0700 | 0.4940 | 105.3261 | <.0001 |
| **Intercept** | **Advanced** | 1 | -2.8024 | 0.3203 | 76.5406 | <.0001 |
| **Quan** |  | 1 | 1.5989 | 0.2628 | 37.0051 | <.0001 |
| **RT** |  | 1 | 1.2988 | 0.2536 | 26.2334 | <.0001 |

| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 92.5 | **Somers' D** | 0.851 |
| **Percent Discordant** | 7.4 | **Gamma** | 0.852 |
| **Percent Tied** | 0.1 | **Tau-a** | 0.284 |
| **Pairs** | 14957 | **c** | 0.925 |

| **Parameter Estimates and Wald Confidence Intervals** | | | | |
| --- | --- | --- | --- | --- |
| **Parameter** |  | **Estimate** | **95% Confidence Limits** | |
| **Intercept** | **Accelerated** | -5.0700 | -6.0382 | -4.1017 |
| **Intercept** | **Advanced** | -2.8024 | -3.4302 | -2.1746 |
| **Quan** |  | 1.5989 | 1.0837 | 2.1140 |
| **RT** |  | 1.2988 | 0.8018 | 1.7958 |

| **Odds Ratio Estimates and Wald Confidence Intervals** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Unit** | **Estimate** | **95% Confidence Limits** | |
| **Quan** | 1.0000 | 4.947 | 2.956 | 8.281 |
| **RT** | 1.0000 | 3.665 | 2.230 | 6.024 |





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