Studying changes in Cognitive Pattern with Neuropsychological Tests using the National Health and Nutrition Examination Survey

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Introduction

Cognitive health has emerged as an important public health concern that most influences the world's aging population. In this project, Professor Sungur and I have conducted research on how cognitive functioning patterns change over time for a population using the 2011-2012 and 2013-2014 *National Health and Nutrition Examination Survey* (NHANES). In both years of the survey, a series of neuropsychological tests were implemented on an eligible sample population. The tests included: 1) word learning and recall modules from the *Consortium to Establish a Registry for Alzheimer's disease* (CERAD), 2) the Animal Fluence Test; and 3) the *Digit Symbol Substitution Test* (DSST). A total of 1686 individuals completed the series of neuropsychological tests for both years of the NHANES data that would be used to predict the cognitive functioning using several logistic regressions models.

Data and Modeling

Due to the nature of the NHANES datasets, it required to do a lot of data manipulation such as finding the covariates that would explain the variation in Cognitive Functioning of the individuals, categorizing the variables into a usable format, and make the best decision with the missing values that existed in the dataset. The covariates that we found useful for the study were Cerad Trial scores. Cerad Delayed scores, Cerad Intrusion Trial scores, Animal Fluency Scores, Digital Symbol Scores, Age of the respondents, Gender and Race. We can potentially work with 2 different datasets - (1) where we removed all the missing values from the dataset to perform the analysis, (2) imputed the missing values with the mode value for each predictor and compared the estimates. The following analysis was performed removing the missing values from the dataset.

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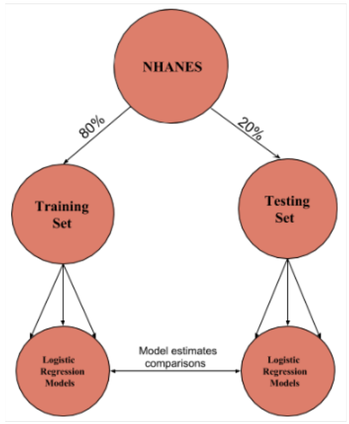

In the later stages of the investigation, we will be using 3 separate models with each neuropsychological test scores as predicting variables along with age, gender, and race. We hope to distinguish the predictive ability of cognitive skills with each neuropsychological tests and how it varies over age across age and gender.

Models : (1) CogFunc = CeradTrial1 + CeradTrial2 + CeradTrial3 + Gender + Race + Age

(2) CogFunc = AnimalFluenceScore + Gender + Race + Age

(3) CogFunc = DigitalSymbolScore + Gender + Race + Age

(4) CogFunc = CeradTrial3 + AnimalFluenceScore + DigitalSymbolScore + Gender

Model Diagnostics

The survey-weighted logistic regression model is appropriate for survey data obtained complex sampling techniques, such as stratified random or cluster sampling and used to design correct variance estimates. Various sample weights were available on the data release files. Since we combined two years of survey data, the multi-year sample weights were calculated by estimating the average of combined sample weight.

ANOVA test had been implemented to compare models that consists of all the test scores in the study versus test scores that have evidence to explain the variation of each individual's cognitive functioning. The large p-value and lowest AIC value (p=0.79) indicated that there is enough evidence that model consisting only Cerad Trial 3, Animal Fluence Score, Digital Symbol Score and Gender helps explain the variation in each individual's cognitive functioning ability and their effects on cognitive functioning ability are statistically significant.

Influence plots, Dfbetasplots, Cook distance were implemented to identify whether the data had any potential outliers that would influence the model estimates. Results showed that ***row-382*** had very high unusual cook's distance and Bonferonni test result proved it to be an outlier. An analysis was done after removing the outlier from the data and model estimates showed no significant difference.

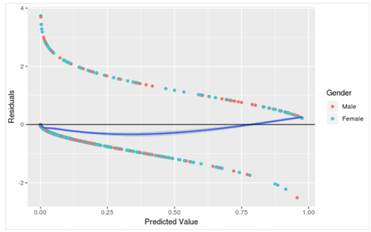

Figure 1 : Residual plot of the model

Figures

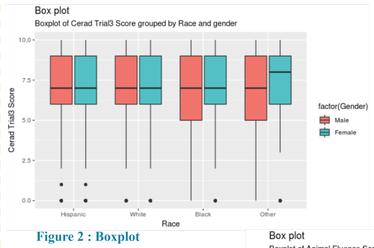

Figure 2 : Boxplot

Figure 3 : Boxplot

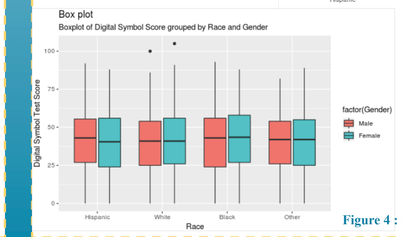

Figure 4 : Boxplot

Table 1 : Correlation Table among the covariates (*n= 1686)*

Covariates	Cerad Trial 1	Cerad Trial 2	Cerad Trial 3	Animal Fluence Score	Digital Symbol Score	Age
Cerad Trial 1	1.00	0.80	0.77	0.61	0.61	-0.019
Cerad Trial 2	0.80	1.00	0.88	0.66	0.64	-0.0032
Cerad Trial 3	0.77	0.88	1.00	0.67	0.63	0.0054
Animal Fluence Score	0.61	0.66	0.67	1.00	0.66	0.0020
Digital Symbol Score	0.61	0.64	0.63	0.66	1.00	-0.024
Age	-0.019	-0.0032	0.0054	0.0020	-0.024	1.00

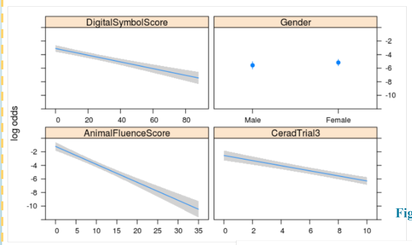

Figure 5 : Test score Effects plot

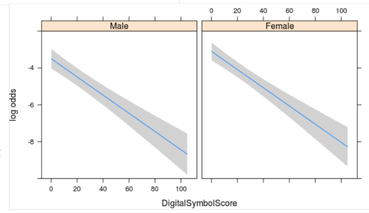

Figure 6 : DSST score Effects plot across gender

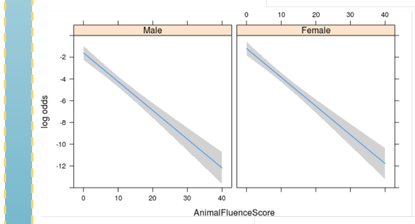

Figure 7 : Animal Fluence score Effects plot across gender

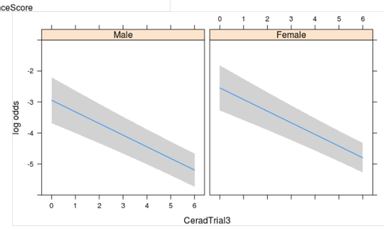

Figure 8 : Cerad Trial 3 score Effects plot across gender

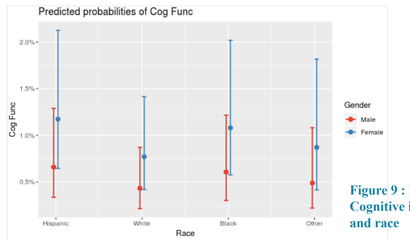

Figure 9 : Predicted probability plot of Cognitive impairment across gender and race

Results

Table 2: Multiple Logistic Regressions of Cognitive Functioning on covariates (*n = 1686)*

Covariates	Model 1		Model 2		Model 3		Model 4	
	Estimates	P-value	Estimates	P-value	Estimates	P-value	Estimates	P-value
Cerad Trial 1	0.69	0.467	--	--	--	--	1.04	0.66
Cerad Trial 2	0.85	0.396	--	--	--	--	1.00	0.98
Cerad Trial 3	0.58	8.6e-16***	--	--	--	--	0.65	2.1e-07 ***
Animal Fluence Score	--	--	0.63	2e-16 ***	0.89	2e-16 ***	0.77	2e-16 ***
Digital Symbol Score	--	--	--	--	--	--	0.96	5.7e-12 ***
Gender : Male	6.85	8.4e-13 ***	6.78	0.0015***	1.85	0.333	22.53	2e-16 ***
Gender : Female	9.61	2.4e-15 ***	8.94	0.01231 *	2.01	0.846	39.66	2e-16 ***
Race	0.83	0.157	0.78	0.81425	0.80	0.097	0.65	0.17
Age	1.00	0.255	1.00	0.46	1.00	0.445	--	--

Conclusion

- Cerad Trail 3 showed clear evidence of being negatively associated with cognitive functioning with less chance of being cognitively impaired as an individual scored more in Cerad Trial 3. By looking at the odds ratio, we could tell that Cerad Trial 3 scores had 0.65 times the chance of predicting that an individual is cognitively impaired.
- Animal Fluence Score showed clear evidence of being negatively associated with cognitive functioning with less chance of being cognitively impaired as an individual scored more in Animal Fluence Score. By looking at the odds ratio, we could tell that Animal Fluence Score scores had 0.77 times the chance of predicting that an individual is cognitively impaired.
- Digital Symbol Score showed clear evidence of being negatively associated with cognitive functioning with less chance of being cognitively impaired as an individual scored more in the Digital Symbol Score. By looking at the odds ratio, we could tell that Digital Symbol scores had 0.96 times the chance of predicting that an individual is cognitively impaired.
- Gender: Male showed clear evidence of being positively associated with cognitive functioning with a lower chance of being cognitively impaired as compared to Female. By looking at the odds ratio, we could tell that Male had 22.53 times the chance of being predicted as cognitively impaired.
- Gender: Female showed clear evidence of being positively associated with cognitive functioning with a higher chance of being cognitively impaired as compared to Male. By looking at the odds ratio, we could tell that Female had 39.66 times the chance of being predicted as being cognitively impaired.
- There were differences in Cognitive Functioning across difference Race with White having the lowest chances of being cognitively impaired, Hispanic and Black having the highest chance of being cognitively impaired. However, there was no evidence of the differences in Cognitive Functioning across different races and hence the Race effect was not statistically significant.
- There was no evidence of Age effect on predicting cognitive functionality of each individual and hence the Age effect was statistically significant.

References

- Alzheimer's Association and Centers for Disease Control and Prevention. The Healthy Brain Initiative: The Public Health Road Map for State and National Partnerships, 2013–2018: Chicago, IL: Alzheimer's Association; 2013.'
- "NHANES 2011-2012: Cognitive Functioning Data Documentation, Codebook, and Frequencies." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, n.d. Web.
- "NHANES 2013-2014: Cognitive Functioning Data Documentation, Codebook, and Frequencies." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, n.d. Web.