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ABSTRACT

An existing large data set, the Health and Retirement Study 2000 (HRS 2000) was used to explore the relationship between cognition and other factors for individuals aged 65 and older, with a final sample of 1,610 males and 3,549 females. Using structural equation modeling, the entire model was tested to determine if there were differences in how well the model fit data from both men and women. The influences of direct and indirect contributing factors on cognition were also investigated. Although there were no significant gender differences in the fit of the model for data from this population, future research might study the relationship between cognitive decline and gender within specific age or cultural groups. (Contains 1 table, 3 figures, and 42 references.) (Author/SLD)

Running Head: Social/Biological Factors with Cognition

Structural Equation Modeling Analysis of the Effects of Social and Biological Factors on Geriatric Cognition: Does Sex Matter?

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Abstract

An existing large data set, The Health and Retirement Study 2000 (HRS 2000) was used to explore the relationship between cognition and other factors for individuals age 65 and older. Using structural equation modeling, the entire model was tested to determine if there were differences in how well the model fit data from both men and women. The influences of direct and indirect contributing factors on cognition were also investigated.

Using data from the Assets and Health Dynamics of the Oldest Old Survey (AHEAD), Zsembik and Peek (2001) investigated differences in cognitive functioning among older adults relative to race, socioeconomic inequality and health status. Structural equation models were used to estimate the direct effect of race on cognitive functioning and the indirect effect of race through social risk factors such as education and insurance. Possible differences in cognition between males and females, however, were not examined.

The intent of the current study was two-fold: (1) to build a model depicting the factors that influence cognition; and (2) to determine if there are differences between elderly males and females based on the constructed model. The most recently released data by the University of Michigan Health and Retirement Survey, now called The Health and Retirement Study 2000 (HRS 2000), was used for the investigation.

Previous studies suggest that the same confounding variables may exist in examining sex differences as well as racial differences. The cumulative advantage and disadvantage theory postulated by Crystal & Shea (1990) and others, suggests that economic inequalities are established in early life and become greater with age. Furthermore, these inequalities can have effects on health and education. Until recently, females have tended to have less education than males, and still tend to be economically disadvantaged, either as single women, or as older women (Federal Interagency Forum on Aging-Related Statistics, 2000).

In addition, there are neurobiological differences in males and females (George et al., 1997; Gur et al., 1995; Meisinger et al., 2002). Any of these neurological or

physiological factors may influence cognition. However, there is little research investigating the relationship between sex and cognition in older adults.

Although cognitive decline is not an inevitable function of aging (Baltes & Willis, 1982; Christensen, Henderson, Griffiths, & Levings, 1999), it does occur in some individuals (Kaufman & Horn, 1996; Nelson & Dannefer, 1992). Barrett-Connor and Kritz-Silverstein (1999) found a significantly steeper decrement in cognitive function with age in men on the total recall and long-term memory tests ($p<.001$), on the immediate ($p<.01$) and delayed ($p<.05$) recall tasks of visual reproduction tests, and on category fluency ($p<.05$). Another cognitive factor, dementia, also has both psychological and biological components. Several studies have suggested that the frequency of dementia is higher among females than males (e.g. Anderson, et al., 1999; Mortensen & Hogh, 2001). A study by Hebert, et al. (2000) however, found no significant association between gender and cognitive decline in Alzheimer's patients.

The aforementioned research suggests that there may be differences in cognition between males and females of any age and that some individuals experience cognitive decline with age. Only a limited amount of research, however, has studied the cognitive differences between elderly males and females (e.g. Anderson, et al., 1999; Barrett-Connor & Kritz-Silverstein, 1999). The purpose of this study was not only to build a model displaying factors that influence cognition, but also to determine if the same model would fit elderly men and women similarly.

Method

Data for this study were obtained from the HRS 2000 database maintained by the University of Michigan. Initially, the 21 available files were divided among the seven

investigators to search for relevant variables. Each team member evaluated and selected pertinent variables that were ultimately merged to form the database used for this study. There were more than 18,000 respondents included in the original database. For this study, individuals who were 65 years of age and older and were the primary household respondent were chosen. This yielded a sample size of 6,598 participants. Because some of the variables used contained missing values, the final database consisted of 5,159 respondents: 1,610 males and 3,549 females.

Manifest variables (directly measured variables) for this study were constructed by combining apparently related item responses using SPSS 10.0. For example, the manifest variable "chronic" was created by combining the responses from previous waves and current data related to diabetes with previous waves and current data associated with blood pressure. All responses were coded as 1 (Yes) if the respondent had diabetes (or high blood pressure) or 0 (No) if the respondent did not have diabetes (or high blood pressure). Thus a larger number represented a greater degree of chronic illness. Detailed information concerning each variable is provided in Appendix A. After constructing variables to be used, the resultant data were entered into the LISREL 8.3 structural equation modeling program in order to assess how factors contributed directly and indirectly to cognition. When the data were collected, cognition was measured by having respondents employ immediate and delayed word recall skills (number of words remembered from a list of 10) and multiple subtractions (starting at 100 and consecutively subtracting seven). Explanatory latent variables (constructs indirectly measured by multiple manifest variables) included the respondents' "Self Rating of Health", "Self-Rating of Memory", and an "Illness" construct. The "Illness" construct

consisted of the indicators of 'Chronic Diseases', 'Stroke/ Disabilities', and 'Cardiopulmonary'. Another latent variable, the respondents' "Healthy Behaviors" was measured by 'Preventive Measures' (flu shots and cholesterol screening) and 'Exer/Smo' (current vigorous exercise behavior and current smoking behavior). Because "Financial" condition might indirectly affect cognition through "Healthy Behaviors" and/or "Depression", measures for each of these constructs were also included in the model.

The analysis initially used a fully recursive model (i.e., each construct was tested as a direct cause of any construct following it). Paths that did not contribute (statistically significantly or practically) were removed. After obtaining a final "best" model, the sample was split into two groups: males and females. Determination was made at that time as to whether the *structural model* fit both males and females equally and whether the *measurement model* fit both males and females equally.

In addition, the manifest variables indicating the "Financial" construct were not normally distributed. A constant was added to each of these indicators so that none of them were negative numbers or zero. These indicators were then transformed using the log 10 function to approximate a normal distribution.

Because chi-square is severely influenced by sample size, trivial differences between the sample and the reproduced covariance matrices may be statistically significant leading to rejection of the model. Consequently, other measures of fit were also used to evaluate the model. The root mean square error of approximation (RMSEA) was used to provide a measure of model mis-specification and a measure of discrepancy between the sample and reproduced covariance matrices per degree of freedom (Browne & Cudeck, 1993). A value of 0.06 (Hu & Bentler, 1999), 0.05 (Browne & Cudeck, 1993)

or less indicates one measure of adequate fit. The Tucker-Lewis coefficient or non-normed fit index (NNFI; Bentler & Bonnett, 1980) was used to provide a measure of incremental fit when compared to a null model. Values above 0.9 for this index suggests acceptable fit. Finally, we report the parsimonious normed fit index (PNFI; James, Muliak, & Brett, 1982). This criteria provides a measure of model fit versus the degrees of freedom needed to achieve that fit.

Results

Although chi-square (χ^2 = 1761.42, df 98, $p<.05$) was statistically significant for the initial model, the root mean square error of approximation (RMSEA) was an acceptable 0.057 and the NNFI provided an adequate fit of 0.92. The PNFI was 0.68. Although the alternative measures to chi-square indicated an adequate fit of the model, reviewing the initial fully recursive model with all manifest variables (see Figure 1), it is obvious that some paths were not contributing to the overall model. For example, the coefficient for the path between "Healthy Behaviors" and "Cognition" was 0.00. This path did not help explain the model and, indeed, caused it to be less parsimonious. Consequently this path was removed, the model was re-assessed, and other paths were considered. This process was repeated until all remaining paths were statistically significant indicators.

Insert Figure 1 about here

Analysis of the measurement model indicated that the best-measured latent variable was "Financial" (in-common variance .78) and the least reliable measurement was the "Illness" construct (in-common variance .20). The "Healthy Behaviors" construct, however, was of most concern because it was measured almost totally by the exercise/smoking manifest variable. The preventive manifest variable had very little influence.

In addition, scaling for constructs varied. For example, in Figure 1, the path from "Self-reported Health" to "Financial" was a –0.29. The negative relationship between the two constructs was due to two conditions: (1) a higher number for financial represents larger finances, and (2) a higher number for health represents lower health. In the case of the "Illness" construct (higher number - more problems with illness), the "Self-reported Memory" construct (higher number - more problems with memory), the "Depression" construct (higher number - more depressed) and the "Self-reported Health" construct, higher numbers imply worse conditions. In the case of the "Cognition" construct (higher number – better recall), the "Healthy Behaviors" construct (higher number – more healthy behaviors) and the "Financial" construct, higher numbers indicate better conditions. Construction of the manifest indicators is described in Appendix A, Table 1.

The final model (shown in Figure 2) accounted for 16% of the variance in cognition. Although chi-square (1769.06, df = 105) was still statistically significant, other fit measures had improved. RMSEA was now a 0.055, NNFI a 0.93, and PNFI a 0.73.

Insert Figure 2 about here

"Self reported Health" had the largest total effect (-.22) on cognition followed by "Financial" (.20), "Self-reported Memory" (-.18), and "Illness" (.11). Although there was a negative indirect effect of "Self-reported Health" through "Financial" (-.29*.20 = -.058), this was canceled by the positive indirect effect through "Illness" (.51*.11 = .056). Consequently, in the final model, the direct effect of each latent construct is also the total effect.

When males and females were split into two samples, the paths (paths from each latent variable to other latent variables and from the manifest variables to each latent variable) were constrained to the same pattern (model). This model provided a baseline measure of the two groups within the same model (χ^2 =1819.43, df=200, $p<.01$). Then the measurement model (paths from each latent construct to its manifest variables) were constrained to be equal across groups. This resulted in a non-significant chi-square change ($\Delta\chi$) from 1,819.43 in the baseline model to 1,846.45 (df=217) in the constrained model ($\Delta\chi = 27$, $\Delta df = 17$). When the structural model (paths from the latent variables to other latent variables) was constrained to equivalence across groups, chi-square increased to 1,861.65 (df=230), again resulting in a non-significant increase ($\Delta\chi = 15.2$, $\Delta df = 13$). Thus, the data fit the model for males and females equally. This model is depicted in Figure 3. Path coefficients for males are enclosed in parentheses; those for females are not enclosed.

Discussion

Contrary to expectation, there were no statistically significant differences in the cognition model between males and females. The construction of the structural model provides some indication of what variables inter-relate to affect cognition and illustrates

the advantage of using structural equation modeling in that indirect effects can be identified which cannot be identified with other methods. In this model, there were no significant indirect effects.

In our study, the construct self-reported health is composed of 2 single-item manifest variables: current self-rating of health and past self-rating of health. Subjective health rating is an individual's perception and evaluation of his or her physical health (Liang, 1986). Like all self-reports, they are influenced by culture and language (Angel & Frisco, 2001). Reports of subjective states are, therefore, problematic when used in comparisons of individuals who differ significantly in those cultural and social factors that influence the meaning of subjective information. This may account for the minimal indirect effects that self-rated health had on other constructs. However, our model does show a direct effect of self-rated health on cognition. This result is consistent with previous research by Liang, (1986), where their research demonstrated a correlation of subjective health rating and functional capacity and instrumental activities.

Another construct, "Self-Reported Memory", consisted of two manifest measures: participant's perception of memory ability at present and in the past. According to the model proposed, "Self-Reported Memory" has a small but significant direct effect on cognitive task performance (-.17), indicating that participants' perceived memory ability corresponds to their actual cognitive performance (e.g. recall and subtraction tasks), although the relationship between self-reported memory and cognitive performance is modest. This result is consistent with other studies (e.g. Dixon & Hultsch, 1983; Herrmann, 1982; Zelinski, Gilewski, & Anthony-Bergstone, 1990). Zelinski, Gilewski, and Anthony-Bergstone found that self-reports of memory ability were modestly related

to objective memory performance when effects of depression, education, and health were partialed out.

"Financial Condition" produced a direct effect on cognition of .20. This finding contrasts with Smith and Kulegel (1982), who found no direct effects of economic status on depression or cognition, but observed a powerful indirect effect, through perceived outcomes. Individuals with higher levels of income tended to report more positive life outcomes, which in turn, led to diminished indicators (specifically, increased satisfaction, happiness, and confidence, and decreased disappointment) traditionally associated with decreased cognition. In another study, Rozzini, Frisoni, Ferrucci, and Trabucchi (1997) examined economic status as one of five categories of disadvantage conditions in relation to depressive symptoms in elderly subjects. Those participants whose financial welfare was in the lower tertile, were found to have a 3.2 times greater risk for depression than participants in the upper tertile. The results of these studies affirm the likelihood of individual's financial situation having effects, albeit indirect, on cognition. The present model suggests a more direct relationship.

The latent variable, "Illness", had a direct effect of .11 on cognition. This result was surprising because it appears that as illness conditions increase, cognition also increases. "Illness" was comprised of the self-reported chronic disorders hypertension, heart condition, diabetes mellitus, and history of stroke. Hypertension, smoking, diabetes, obesity, and physical inactivity are well-established risk factors for stroke in both men and women (Wyler 1999). In addition, significant coronary artery obstruction and multiple vessel disease are seen in individuals with diabetes compared to their non-diabetic counterpart. Singh et al. (2001) related that there was an enhanced risk of

mortality in individuals with diabetes in conjunction with factors such as hypertension, lipid abnormalities, obesity, smoking, and fibrinogen abnormalities. Tabbarah, Crimmins, and Seeman (2002) found a direct relationship between decline in cognition and increase in negative health conditions, specifically current smoking, stroke, diabetes, and high blood pressure (*ps* <.05.). VanBoxtel, et al (1998) also found diabetes to be directly linked to decline in cognitive ability in adults. One possible reason this study differed from prior research is that most respondents were relatively healthy. Thus there was little range within these variables.

The construct of "Healthy behaviors" was indicated by the manifest variables "Preventive" and "Exer/Smo". "Preventive" was comprised of the sum of the database variables preventive flu shot and preventive cholesterol. Exer/Smo was comprised of the sum of does perform vigorous exercise and does not smoke now. This construct had no effect on cognition in this analysis. Further, it appears to be measured primarily by vigorous exercise and does not smoke now. Thus, other preventive measures had little influence.

The inter-relationship between physical and mental health is a complex one, each influencing the other in multiple ways. Regular exercise behavior that results in greater aerobic fitness has been shown to influence cognition, mood, and cognitive processing speed (Osness & Mulligan, 1998; Rikli & Edwards, 1991; VanBoxtel et al., 1997). Penninx, et al. (2002) found persons with a greater number of physical problems also reported higher depressive symptoms and aerobic exercise significantly lowered those depressive symptoms. With the possible exception of stroke, all of the above mentioned morbidities can be mediated by regular exercise behavior (ACSM, 1993; CDC, 1996).

The latent variable "Depression" had no apparent correlation with cognition. This result seems contrary to what was expected because poor concentration, memory difficulties, impaired ability to think or make decisions comprise one aspect of the diagnostic criteria in the DSM-IV-TR (Diagnostic and Statistical Manual of Mental Disorders) for depressive disorders (American Psychiatric Association, 2000). This fact would seemingly promote a significant negative correlation with cognition. However, there are eight other criteria for diagnosing depression not directly related to cognitive impairment. Furthermore, Gallo and Rabins (1999) found that older adults with depression may exhibit great concern about memory loss, yet display no objective evidence of this in brief memory assessments. Another possible explanation for the non-significant relationship between depression and cognition could be that the sample we employed in our analysis showed little depression (mean = 2.1, median=1.0, mode=0.0, standard deviation= 2.17). The majority of the respondents in this distribution, (more than 95%), lie well below a suggested cutoff score for clinical depression on the CESD-10 (Andresen, Malmgren, Carter, & Patrick, 1994).

Implications for Future Research

A number of refinements to this model could be made in the future. The mean scores of the cognition measures for both genders seemed relatively high, suggesting that the surveyed sample may have suffered from limited range. It is possible that using only primary respondents from each household skewed the sample. It would be informative to analyze the data from other respondents to see if they contributed a broader range.

In addition, other indicators of "Healthy Behaviors" and "Illness" may provide a more accurate measures of those constructs. Education was one of the stronger predictors of cognition in the Zsembik and Peek (2001) study. However, data related to educational status were not complete for the HRS 2000 survey and thus were not available for analysis in the present study. It is hoped that examination of the direct and indirect effect of educational achievement on cognition will be possible when the data are available.

Although there were no significant gender differences in the fit of the model for data from this population, future research might study the relationship between cognitive decline and gender within specific age or cultural groups. Also, a more thorough examination of the relationships between depression and cognition and between education and depression might prove useful.

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Appendix A
Table 1
Variables used to Measure Constructs

Construct	Indicator	Sum of	Scaling
SR Health	Health	Q1226	1= Excellent to 5 = Poor
	PastHealth	Q1229	1=Better, 2= Same, 3=Worse
SR Memory	Memory	Q1654	1= Excellent to 5 = Poor
	PastMem	Q1655	1=Better, 2= Same, 3=Worse
Financial	LogAssets LogIncome LogNetWorth		Calculation provided by data source
Healthy Behaviors	Preventive	Q1385 Flu Shot	0=No, 1=Yes
		Q1386 Cholesterol Screening	
	Exer/Smo	Q1395 Vigorous Exercise	0=No, 1=Yes
		Q1400 Smoke Now (recode)	0=Yes, 1=No
	Chronic	Q1262 Cancer	0=No, 1=Yes
		Q1279 Lung	
		Q1266 Can Better/Worse	1=Better, 2= Same, 3=Worse
Illness	StroDis	Q1309 Stroke	0=No, 1=Yes
		Q1312 Problems	
		Q1238 BloodPressure	
		Q1289 Heart Condition	0=No, 1=Yes
	CardioPulm	Q1245 Diabetes	
		Q1242 BP Better/Worse	
		Q1292 Ht Better/Worse	1 = Better, 2 = Same, 3 = Worse
		Q1255 Diab Better/Worse	
Depression	HappyCESD	Q1672, Q1674, Q1677	0=Yes, 1=No
	SadCESD	Q1669, Q1670, Q1671,	
		Q1673, Q1675, Q1676	0=No, 1=Yes
Cognition	DelayRecall	Q1815m1 to Q1815m10	
	Reverse7s	Q1806 to Q1810	0 = Incorrect, 1 = Correct
	ImmedRecall	Q1666m1 to Q1666m10	

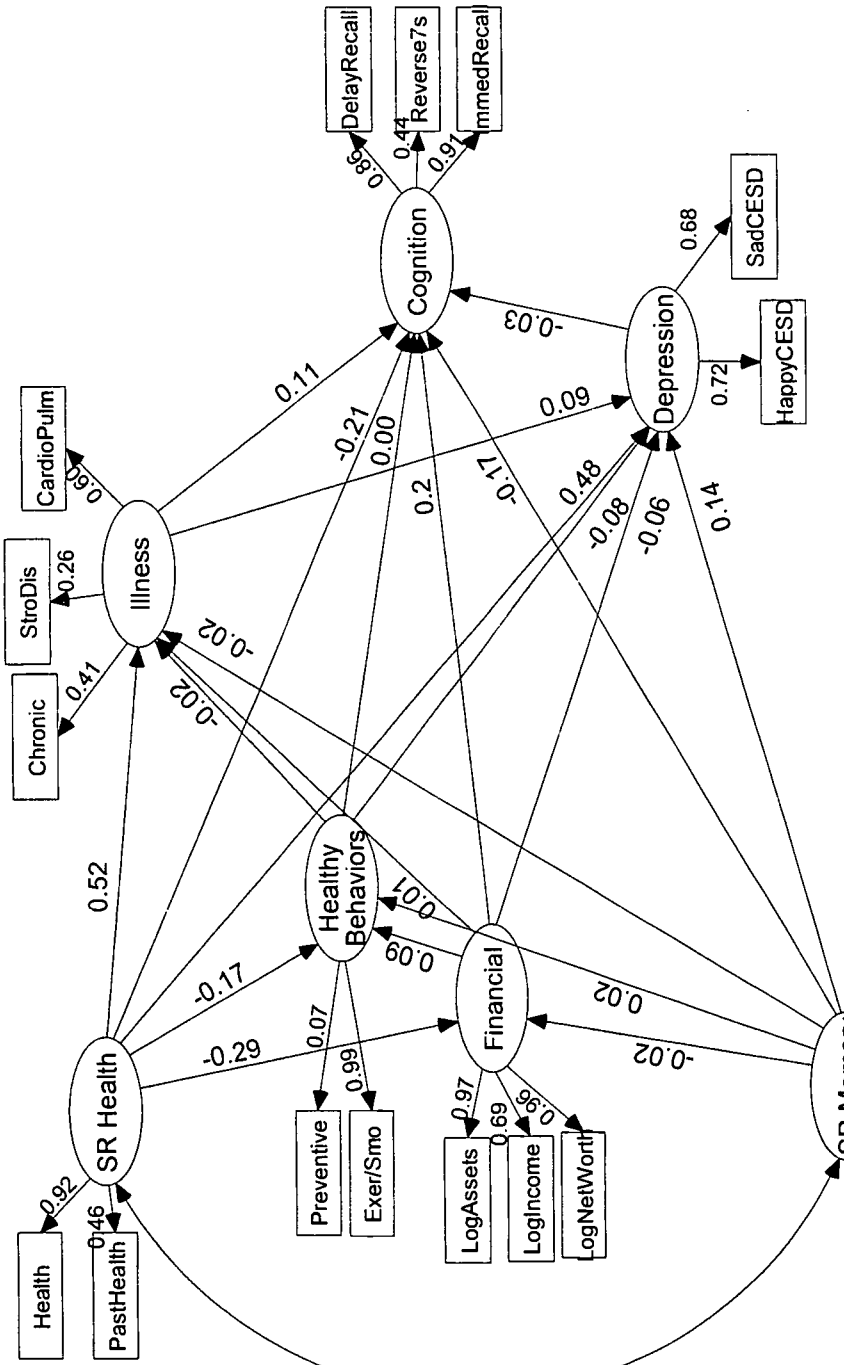

Figure 1
Initial Model
Chi-Square = 1761.42, df 98
RMSEA= .057, NNFI=.92, PNFI=.68

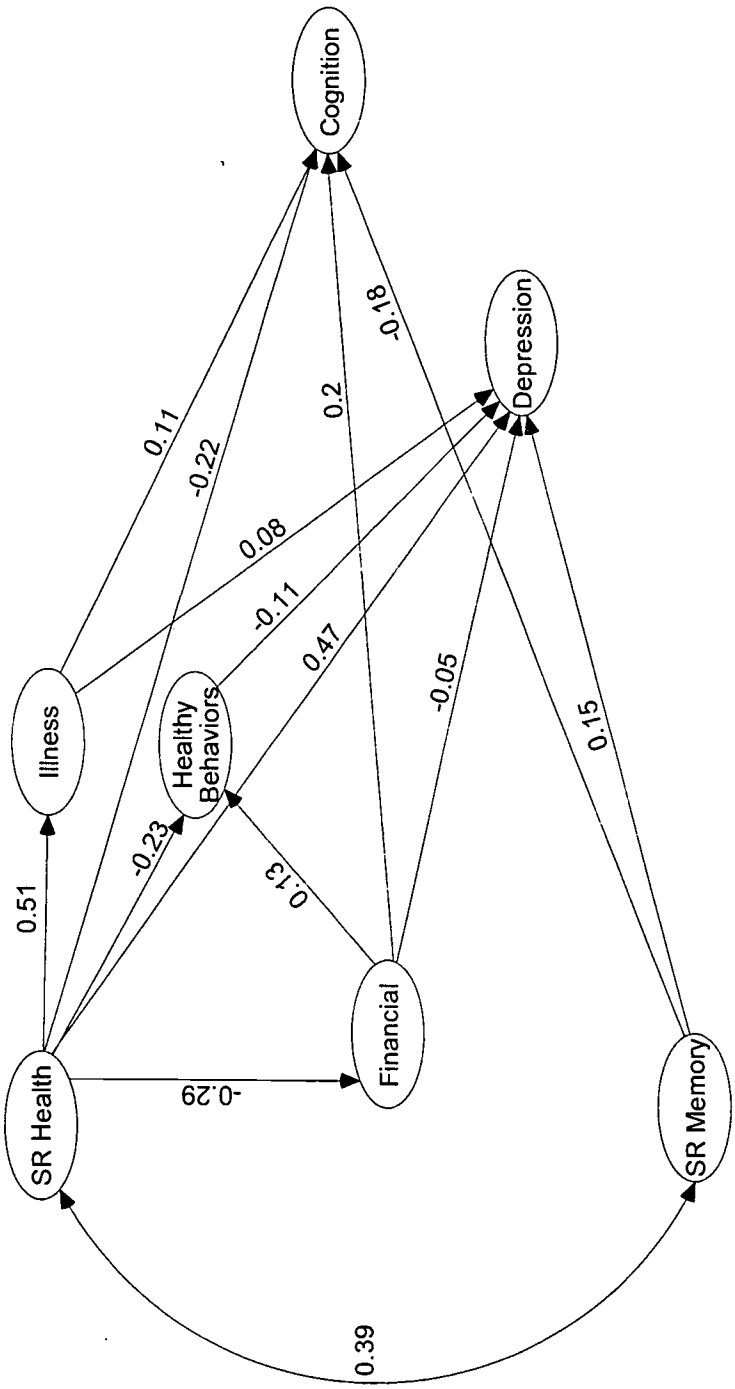

Figure 2
Final Model
Chi-Square = 1769.06, df 105
RMSEA = .055, NNFI= .93, PNFI=.73

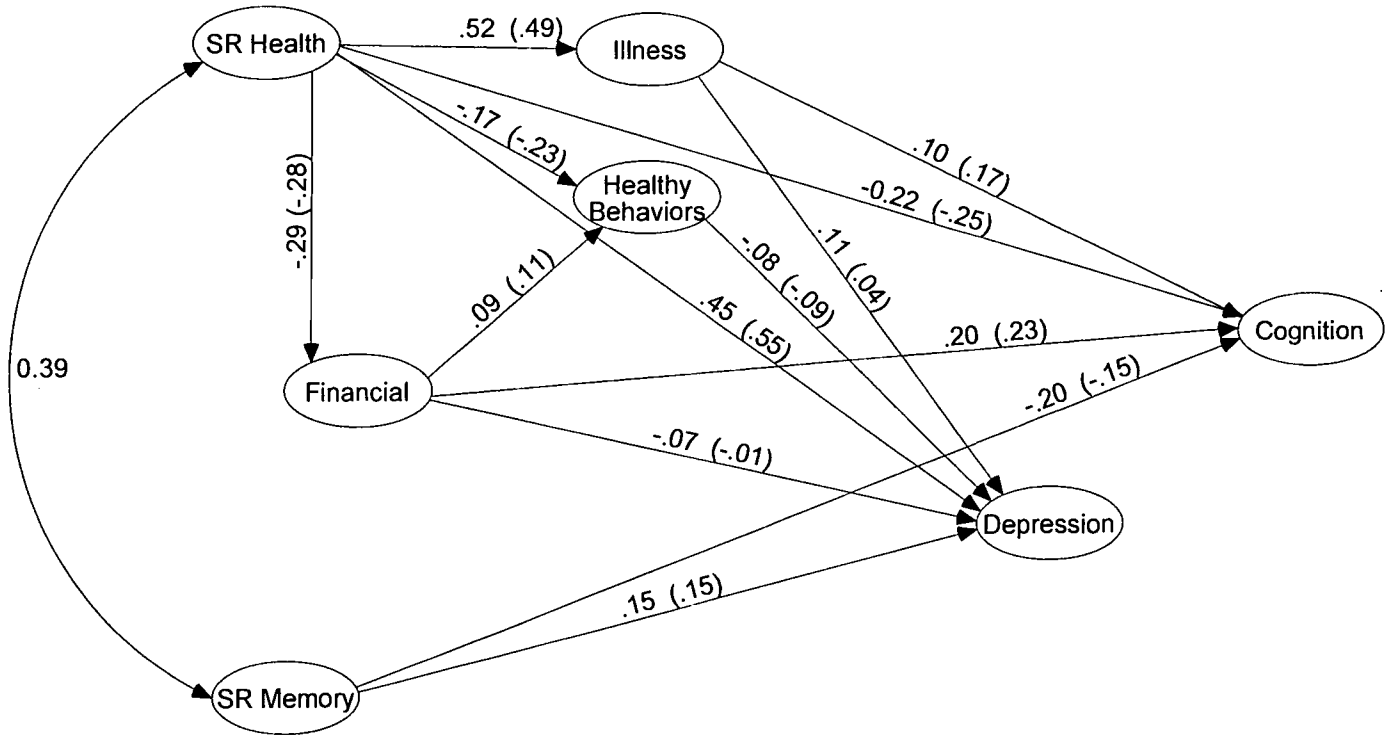

Figure 3
Model by Sex [Male estimates in parentheses]
Chi-Square = 1158.94 (660.50), df 105
RMSEA = .052 (.057), NNFI= .93 (.92), PNFI=.69 (.72)

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