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# Research Brief

## **Confirmatory Factor Analysis of CHC Theory with a Neurologically Impaired Sample**

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# Confirmatory Factor Analysis of CHC Theory with a Neurologically Impaired Sample

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## Introduction

The Cattell-Horn-Carroll (CHC) theory of cognitive abilities is based on the work of Cattell (i.e., 1963), Horn (i.e., 1965), and Carroll (i.e., 1997) and currently serves as the theoretical foundation for the *Woodcock-Johnson III Tests of Cognitive Ability* (WJ COG, Woodcock, McGrew, & Mather, 2001). The CHC theory of cognitive abilities can be considered a factor analytically derived theory that incorporates a wide range of cognitive abilities that are thought to assess all of the major domains of cognitive processing. Specifically, the WJ COG assesses the Stratum II factors, which are domains of processing abilities that entail the wider range of cognitive abilities, and together the Stratum II factors comprise *g*, or a global measure of intelligence. The CHC theory, and the underlying *Gf-Gc* theory (i.e., Horn & Cattell, 1966) has been widely assessed through exploratory factor analysis, confirmatory factor analysis, and seems to demonstrate excellent levels of validity and psychometric integrity. The current study attempted to match the results from a battery of cognitive tests, which were administered to a very large neurologically impaired sample, to CHC theory through confirmatory factor analysis.

## Methodology

The current study examined 1,315 individuals (mean age = 223.25 months, standard deviation = 157.50) who had been referred for neuropsychological assessment and had been given either a neurological or psychiatric diagnosis. The sample consisted of 888 males and 427 females and represents a wide range of impaired individuals, including individuals with Attention-Deficit Disorder, Traumatic Brain Injury, Cerebral Vascular Accident, Dementia, and Learning Disorders. Each subject received a comprehensive battery of 14 cognitive tests that were drawn from the *Woodcock-Johnson Psycho-Educational Battery-Revised* (WJ-R, Woodcock & Johnson, 1989). The authors hypothesized that the cognitive subtests from the WJ-R, which were designed to assess *Gf-Gc* theory (Mather, 1991), would match the CHC theory. Specifically, the Stratum II CHC factors that were examined for model fit were Comprehension-Knowledge (*Gc*), Long-Term Retrieval (*Glr*), Visual-Spatial Thinking (*Gv*), Auditory Processing (*Ga*), Fluid Reasoning (*Gf*), Processing Speed (*Gs*), and Short-Term Memory (*Gsm*).

## Promax Factor Loading Matrix for Seven Factor Solution

Subtest	<i>Gf</i>	<i>Gs</i>	<i>Gsm</i>	<i>Glr</i>	<i>Ga</i>	<i>Gc</i>	<i>Gv</i>
Concept Formation	.903						
Analysis-Synthesis	.839						
Visual Matching		.906					
Cross Out		.756					
Memory for Words			.884				
Memory for Sentences			.745				
Memory for Names				.802			
Visual Auditory Learning	.339			.614			
Incomplete Word					.660		
Sound Blending					.472		
Picture Vocabulary						.805	
Oral Vocabulary						.596	
Visual Closure							.667
Picture Recognition							.303

## Results and Summary

Results of the confirmatory factor analysis (CFA) used to assess the theoretical model for the CHC theory suggested a good model fit.

A number of approaches are typically used to assess the fit of a CFA model to a set of data, including the Comparative Fit Index (CFI), the chi-square goodness of fit test, the chi-square divided by degrees of freedom, and the Root Mean Square Error of Approximation (RMSEA, Meuller, 2000).

There are a variety of guidelines for interpreting the fit of a specific model based on these indices. Generally, CFI values greater than 0.95, the ratio of chi-square to degrees of freedom less than 5 and RMSEA values less than 0.05 all indicate acceptable fit (Kline, 2005). A statistically significant chi-square value suggests poor fit, but this test is very sensitive to sample size and may be statistically significant when *n* is large, as it is in the current study (Mueller, 2000).

The CFI for the CHC model was 0.978, while the chi-square by degrees of freedom ratio was 4.656. In addition, the RMSEA was 0.053, and the chi-square goodness of fit test was statistically significant with the p-value < 0.001. It should be noted that the 90% confidence interval for the RMSEA value was from 0.046 to 0.059, suggesting that values below 0.05 are reasonable estimates for the CHC model. Given that the CFI and chi-square to degrees of freedom ratio values are within acceptable limits, and the confidence intervals for the RMSEA suggests that values below 0.05 are reasonable, it appears that the proposed model does fit the data at hand.

The results of the significant chi-square test must be interpreted cautiously given the very large sample size of 1,351 participants. Furthermore, taken in light of the other measures, which suggest adequate fit, the results of the chi-square test should not be taken in isolation as evidence of poor model fit since large sample sizes tend to artificially inflate chi-square values.

As a follow up to the CFA, the authors conducted an exploratory factor analysis on the same data. After setting the seven CHC factors a priori, principle axis factoring with promax rotation indicated that the cognitive subtests loaded in a fashion highly consistent with CHC theory with minimal cross loadings.

Although the CHC and *Gf-Gc* theoretical models are well researched, especially through the standardization of the WJ-R and WJ-III, the present study employed an extremely large neurologically impaired sample. In sum, the cognitive tasks that were administered to the large group of neurologically impaired individuals were a good fit for the CHC model of cognitive processing, and provides construct validity to the use of the WJ-R and WJ-III tests with neurologically impaired individuals.

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