What subtests on the WAIS-III measure Social Cognition?

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Abstract

Factor analytic studies of the Wechsler Adult Intelligence Scale (WAIS) have provided evidence for a number of distinct cognitive abilities. These include Verbal Comprehension, Perceptual Organization, Working Memory, and Processing Speed. Recent research using confirmatory factor analysis has also identified a Social Cognition factor on the WAIS-R (Wechsler, 1981). The purpose of this study was to extend this research to the 14 subtests on the WAIS-III (Psychological Corporation, 1997). Using the standardization sample, several confirmatory factor analytic models were compared to determine the optimal combination of subtests on the Social Cognition factor. The best fit was obtained by the model where the Social Cognition factor was composed of the Picture Arrangement, Picture Completion, and Object Assembly subtests. These results provide support for the construct validity of a Social Cognition factor. Additional research is necessary to determine its stability across age groups and clinical populations, as well as its sensitivity to various forms of brain dysfunction.

Introduction

The Wechsler Adult Intelligence Scale (WAIS) was designed to assess a variety of cognitive abilities and factor analysis often has been used to identify the underlying abilities that are assessed by its various subtests. From very early on factor analyses commonly demonstrated that the WAIS subtests measured the three latent constructs of Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility or alternatively Working Memory (Balinsky, 1941; Cohen, 1952, 1957). While these early results were partially consistent with Wechsler's original conceptualization of intelligence along verbal and performance domains, identification of the memory factor provided clear evidence for a more complex structure of intellectual abilities. The stability of the three-factor solution across various clinical and non-clinical populations and across various age groups (Allen, Seaton, Huegel, Goldstein, Gurklis, & van Kammen, 1998; Beck, Horwitz, Seidenberg, Parker, & Frank, 1985; Bowden, Cook, Bardenhagen, Shores, & Carstairs, 2004; Burton, Ryan, Paolo, & Mittenberg, 1994; Dickinson, Iannone, & Gold, 2002; McGeorge, Crawford, & Kelly, 1996; Plake, Gutkin, Wise, & Kroeten, 1987; Ryan, Paolo, & Brungardt, 1990; Ward, Ryan, & Axelrod, 2000a, 2000b), along with the differential sensitivity of the factors to various forms of brain dysfunction (Goldstein, 1984; Lawson & Inglis, 1983; Matarazzo, 1972; Warrington, James, & Maciejewski, 1986) lead to the interpretation of factor scores in addition to or instead of the Verbal and Performance IQ scores. Thus, factor analysis has been useful not only to evaluate the structure of intellectual abilities assessed by the WAIS, but has also provided valuable information that has assisted in its application and interpretation in various clinical settings and with diverse populations.

For the latest revision of the WAIS, the WAIS-III (Psychological Corporation, 1997), inclusion of a number of new subtests has allowed for the identification of a fourth factor, Processing Speed, in addition to the Verbal Comprehension, Perceptual Organization and Working Memory factors. The four-factor solution was established in the normative sample using confirmatory factor analysis and has since been replicated in other samples (Donders, Tulsky, & Zhu, 2001; Hawkins, 1988; Ryan & Paolo, 2001; Taylor & Heaton, 2001; Ward et al., 2000a). More recently, two confirmatory factor analytic studies of the 11 WAIS-R subtests (Wechsler, 1981), one examining high functioning autism (Goldstein, Allen, Minshew, Williams, Volkmar, Klin, & Schulz, 2006) and the other schizophrenia (Allen, Strauss, Donohue, & van Kammen, 2007), have identified an additional factor that ostensibly measures social cognition. Social cognition is that unique aspect of cognition that is dedicated to the processing of social information and allows for adaptive social interaction (Ostrum, 1984). Support for the distinction between social and nonsocial cognition comes from a number of areas, including studies demonstrating small to moderate correlations among standard neurocognitive and social cognitive measures, as well as the involvement of unique neural substrates in the processing of social and nonsocial information (for a review see Couture, Penn, & Roberts, 2006). This specialized processing of social information is also consistent with the more general view that the development of specialized information processing systems is adaptive, allowing the brain to address specific environmental challenges (Tooby & Cosmides, 2000). Hence, social cognition is itself a multi-factorial construct, with examples of social cognitive abilities including facial affect perception and processing, social perception, and knowledge of social norms. Interestingly, while Wechsler himself was critical of the concept of social cognition, or what was then referred to as social intelligence, he notes that because the items on the Picture Arrangement subtest nearly always involved "some human or practical situation…[it]…more nearly corresponds to what other writers have referred to as 'social intelligence' " (Wechsler, 1958, p. 75). Much earlier, Thorndike (1920) had suggested three types of intelligence including mechanical, abstract, and social, with the latter type allowing one to understand, interact with, and manage others (Thorndike, 1920; Thorndike & Stein, 1937). His suggestion of a social intelligence thus gained some popularity, and more recently has received increasing interest as reflected through studies of emotional intelligence (e.g., Amelang & Steinmayr, 2006; Barchard, 2003; Barchard & Hakstian, 2004; Lee, Wong, & Day, 2000; Salovey & Mayer, 1990) and social cognition (Green, Olivier, Crawley, Penn, & Silverstein, 2005; Ostrum, 1984). Despite these early indications by Wechsler and others regarding the social cognitive aspects of subtests such as Picture Arrangement and Comprehension (Rapaport, Gill, & Schafer., 1968; Schafer, 1948; Wechsler, 1958), and the extensive factor analytic work with the Wechsler scales, confirmatory factor analysis has only recently been applied to investigate the possibility of a WAIS factor that might assess social cognition, although some studies have examined associations between individual WAIS subtest scores and some aspects social functioning and personality (Campbell & McCord, 1996; Lipsitz Dworkin, & Erlenmeyer-Kimling, 1993; Shean, Murphy, & Meyer, 2005).

Two recent studies that have directly evaluated the possibility of a social cognition factor in individuals with autism or schizophrenia (Allen et al., 2007; Goldstein et al., 2006). The impetus for hypothesizing a social cognition factor in autism and schizophrenia was based on the observation that deficits in social interaction are core features of both disorders. For children and adults with high-functioning autism, confirmatory factor analysis of the 11 traditional subtests of the WAIS-R supported a four-factor model of neurocognitive abilities consisting of Verbal Comprehension, Perceptual Organization, Working Memory, and Social Cognition (SC) factors (Goldstein et al., 2006). Consistent with these findings, Allen et al. (2007) also demonstrated the presence of this SC factor on the WAIS-R in males with schizophrenia. This factor structure differed from those previously reported for schizophrenia (Allen et al., 1998; Dickinson et al., 2002) by identifying an SC factor, which was loaded on by the Picture Arrangement and Picture Completion subtests. In both of these studies, the SC factor also emerged when the 11 WAIS-R subtests were examined in selected age groups from the WAIS-R or WAIS-III standardization sample. Thus, while direct comparisons between the factor structures identified for autism and schizophrenia were not accomplished in these studies, their results provide support for a factor structure that is similar across groups in two respects. First, a model incorporating an SC factor composed of Picture Arrangement and Picture Completion provided the best fit of the data in both clinical samples and normals. Second, the WAIS-R subtest loadings on the various factors were also consistent across studies and groups. These results provide more general support for an SC factor that is not specific to a particular population or clinical group and apparently reflects the social and contextual properties of the subtest that composes it.

The current investigation extends findings beyond the 11 traditional subtests of the WAIS-R by using confirmatory factor analysis of the complete set of 14 subtests to test competing hypotheses regarding the factor structure of the WAIS-III. Various models were examined and compared, to determine which combination of subtests on the social cognition factor creates the best fit. Based upon previous research, we hypothesized that the model incorporating an SC factor composed of the Picture Arrangement and Picture Completion subtests would be the best of the competing models. Given its wide use and excellent psychometric properties, further investigation of the WAIS-III factor structure may provide a clearer understanding of the cognitive constructs that it measures and thereby assist with its application in clinical settings.

Method

Participants

The correlation matrix for the entire standardization sample of 2450 individuals reported in the WAIS-III WMS-III Technical Manual was used (Psychological Corporation, 1997, Table 14.12, p. 98). The technical manual indicates the standardization sample was selected to represent the US population in terms of geographic region, race/ethnicity, sex, and education. It includes individuals aged 16-89 distributed across 13 age groups. Two hundred individuals are included in each of the 11 age groups from ages 16-79, with the 80-84 year old group containing 150 individuals, and the 85-89 year old group consisting of 100 individuals. Geographic regions included south, west, northeast and north central. Categories for race/ethnicity included White, African American, Hispanic and Other. Equal numbers of males and females were included in the 8 age groups from 16-64 years old. For the remaining five age-groups, the numbers of males and females were determined to represent the general population. Years of education was divided into five levels that included 8 or fewer years, 9-11 years, 12 years, 13-15 years, and 16 or more years. It should be noted that the Letter-Number Sequencing subtest was administered to only 1250 individuals in the standardization sample (Wechsler, 1997) rather than the total 2450, so correlations reported in the Technical Manual are based on this reduced number of individuals.

Models Tested

To determine the optimal composition of the Social Cognition factor, we compared four different models. These models each had five factors and are shown in Table 1. To explain these five factor models, we will first discuss one-, two-, three-, and four-factor models that have been examined in the literature.

The one- and two-factor models are historical models related to early conceptualizations of intelligence. In the one-factor model (M1), all subtests load on a single factor. This model was used to evaluate the hypothesis that intelligence involves a single latent trait or "g" (Spearman, 1904). The two-factor model (M2) divides subtests into Verbal and Performance factors. M2 is consistent with Wechsler's early conceptualization of IQ along verbal and performance dimensions (Wechsler, 1958), and has been suggested as the most parsimonious of the various models (Leckliter, Matarazzo, & Silverstein, 1986).

Despite their increased complexity, three-factor models of the WAIS have generally gained acceptance over the less complex two-factor models. The three factors are Verbal Comprehension, Perceptual Organization, and Working Memory. In all three-factor models, the Working Memory factor borrows subtests from the Verbal factor (Arithmetic, Digit Span, Letter-Number Sequencing) and the Performance factor (Digit Symbol-Coding, Symbol Search). However, three-factor models vary in terms of Digit Symbol-Coding. In some studies, Digit Symbol-Coding loads on the Perceptual Organization factor, in some studies it loads on the Working Memory factor, and in some studies it loads on both (compare Allen et al., 1998, Burton et al., 1994, and Ward et al., 2000a). In Table 1, we specified that Digit Symbol-Coding loads on the Working Memory factor. Previous research has shown that this three-factor model fits the WAIS-R and WAIS-III data better than the one- and two-factor models (Leckliter et al., 1986; Psychological Corporation, 1997). It should also be noted that the three-factor model described here differs from the one reported for the standardization sample (Psychological Corporation, 1997), in that the Arithmetic subtest was specified to load on the Working Memory factor in this study rather than the Verbal Comprehension factor (Leckliter et al., 1986). However, Arithmetic has been consistently placed on the Working Memory factor in factor analytic studies of the Wechsler scales, probably because it requires the maintenance and manipulation of numerical information in the short-term memory store.

As previously mentioned, with the development of the WAIS-III, a four-factor model has gained acceptance. This model retains the Verbal Comprehension, Perceptual Organization and Working Memory factors, but separates out the Digit Symbol-Coding and Symbol Search subtests from the Working Memory factor to form a Processing Speed factor. In the WAIS-III WMS-III Technical Manual (Psychological Corporation, 1997) the model that provided the best fit for the standardization sample apparently allowed the residual errors for Digit Span and Letter Number Sequencing to correlate (see Ward et al., 2000a), but had the four factors described here.

Finally, a number of five-factor models have been investigated, which retained the Verbal Comprehension, Perceptual Organization, Working Memory, and Processing Speed factors from the four-factor model, but also included a Social Cognition factor. The purpose of this current study was to compare the five-factor Social Cognition models to each other, to determine the optimal composition of this factor.

For each of these Social Cognition models, various combinations of subtests that contained social content were specified to load on an SC factor. Selection of subtest combinations for the SC factors in this current study was guided primarily by prior investigations (Allen et al., 2007; Goldstein et al., 2006), but also by long-held clinical interpretations of subtest content (Rapaport et al., 1968; Schaefer, 1948). In the first of the five-factor social cognition models, the SC factor consisted of the Picture Arrangement and Comprehension subtests (M5:PA,C). These two subtests have been traditionally viewed as requiring the greatest amount of social reasoning abilities (Rapaport et al., 1968; Schaefer, 1948). In the second five-factor social cognition model, Picture Arrangement and Picture Completion comprised the SC factor (M5:PA,PC). This composition of the SC factor has demonstrated the best fit in studies using the 11 traditional subtests included in the WAIS-R (Allen et al., 2007; Goldstein et al., 2006). Two additional five-factor models were tested that incorporated Object Assembly into the SC factor, because the Object Assembly subtest contains social content (e.g., human figure, face). In the third five-factor social cognition model, the SC factor consisted of Picture Arrangement and Object Assembly (M5:PA,OA), and in the fourth five-factor model, the SC factor consisted of the Picture Arrangement, Picture Completion, and Object Assembly subtests (M5:PA,PC,OA). Each of these models attempts to separate subtests with social content (Picture Completion, Picture Arrangement, and in some cases Object Assembly) from those with neutral content (Block Design and Matrix Reasoning).

Statistical Analyses

All models were tested with confirmatory factor analysis using LISREL 8 (Jöreskog & Sörbom, 1993). To determine which model best fit the standardization sample data, four goodness-of-fit statistics were examined: the maximum-likelihood chi-square test, the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Akaike Information Criterion (AIC). Rationale for the selection of these indices are provided in detail elsewhere (Byrne, 2006; Kline, 2005). Briefly, these four statistics capture different aspects of model fit. The maximum-likelihood chi-square test indicates how well the hypothesized statistical model fits the actual data set. A significant chi-square test is one indication that the sample data did not come from a population in which the proposed model is valid. However, because the chi-square test is sensitive to sample size, it often rejects models that fit the data quite well (Bentler & Bonnett, 1980). Nevertheless, it is reported here because it is the basis for most other fit statistics. The Comparative Fit Index (CFI; Bentler, 1990) is an incremental fit index that compares the relative fit of the hypothesized model and the baseline independence model. It ranges from 0 to 1, with higher values indicating better fit. CFI values greater than .95 indicate good fit (Hu & Bentler, 1999). The Root Mean Square Error of Approximation (RMSEA; Steiger & Lind, 1980) indicates how well the hypothesized model fits the population covariance matrix. Because it takes into account model complexity, it is classified as a parsimony index. It ranges from 0 to 1, with smaller values indicating better fit. Good fit is indicated by values of .05 or less, with values between .06 and .08 indicating adequate fit (Jöreskog & Sörbom, 1993). Finally, the Akaike Information Criterion (AIC; Akaike, 1987) is a predictive fit index that estimates how well the model would fit in a hypothetical replication sample. The AIC takes into account degrees of freedom, and thus is influenced by model parsimony. Lower values indicate better predicted fit. Kline recommends using the AIC to compare non-nested models, and thus we used the AIC to determine which of the SC models provided the best fit. Because AIC is not scaled between 0 and 1, interpretation of AIC is entirely comparative: when comparing two non-nested models, the one with the smaller AIC provides better fit.

Results and Conclusions

We tested four models that included a Social Cognition factor. All of these models fit the data relatively well. See Table 2. Of these four models, the model with Picture Arrangement, Picture Completion, and Object Assembly on the Social Cognition factor had the best overall fit (see Figure 1). The chi-square and AIC values were smaller for this model than for the other SC models tested.

As a new factor on the WAIS-III, it was vitally important for the subtests composing the SC factor to demonstrate strong loadings. In this case, the Picture Completion, Picture Arrangement, and Object Assembly loadings of .69 or above on the SC factor indicate that they are strong measures of this factor. In addition, the SC factor has strong correlations with the Working Memory, Perceptual Organization, Processing Speed, and Verbal Comprehension factors, as would be expected. These results provide support for the construct validity of a Social Cognition factor. Additional research is necessary to determine its stability across age groups and clinical populations, as well as its sensitivity to various forms of brain dysfunction.

Table 1

Historical Models and Models with a Social Cognition Factor.

WAIS-III Subtest	Historical Models				Models with Social Cognition Factor			
	M1	M2	M3	M4-PS	M5: PA,C	M5: PA,PC	M5: PA,OA	M5: PA,PC,OA
Vocabulary	g	V	VC	VC	VC	VC	VC	VC
Information	g	V	VC	VC	VC	VC	VC	VC
Similarities	g	V	VC	VC	VC	VC	VC	VC
Comprehension	g	V	VC	VC	SC	VC	VC	VC
Arithmetic	g	V	WM	WM	WM	WM	WM	WM
Digit Span	g	V	WM	WM	WM	WM	WM	WM
Letter-Number Sequencing	g	V	WM	WM	WM	WM	WM	WM
Digit Symbol-Coding	g	P	WM	PS	PS	PS	PS	PS
Symbol Search	g	P	WM	PS	PS	PS	PS	PS
Matrix Reasoning	g	P	PO	PO	PO	PO	PO	PO
Block Design	g	P	PO	PO	PO	PO	PO	PO
Picture Arrangement	g	P	PO	PO	SC	SC	SC	SC
Picture Completion	g	P	PO	PO	PO	SC	PO	SC
Object Assembly	g	P	PO	PO	PO	PO	SC	SC

Note. g=general intelligence. V=Verbal Ability. P=Performance Ability. VC=Verbal Comprehension. PO=Perceptual Organization. WM=Working Memory. PS=Processing Speed. SC=Social Cognition.

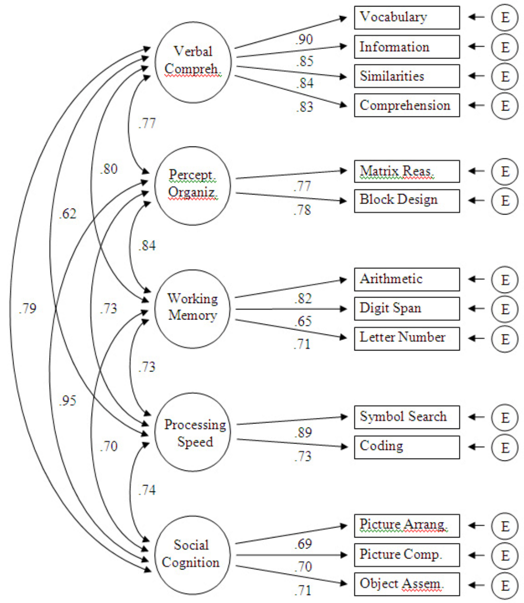
Table 2

Goodness of Fit Indices for all models and subtest combinations for the WAIS-III

Model	Fit Indices				
	χ^2	*df*	CFI	RMSEA	AIC
M5:PA,C	912.87	67	0.96	0.07	988.87
M5:PA,PC	756.7	67	0.97	0.06	832.7
M5:PA,OA	742.23	67	0.97	0.06	818.23
M5:PA,PC,OA	702.6	67	0.97	0.06	778.6

Note. Chi-square for independence model = 20438.27; df = 91; n = 2450.

Figure 1. Model M5:PA,PC,OA. Best fitting model for 14 subtests.



Note. RMSEA = .06. CFI = .97.