CHAPTER

8

Do the WAIS-IV Tests Measure the Same Aspects of Cognitive Functioning in Adults Under and Over 65?

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INTRODUCTION

One of the important questions that needs to be considered when evaluating cognitive functioning in older adults is whether the scores on the tests have the same meaning as they do in young and middle-aged adults. While it is generally agreed that crystallized intelligence (*Gc*) measures such as those derived from vocabulary subtests tend to "hold" well with age, barring neurological complications arising from, for example, Alzheimer's disease, traumatic brain injury (TBI), or stroke, other areas commonly tapped by intelligence tests such as abstract reasoning, working memory, and processing speed tend to show decline with normal aging. Thus two questions come to the fore when evaluating the results of a test such as the fourth edition of the Wechsler Adult Intelligence Scale (WAIS-IV; Wechsler, 2008); specifically, do the cognitive abilities of adults change quantitatively or qualitatively with age, and do the scores obtained from them reflect the same constructs in people of different ages? These questions are relevant to the clinical evaluation of older adults because the test scores may not have the same interpretation at different ages if the meanings are different for adults under and over 65 years of age. The major purpose of the current chapter is to address this issue using the normative data from the WAIS-IV standardization study.

It is sometimes suggested that adult age differences in the performance on cognitive tests might reflect qualitative differences as much as, or more than, quantitative differences, because people of different ages vary considerably in their backgrounds and life situations. For example, adults over the age of 65 may have less recent testing experience, and therefore it is possible that their performance on cognitive tests could be more limited than in younger adults by unfamiliarity with testing situations. In addition, the amount of education and differential exposure to educational opportunities by younger versus older adults may very well influence how assessment and evaluation is viewed as part of everyday life. Older adults might be less concerned with how others evaluate them, and hence could have lower levels of motivation in the test situation. It is also possible that adults of different ages could have different perceptions of the face validity of certain tests, such as the Block Design test, which some older adults might view as similar to activities performed by their grandchildren and thus may not take very seriously. Finally, as postulated by Socio-Emotional Selectivity Theory (Carstensen, Fung, & Charles, 2003), adults of different ages might have different goals, with young adults more focused on information acquisition and older adults more focused on emotion regulation and positive emotion as well as addressing every day practical needs, and these different goals could affect how adults of different ages approach and perform cognitive tests.

There are clearly a large number of potential reasons why cognitive assessments might have different meanings at different ages. However, little empirical evidence relevant to these speculations is currently available, and a major goal of this chapter is to examine data from the standardization sample to evaluate whether the WAIS-IV cognitive tests measure the same areas and factors of intelligence among adults under and over 65 years of age. To anticipate, although a definitive conclusion is not yet possible, the available evidence strongly suggests that the tests in this battery have similar meaning at different ages, although measured ability levels may change on some factors.

A number of analyses using data from the USA standardization of the WAIS-IV will be reported in this chapter. Because the primary interest is in evaluating measurement properties in older adults, the normative sample was divided into two broad age bands. While other age sampling categories could be applied, we elected to define two groups for this analysis. Adults between 16 and 64 years of age ($n = 1600$) were designated as younger adults, and adults between 65 and 90 years of age ($n = 600$) were considered older adults. Because the sample sizes are moderately large, there is considerable power to detect even small differences as statistically significant, and therefore effect sizes are reported rather than significance levels. By convention (see, for example, Cohen, 1988), effect sizes in *d* units (i.e., the difference between the means divided by the pooled standard deviation) less than about 0.3 are considered small, while those greater than 0.8 are considered large, and intermediate values are considered to represent medium-sized effects.

COMPARISONS OF LEVEL OF PERFORMANCE

The first analysis simply examined mean raw score levels of performance on each subtest in the two age groups. The means for each WAIS-IV variable are reported in Table 8.1, where it can be seen that the values for most of the variables were higher in the younger (under-65) age group. Entries in the right column of the table indicate that the effect sizes were small for the Verbal Comprehension variables, moderate for the Working Memory variables, and very large for the Perceptual Reasoning and Processing Speed variables. The bottom portion of the table reports the same type of information for composite scores and index scores. Composite scores are created by averaging the z-scores across all ages for the subtests in each of the four domains of ability. Index scores are based on age-corrected scaled scores, and are transformed to have means of 100 and standard deviations of 15 in the total sample. The patterns for the subtests and composite scores are similar to those in many previous studies of adult age differences in cognition (see, for example, Craik & Salthouse, 2008; Salthouse, 2010). As might be expected, the age trends are much smaller for the index scores because these scores are based on scaled scores that are equated across age groups.

A popular interpretation of the cross-sectional age differences in cognitive functioning attributes them to cohort effects, which are often interpreted as generational differences in quantity or quality of schooling, cultural stimulation, health practices, etc. Although the idea of cohort influences has been widely accepted, it has been difficult to identify measures reflecting cohort status to allow this interpretation to be directly investigated. That is, if the cross-sectional differences in cognitive functioning are attributable to cohort differences, then successive age groups should differ in the values of the cohort-defining measures, and statistical control of the variation in those measures should result in a reduction of the cross-sectional age-cognition differences.

One variable that can be investigated in this manner is amount of formal education. The rationale is that if some of the cross-sectional age differences in cognitive test performance are attributable to progressively lower or higher amounts of education with increased age, then statistical control of amount of education should be associated with a reduction in the magnitude of the age differences in cognitive test performance. A statistical

TABLE 8.1 Means and standard deviations in the two groups and effect sizes for the group differences

Variable	Mean (SD) 16–64	Mean (SD) 65–90	*d*	*d(Ed)*
Verbal Comprehension (VC)				
Vocabulary	34.5 (10.9)	34.8 (11.6)	−0.02	−0.29
Information	13.6 (5.1)	13.4 (5.7)	0.03	−0.20
Similarities	24.5 (5.5)	22.4 (6.4)	0.33	0.18
Comprehension	23.2 (6.0)	22.0 (6.4)	0.20	−0.02
Working Memory (WM)				
Arithmetic	14.0 (3.7)	12.6 (3.5)	0.38	0.20
Letter–Number Sequencing	19.7 (3.7)	18.1 (3.9)	0.43	0.35
Digit Span Forward	10.5 (2.4)	9.5 (2.3)	0.41	0.30
Digit Span Backwards	8.8 (2.5)	7.6 (2.2)	0.49	0.16
Digit Span Sequencing	8.7 (2.3)	6.9 (2.7)	0.70	0.57
Perceptual Reasoning (PR)				
Block Design	42.3 (13.0)	29.5 (10.9)	1.07	0.96
Matrix Reasoning	17.6 (4.8)	11.6 (5.0)	1.20	1.09
Visual Puzzles	14.9 (4.8)	10.1 (3.9)	1.10	0.98
Picture Completion	13.1 (4.0)	9.4 (4.1)	0.92	0.81
Figure Weights	14.9 (4.9)	9.4 (4.2)	0.74	0.71
Processing Speed (Speed)				
Symbol Search	32.5 (8.4)	21.6 (7.9)	1.34	1.21
Coding	69.1 (16.9)	46.0 (16.6)	1.37	1.25
Cancellation	40.2 (9.6)	35.0 (9.1)	0.55	0.52
Composite Scores				
Verbal Comprehension	0.05 (0.83)	−0.14 (0.90)	0.22	−0.03
Working Memory	0.13 (0.78)	−0.35 (0.77)	0.63	0.47
Perceptual Reasoning	0.26 (0.75)	−0.69 (0.71)	1.31	1.19
Processing Speed	0.31 (0.79)	−0.84 (0.78)	1.47	1.34
Index Scores				
Verbal Comprehension	100.7 (15.0)	98.1 (14.7)	0.18	0.17
Working Memory	100.5 (14.9)	98.6 (15.1)	0.13	0.12
Perceptual Reasoning	100.4 (15.1)	98.7 (14.8)	0.11	0.12
Processing Speed	100.6 (14.9)	98.5 (15.3)	0.14	0.13

Note: *d* is effect size, and *d(Ed)* is effect size after partialling educational level from the variable.

adjustment of this type essentially allows adults of different ages to be compared at the same average level of education. The *d* values in the rightmost column of Table 8.1 are the effect size estimates for each subtest score after statistically controlling level of education. Although many of the values are smaller after amount of education was controlled, the effect sizes were still in the very large range for the Perceptual Reasoning and Processing Speed variables. Research with other data sets has also found relatively small attenuation of the cross-sectional age differences in cognitive functioning after adjusting for amount of education (see, for example, Salthouse, 2009a). These results suggest that although educational differences can distort age comparisons in cognitive functioning, they are unlikely to be responsible for large proportions of the observed differences in the WAIS-IV or other similar data sets.

There are at least two other reasons to question the cohort interpretation of cross-sectional age differences in cognition. One is that although the absolute level of test performance has increased in several generations, as documented in the Flynn Effect (see, for example, Flynn, 2007), if people of all ages experience these increases, then the influence would likely be greater for longitudinal comparisons than on cross-sectional comparisons (*cf*. Salthouse, 2010). That is, because longitudinal observations are obtained at different points in time they may be distorted by time-related inflationary effects on the test scores, whereas cross-sectional comparisons are unlikely to be distorted by time-related changes since all of the observations are obtained at the same point in time.

A second reason to be cautious about cohort interpretations of cross-sectional age differences is the results of a clever set of analyses by Kaufman (Kaufman, 2001; Lichtenberger & Kaufman, 2009). He compared similar scales in different versions of the Wechsler tests for people in the same birth cohort after adjusting for time-of-measurement or period effects. These contrasts do not involve the same people and thus are not true longitudinal studies, but they do involve people from the same birth cohorts, and thus are relevant to the question of whether cross-sectional age differences primarily reflect cohort differences. Lichtenberger and Kaufman (2009: 276) concluded that these "cohort-substitution studies provide results that agree remarkably well with the cross-sectional data." It is premature to conclude on the basis of the results just described that cohort factors do not contribute to cross-sectional age differences in cognitive functioning, but, by the same token, it is also too early to conclude that all of the cross-sectional age differences are artifacts of cohort differences.

Because it is sometimes postulated that a presumed lifetime of differential experiences results in people becoming more different from one another as they grow older, the magnitude of the individual differences in test performance was also examined in the two age groups. Group differences in between-person variability (i.e., the square of the standard deviation) in the level of performance were investigated for all variables with *F*-tests. The individual differences in test scores were significantly greater in the older group on only four variables (i.e., Digit Span Sequencing, Vocabulary, Information, and Similarities). It is noteworthy that three of these variables represent the Verbal Comprehension factor, which tends to have relatively small mean age differences. The individual differences were significantly larger for adults under 65 years of age for Block Design and Visual Puzzles, which are both tests that load on the Perceptual Reasoning factor. Even though many of the mean subtest raw scores were lower in the older group, these results indicate that there was no consistent pattern of age differences in the magnitude of between-person variability. In other words, for most of the subtests of the WAIS-IV, the performance differences among people under age 65 were approximately the same as the performance differences among people 65 and older.

Another potentially informative comparison involving level of performance consists of contrasts of the age differences across different percentiles of the score distribution within each age group. That is, rather than simply focusing on average differences in the middle of the distribution, the two groups can be contrasted at different regions of the distribution. Comparisons such as these allow determination of whether the differences are more pronounced among the highest- or lowest-performing individuals within each group, or are nearly constant across all ability levels.

The procedure used to make these comparisons involved first dividing the distribution of scores within each age group into percentiles (i.e., 0–10 percent, 11–20 percent, etc.), and then computing regression equations relating performance of the older group at each percentile to the performance of the younger group at the corresponding percentile. If there is no difference between the groups, then these functions will have intercepts close to 0 and slopes close to 1, and if the difference is constant across all regions of the distribution then the intercept will differ from 0 but the slope will be 1. However, if there are larger age differences at lower ability levels then the slope of the regression equation will be greater than 1, and if age differences are larger at higher ability levels then the slope will be less than 1.

The intercepts, slopes, and R^2 values (which indicate how accurately the equations described the data) for each variable common to the two age groups are presented in Table 8.2. Because the Figure Weights, Letter–Number Sequencing, and Cancellation tests were not administered to adults over 69 years of age, these variables are not included in the analyses. The pattern of age differences reflected in the intercepts resembles that for the means in Table 8.1, and in fact the correlation between the *d* values in

TABLE 8.2 Regression coefficients relating successive percentiles in the under-65 and over-64 groups for individual variables

Variable	Intercept	Slope	R^2
Verbal Comprehension (VC)			
Vocabulary	0.04	1.06	0.98
Information	−0.04	1.22	0.99
Similarities	−0.37*	1.14*	0.99
Comprehension	−0.28*	1.18	0.99
Working Memory (WM)			
Arithmetic	−0.42*	0.94	0.97
Digit Span Forward	−0.33*	0.96	0.96
Digit Span Backwards	−0.44*	0.93	0.90
Digit Span Sequencing	−0.68*	1.35	0.96
Perceptual Reasoning (PR)			
Block Design	−0.94*	0.75	0.95
Matrix Reasoning	−1.11*	0.98	0.86
Visual Puzzles	−0.91*	0.68	0.91
Picture Completion	−0.86*	1.01	0.97
Processing Speed (Speed)			
Symbol Search	−1.14*	0.94	0.99
Coding	−1.19*	1.00	0.99

*$P < 0.01$ for intercept compared to 0, and for slope compared to 1.

Table 8.1 and the intercepts in Table 8.2 was −0.99. The pattern with the slopes differed across variables, with the slope values ranging from 0.68 to 1.35.

Figure 8.1 portrays the percentile comparisons for composite scores of the four abilities created by averaging the relevant z-scores. It can be seen that the Verbal Comprehension composite score had an intercept close to 0 but a slope greater than 1, indicating that the age differences were greater among the lowest-performing individuals in the two groups. A different pattern is evident with the Perceptual Reasoning composite score, as the intercept was negative and the slope was slightly less than 1, indicating that age differences were evident at all ability levels but were somewhat more pronounced among the highest-performing individuals. The slopes were very close to 1 with the Working Memory and Processing Speed composites, indicating that the age differences in these variables were nearly constant at all ability levels.

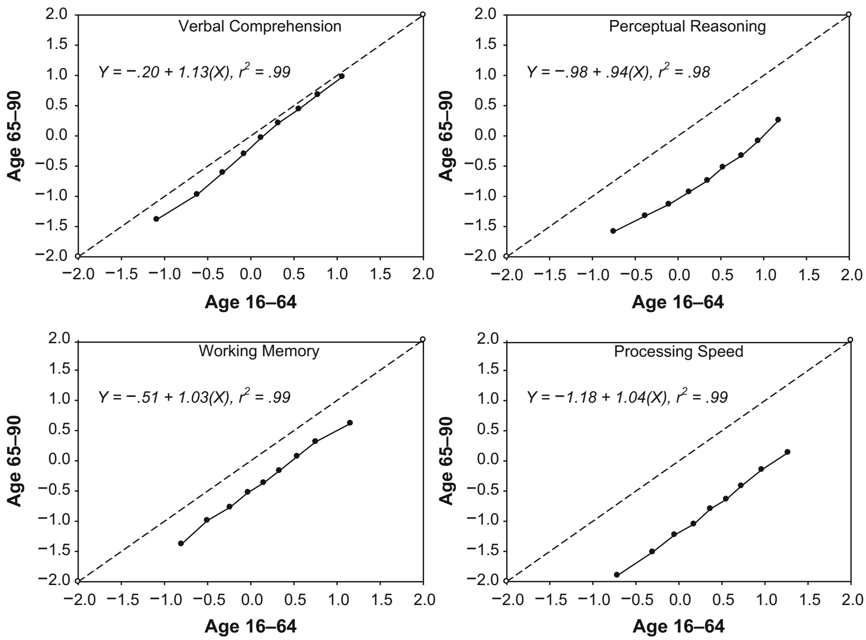

FIGURE 8.1 Plot of percentiles from the distribution from adults 65–90 as a function of percentiles of the distribution from adults 16–64.

The results summarized in Table 8.2 and Figure 8.1 raise the possibility that age differences might not be uniform across all ability levels, but rather may be larger at lower ability levels for Verbal Comprehension, and larger at higher ability levels for Perceptual Reasoning. However, there are at least two reasons why this conclusion should be considered cautiously. One reason is that the patterns do not hold for all subtests within each factor. In particular, the Vocabulary subtest within Verbal Comprehension, and the Matrix Reasoning and Picture Completion subtests within the Perceptual Reasoning factor, each had slopes very close to 1. These discrepancies raise the possibility that the phenomenon of differential aging according to region of the score distribution may be specific to particular variables and not necessarily to broader abilities. The second reason why the patterns in Table 8.2 and Figure 8.1 need to be interpreted cautiously is that they could be attributable to differential selection at different ages, such that the entire distribution may not have been represented to the same degree at all ages. The sampling procedures in the WAIS-IV project were designed to obtain a sample that was stratified with respect to major demographic characteristics, but it is very difficult to ensure complete representation of all relevant characteristics, such as ability levels within specific tests, in each demographic category.

The next set of analyses examined relations of age to the level of performance within each of the two age groups. These analyses differ from the earlier ones in that instead of comparing the mean levels of performance for the entire group, or group differences at different percentiles within the groups, the relation between age and performance (i.e., the slopes of performance as a function of age) is examined in each age group defined for this analysis. Age slopes in total sample standard deviation units per year are presented in Table 8.3 for all variables except those in which the maximum age in the sample was 69 years of age (i.e., Figure Weights, Letter–Number Sequencing, and Cancellation). Inspection of the values in the table reveals that the relation with age was more negative in the older group for every variable, and most of the effect sizes were in the small to moderate range. These results indicate that not only is the average level of performance in many cognitive variables lower in the

TABLE 8.3 Relations between age and performance in *z*-score units in the two groups and effect sizes (*d* units) for the group difference

	Age slope		
Variable	**18–64**	**65–90**	***d***
Verbal Comprehension (VC)			
Vocabulary	0.02	−0.03	−0.44
Information	0.01	−0.03	−0.40
Similarities	0.01	−0.04	−0.49
Comprehension	0.01	−0.04	−0.52
Working Memory (WM)			
Arithmetic	0.01	−0.03	−0.45
Digit Span Forward	−0.00	−0.02	−0.13
Digit Span Backwards	−0.00	−0.02	−0.18
Digit Span Sequencing	−0.01	−0.04	−0.36
Perceptual Reasoning (PR)			
Block Design	−0.02	−0.04	−0.25
Matrix Reasoning	−0.02	−0.04	−0.33
Visual Puzzles	−0.02	−0.04	−0.31
Picture Completion	−0.01	−0.04	−0.36
Processing Speed (Speed)			
Symbol Search	−0.01	−0.05	−0.50
Coding	−0.01	−0.05	−0.47

older group, but the relation of the variable to age is also more negative than among adults at younger ages. Other studies have reported similar acceleration of the cross-sectional age-related declines on cognitive variables (see, for example, McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Salthouse, 2004, 2009b; Lee, Gorsuch, Saklofske, & Patterson, 2008).

Results such as those just described are the kinds of findings that have led to speculations that there might be qualitative differences in what cognitive tests are assessing among adults of different ages. The remaining sections of this chapter describe analyses designed to examine the plausibility of these sorts of speculations.

RELIABILITY

One type of evidence relevant to the issue of measurement equivalence in different age groups is whether the scores on the tests are equally consistent, or systematic, among adults of different ages. Reliabilities (internal consistency and test–retest) obtained from the WAIS-IV Manual are reported in Table 8.4 for the two age groups. It can be seen that the retest reliability for the composite Digit Span variable was slightly higher in the older group, although it was slightly higher in the younger group for the Visual Puzzles variable. Most of the remaining values were very similar in the two groups, and only two were not within 0.1 units of each other. Based on this reliability information, it appears that whatever is being measured in the tests is assessed as consistently in adults over and under age 65.

CORRELATIONS AMONG VARIABLES

The magnitudes of the interrelations among the variables in the two groups are also relevant to the issue of measurement equivalence. One method of examining interrelations among variables is with a factor analytic model. Confirmatory factor analyses based on the model described in Chapter 4 of the *WAIS-IV: Technical and Interpretive Manual* (Wechsler, Coalson, & Raiford, 2008) were therefore conducted in the two age groups. The model specified four factors, with only the Arithmetic variable loading on more than one factor.

Standardized factor loadings and correlations between factors for the variables common to both groups are reported in Table 8.5. As in some earlier analyses, the Figure Weights, Letter–Number Sequencing, and Cancellation tests were excluded because they were only administered to adults up to 69 years of age. Because for many variables there were strong age relations within each group, the influence of age within each group

TABLE 8.4 Estimates of internal consistency and test–retest reliability in the two groups

	Internal consistency		Retest	
Variable	**16–64**	**65–90**	**16–64**	**65–90**
Verbal Comprehension (VC)				
Vocabulary	0.94	0.95	0.90	0.91
Information	0.91	0.94	0.88	0.93
Similarities	0.86	0.90	0.83	0.84
Comprehension	0.87	0.87	0.87	0.85
Working Memory (WM)				
Arithmetic	0.89	0.89	0.80	0.80
Letter–Number Sequencing	0.88	0.88*	0.78	NA
Digit Span Forward				
Digit Span Backwards	0.94	0.93	0.74	0.84
Digit Span Sequencing				
Perceptual Reasoning (PR)				
Block Design	0.88	0.83	0.80	0.79
Matrix Reasoning	0.90	0.91	0.78	0.73
Visual Puzzles	0.90	0.89	0.72	0.57
Picture Completion	0.84	0.84	0.71	0.77
Figure Weights	0.90	0.90*	0.76	NA
Processing Speed (Speed)				
Symbol Search	0.81	0.86	0.80	0.80
Coding	0.85	0.86	0.83	0.81
Cancellation	0.81	0.80*	0.74	NA

Note: Internal consistency reliability based on median of correlations across age groups in Table 4.1 of Wechsler (2008). Test–retest reliability based on average correlation of ages 16–29 and 30–54 for the younger group, and ages 70–90 for the older group (from Table 4.5 of Wechsler, 2008). Only a single combined estimate is available from the three digit-span variables.
*indicates that data were only from ages 65 to 69; NA means that the estimate was not available.

was partialled from each variable in these analyses in order to minimize misleading relations attributable to the common relations of the variables with age.

Inspection of the entries in Table 8.5 indicates that the standardized factor loadings in the factor analyses were generally similar in the two groups, and the effect-size estimates computed from the raw coefficients

TABLE 8.5 Standardized coefficients for a four-factor confirmatory factor analysis in the two groups with effect sizes for the group differences

Variable	Standardized factor loading		
	16–64	**65–90**	***d***
Verbal Comprehension (VC)			
Vocabulary	0.87	0.86	−0.05
Information	0.77	0.80	−0.15
Similarities	0.84	0.82	−0.14
Comprehension	0.85	0.81	−0.00
Arithmetic	0.32	0.39	−0.04
Working Memory (WM)			
Arithmetic	0.51	0.41	0.09
Digit Span Forward	0.65	0.61	0.06
Digit Span Backwards	0.74	0.72	0.09
Digit Span Sequencing	0.74	0.69	−0.05
Perceptual Reasoning (PR)			
Block Design	0.77	0.72	0.22
Matrix Reasoning	0.70	0.68	−0.00
Visual Puzzles	0.77	0.66	0.28
Picture Completion	0.62	0.65	−0.05
Processing Speed (Speed)			
Symbol Search	0.77	0.69	0.14
Coding	0.80	0.77	0.05
Factor Correlations			
VC – WM	0.66	0.70	−0.06
VC – PR	0.72	0.77	−0.07
VC – Speed	0.52	0.61	−0.10
WM – PR	0.70	0.77	−0.09
WM – Speed	0.63	0.69	−0.07
PR – Speed	0.63	0.75	−0.15
Factor Variances			
VC	91.44	99.96	−0.05
WM	3.01	3.40	−0.05
PR	101.55	61.57	0.22
Speed	182.59	163.93	0.05

Note: The effect size estimates (*d*) were based on comparisons of the unstandardized coefficients.

were very small. The only trends were for slightly smaller loadings for two Perceptual Reasoning subtests in the older group, and consequently slightly smaller variance for the Perceptual Reasoning factor in that group. For the most part, however, the relations among variables under and over age 65 were quite similar, which is consistent with the assumption that the variables have the same meaning in the two groups.

Because the factors were moderately correlated with one another, they can be organized into a hierarchical structure in which a higher-order factor is assumed to be responsible for the relations among the factors. The standardized coefficients for this model are portrayed in Figure 8.2 for the under-65 and 65-and-older groups. The values in parentheses are the effect sizes in *d* units for the group differences in the loadings. It can be seen that the loadings were slightly higher in the older group for all factors, particularly for the Perceptual Reasoning and Speed Processing factors, but that all of the effect sizes were quite small. These results suggest that the composition of general cognitive ability is similar in the two groups.

First observed by Spearman (Spearman, 1927), and often referred to as Spearman's "Law of Diminishing Returns," a number of researchers have reported that correlations among cognitive variables tend to be highest among individuals with the lowest levels of ability (see, for example, Detterman & Daniel, 1989; Abad, Colom, Juan-Espinosa, & Garcia, 2003; Saklofske, Yang, Zhu, & Austin, 2008; Tucker-Drob, 2009). Saklofske and colleagues (2008) tested this ability differentiation effect using WAIS-III standardization samples from Australia, Canada, the Netherlands, and the United States, and did not find support for either the ability or age aspects of the law of diminishing returns. However, the ability groups employed in

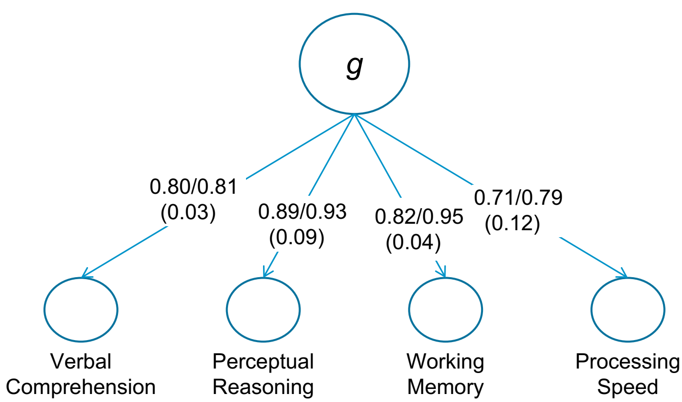

FIGURE 8.2 Standardized loadings of first-order cognitive abilities on a "g" factor. The first number is the coefficient for adults between 16 and 64 years of age, and the second number is the coefficient for adults between 65 and 90 years of age. The numbers in parentheses are the *d* values for the difference between the unstandardized coefficients.

the Saklofske *et al.* (2008) study were split at 45 years of age. Because it is possible that the "ability de-differentiation" phenomenon differs as a function of how the age groups are comprised, this effect was again examined in the two age groups with the current WAIS-IV data. Selection of a measure to stratify groups into different ability levels is somewhat arbitrary, since any measure could be used as a stratification measure. Because the Verbal Comprehension factor had similar mean values at different ages and nearly identical loadings on the higher-order factor in Figure 8.2, the Verbal Comprehension composite score was used as the ability stratification variable in the current analyses. However, it should be noted that a similar pattern was evident when other composite scores were used to create the different ability levels.

There are two contradictory goals in analyses examining relations at different ability levels, because a small number of groups is desirable to increase sample size and precision of the estimates, but a large number of groups is desirable to provide sensitive assessment of ability relations. A compromise was adopted in the current analyses by creating several overlapping groups which allowed each of several ability levels to be examined with moderately large samples. The overlapping subgroups were each composed of 20 percent of the sample, with the first group consisting of individuals up to the 20th percentile, the second group consisting of people with scores from the 10th to the 30th percentile, etc.

The correlations of the composite scores for each ability at different levels of Verbal Comprehension ability are portrayed in the four panels of Figure 8.3. The top left panel contains medians of the three correlations involving Verbal Comprehension ability, which is the composite score used to create the ability levels, and the remaining panels contain correlations between pairs of other composites. The patterns in each panel, and in each group, are generally similar, with the highest correlations at the lowest level of Verbal Comprehension ability, and most of the remaining correlations at nearly the same value. The ability de-differentiation phenomenon in these data therefore appears to be primarily attributable to very high correlations in the lowest ability groups. Of greatest interest in the current context is that although some of the correlations were higher in the 65-and-over age group, the pattern as a function of ability levels in adults under age 65 closely resembled that in adults 65 and over.

CORRELATIONS WITH OTHER VARIABLES

A final set of analyses consisted of examining correlations in the two age groups between the cognitive ability composite scores with two demographic variables, sex and education. The sex variable was coded as 1 for female and 0 for male, and the education variable was coded into five

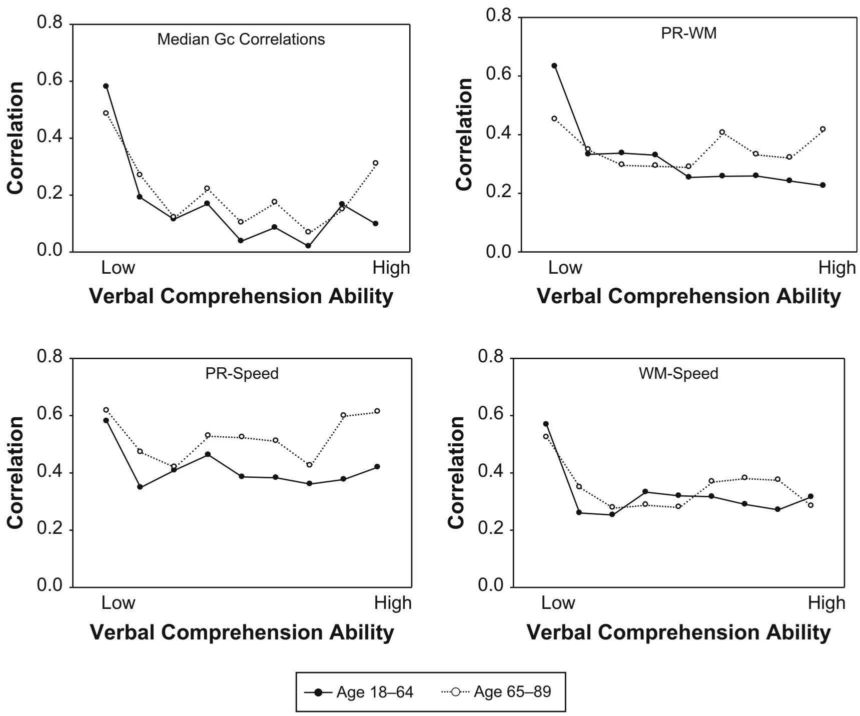

FIGURE 8.3 Correlations between composite cognitive ability scores at different levels of verbal comprehension ability for adults under and over 65.

categories, ranging from 1 for 0–8 years of education, 2 for 9–11 years of education, 3 for 12, 4 for 13–15, and 5 for 16 or more years of education. Results of these analyses are summarized in Table 8.6, where it can be seen that several of the correlations were significantly different from 0. At least in these data, males tended to have higher composite scores on the Verbal Comprehension, Perceptual Reasoning, and Working Memory domains, but females had higher scores in the Processing Speed domain. Whether these differences reflect genuine differences in the population, or are consequences of differential sampling of males and females, cannot be determined from the available data. However, the important point for the current purpose is that similar results were apparent in the two age groups, and the group differences in the correlations were fairly small, with none of the effect sizes exceeding 0.1.

All of the correlations between the educational level variable and the cognitive ability composite scores were moderately large, indicating that people with more years of education had higher scores on the four composite scores. Because causal direction is ambiguous with simple

TABLE 8.6 Correlations of the cognitive factors with sex and education level in the two age groups and effect sizes for the group difference

Variable	Correlation		
	16–64	65–90	*d*
Correlations with sex			
Verbal Comprehension (VC)	−0.09*	−0.07*	−0.02
Perceptual Reasoning (PR)	−0.12*	−0.13*	−0.01
Working Memory (WM)	−0.07*	−0.03	−0.03
Processing Speed (Speed)	0.20*	0.10*	0.09
Correlations with education level			
Verbal Comprehension (VC)	0.54*	0.67*	−0.06
Perceptual Reasoning (PR)	0.35*	0.47*	0.02
Working Memory (WM)	0.41*	0.44*	−0.03
Processing Speed (Speed)	0.34*	0.41*	−0.02

Note: Sex was coded with 0 for males and 1 for females, and education level was coded with higher numbers for greater amounts of formal education (i.e., 1 for 0–8, 2 for 9–11, 3 for 12, 4 for 13–15, and 5 for 16 or more). The effect size estimates (*d*) were based on comparisons of the unstandardized (covariance) coefficients.
*$P < 0.01$.

correlations, these relations could reflect a positive influence of education on cognitive ability, an enabling effect of cognitive ability on access to more education, the operation of some other factor responsible for both education and cognitive ability, or various combinations of influences. Regardless of the causes, it is noteworthy that the association of cognitive ability and education is just as strong among adults 65 years and older as among adults at younger ages.

It is unfortunate that more variables were not available to allow additional comparisons of this type across the two groups. Nevertheless, the discovery of similar correlations with the demographic variables of sex and education in the two groups is consistent with the assumption that the cognitive ability factors have comparable meanings among adults under and over 65 years of age.

DISCUSSION

The analyses reported above should provide some relevant information to clinicians when using the WAIS-IV and trying to understand the effects that age might have on the measurement and interpretation of cognitive abilities. Average levels of performance are clearly lower in adults over 65 years of age compared to adults under age 65 on many cognitive tests. Furthermore, the relation of age to level of cognitive performance is often stronger among older adults, which indicates that age is a more salient predictor of level of cognitive functioning at older ages. However, it is noteworthy that the magnitude of individual differences (i.e., between-person variance) in level of performance was very similar in adults under and over age 65, which implies that factors other than age must have greater influences on the individual differences in performance among younger adults. The estimated reliabilities in Table 8.4 were similar in the two age groups, and thus the non-age variance in the younger group is not simply due to measurement error. Unfortunately there is no evidence in the available data regarding what these other age-independent influences might be, or why they would be greater in young adulthood and middle age than in old age.

The primary question of interest in the chapter was whether, despite the markedly different levels of performance in the two groups, the WAIS-IV tests measure the same aspect of functioning in adults under and over age 65. A tentative answer, based on the results described above, is ''yes''.

Among the evidence leading to this conclusion is the finding that the composite score reliabilities for adults under and over age 65 were very similar, indicating nearly equivalent consistency of measurement. The assessments in older adults were therefore no less systematic than those in younger adults.

One of the most informative methods of investigating the meaning of a variable consists of examining relations of that variable with other variables. The reasoning is that a variable can be inferred to be similar to variables with which it has strong correlations, and to be dissimilar from variables with which it has weak relations. The discovery of a close resemblance of the factor structures based on the patterns of correlations in the two age groups is therefore relevant to the issue of measurement equivalence. That is, variables can be organized into ability factors which are correlated with one another, and the results indicated that this organizational structure was quantitatively very similar in the two groups. Not only were the standardized coefficients in Table 8.5 close in magnitude, but also all of the effect sizes computed from the unstandardized coefficients in the two groups were quite small. Furthermore, the coefficients in Figure 8.2 were again very similar, which suggests nearly equivalent composition of the higher-order cognitive ability factor at different ages. Finally, although correlations among the constructs were greatest at lower ability levels, this was true to nearly the same extent for adults under and over 65 years of age. This combination of results is clearly consistent with the interpretation that the subtests and factors reflect the same constructs in the two age groups.

In addition to examining relations among other cognitive variables, relations with other types of variables can also be informative in investigating measurement equivalence. Only two other variables were available from the standardization program to allow examination of external relations: sex and educational level. However, both variables had very similar patterns of relations with the cognitive factors in the two groups, which is compatible with the interpretation that the cognitive variables have similar meaning in adults under and over 65 years of age.

Despite the evidence summarized above, it is still possible that there are qualitative differences in what the variables represent among adults of different ages. For example, when performing various cognitive tests young and old adults could use different strategies, or they could rely on different constellations of regional brain activation. However, until relevant empirical evidence is available, speculations of qualitative differences in cognitive performance at different ages should be viewed as hypotheses to be investigated, rather than as established conclusions. The methods reported above represent only a limited set of those that could be used to investigate measurement equivalence across different groups of people, but they provide no evidence of qualitative differences in the measures in adults under and over 65 years of age.

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