CHAPTER

1

WAIS-IV: Advances in the Assessment of Intelligence

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INTRODUCTION

The Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Wechsler, 2008a) reflects the culmination of over 70 years of progressive revisions to the Wechsler line of adult intelligence measures. It is ironic that the very mention of historical foundations of the Wechsler scales contributes to the misperception that the scales are outdated. In fact, Wechsler's foresight in defining intelligence in practical terms has allowed the very flexibility needed for ongoing revisions to his intelligence scales in light of advances in theory, research, and the measurement of intelligence. The most recent editions of the Wechsler intelligence scales have involved dramatic changes based on burgeoning research advances in neuropsychology, cognitive neuroscience, and contemporary intelligence theory, as well as increasing sophistication in psychological measurement. Despite these substantial innovations, some critics perpetuate the myth that the Wechsler intelligence scales are outdated or atheoretical (Kamphaus, 1993; Shaw, Swerdlik, & Laurent, 1993; Flanagan & Kaufman, 2004). We respectfully disagree and, for this reason, elaborate somewhat on Wechsler's views about intelligence and the progressive adaptations to his intelligence scales in light of contemporary theory and research. We are hopeful that the historical references, often from Wechsler's own writings, will help to clarify the theoretical foundations of the Wechsler intelligence scales, in Wechsler's time and in ours.

WECHSLER'S THEORY OF INTELLIGENCE: PAST AND PRESENT

Much has been written about the historical foundations of intelligence testing, and the reader is referred to these sources (for example, Thorndike, 1990; Sternberg, 2000; Goldstein & Beers, 2003; Tulsky, *et al*., 2003) to gain a greater appreciation and understanding of the evolution of current assessment practices. The introductory chapters of the Tulsky *et al.* (2003) book provide an excellent overview of the history of intelligence and memory testing, including the origins of many subtests that continue to appear in the most recent editions of the Wechsler intelligence and memory scales. Appendix material in the Tulsky *et al.* (2003) book provides brief biographical sketches of pioneers in the field of intelligence testing, and the influence they had on Wechsler's ideas about intelligence test development.

David Wechsler entered the field of psychology at an incredibly exciting and innovative time. Preliminary attempts to measure intelligence by Galton and Cattell had spawned an interest in defining the construct of intelligence, most notably represented by the series of debates between Charles Spearman and Edward L. Thorndike on the structure of intelligence and their differing views regarding a general intelligence factor. Advances in psychometric theory and application, and particularly factor analysis, allowed for a closer evaluation of the content represented by the various intelligence measures.

At the time that Wechsler developed the Wechsler-Bellevue Intelligence Scale – Form I (WB-I; Wechsler, 1939) there were two primary theories of intelligence, represented by the views of Spearman and Thorndike. As clarified through their historical debates in the early part of the century, Spearman believed there was a general factor of intelligence, "g," that determined an individual's ability to perform any mental task. Based on evidence indicating low correlations among some intelligence measures, Spearman revised his original theory and added specific factors to the structure of intelligence (Spearman, 1904). Thus, Spearman's revised theory (1904) asserted that intelligence was composed of both a general and specific factors, with the general factor reflecting overall intelligence, and the various specific factors reflecting more specialized abilities that shared some variance with the general factor. In contrast, Thorndike did not support the position of a general factor in the structure of intelligence, instead asserting that there were different kinds of intelligence, such as abstract, social, and practical intelligences.

Although some may have assumed that Wechsler agreed with Spearman's view of "*g*" based on the inclusion of a summary score (i.e., the Full

Scale IQ) to represent general intelligence, he included aspects from both theoretical camps in his (1939) definition of intelligence as:

> the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his [or her] environment. It is global because it characterizes the individual's behavior as a whole; it is an aggregate because it is composed of elements or abilities which, though not entirely independent, are qualitatively differentiable. **(Wechsler, 1939: 3)**

Thus, the definition clearly supports the existence of a general (or global) intelligence, but also asserts that general intelligence is composed of qualitatively different abilities. Wechsler further argued that these specific abilities included both cognitive abilities and other, non-intellective abilities such as drive, persistence, temperament, and curiosity, an interesting mix of other cognitive, personality, and conatative factors (Wechsler, 1950). Although he was not successful at incorporating measures of non-intellective factors into his intelligence scales during his lifetime, he was successful at selecting measures of cognitive ability (e.g., verbal comprehension, perceptual organization, working memory) for his scales that were later found to be important factors of intelligence (Carroll, 1993).

Perhaps it is the resilience of Wechsler's practical definition of intelligence that leads others to assert that his intelligence scales are outdated. Wechsler's original definition of intelligence remained unchanged throughout subsequent editions of his companion text for his adult intelligence scales, *The Measurement of Adult Intelligence* (Wechsler, 1939, 1941, 1944, 1958), as well as peer-reviewed journal articles (Wechsler, 1950, 1975). In fact, Wechsler's original definition continues to appear in the latest revisions of his intelligence scales (Wechsler, 2003, 2008a), as it is still relevant and practical in light of contemporary views on intelligence. Results of the most comprehensive factor-analytic investigations of intelligence measures to date suggest overwhelming evidence for a general intelligence factor at the apex of a hierarchical intelligence construct that is composed of a set of related, but distinguishable, abilities (Carroll, 1993, 1997). This finding has been replicated in cross-cultural studies of both the child and adult versions of the Wechsler intelligence tests (see, for example, Georgas, Weiss, van de Vijver, & Saklofske, 2003). Research on the predictive validity of general intelligence suggest that it is superior to more narrow cognitive domains in predicting such important life outcomes as academic and occupational performance (Deary, 2009; Gottfredson, 2009). Factor-analytic results also suggest that general intelligence is composed of 8–10 broad domains of intelligence that are, in turn, composed of more specific abilities (Carroll, 1993; Horn & Noll, 1997). In light of these cumulative findings, subsequent revisions of the Wechsler scales have expanded measures of additional cognitive domains (e.g., fluid reasoning, working memory, processing speed) while continuing to provide a reliable estimate of general intelligence, the Full Scale IQ (FSIQ).

Wechsler's foresight in distinguishing between intelligence and the cognitive abilities he used to measure it allowed him to avoid one of the major fallacies used to discredit intelligence testing: that is, that the lack of consensus in definitions of intelligence negates the construct validity of intelligence tests (Gottfredson, 2009). Disagreement about the definition of intelligence does not imply that intelligence scales do not measure intelligence. The most important issue in evaluating what a scale measures is construct validation (Gottfredson, 2009; Gottfredson & Saklofske, 2009). With over 70 years of continued use and research, the Wechsler intelligence scales have an enormous literature base attesting to their validity as measures of intelligence.

Substantial changes have been made to the structure and content of more recent editions of the Wechsler scales, and the origins of many of these changes began during Wechsler's lifetime. As the methodology of factor analysis improved, Wechsler came to appreciate that a number of cognitive factors comprised intelligence. He embraced the use of alternate composite scores based on factor-analytic research (see Cohen, 1957a, 1959; Kaufman, 1975) and evidence from clinical studies indicating their utility in differential diagnosis (Wechsler, 1958). The impact of war and the resulting emergence of the field of neuropsychology were also evident in Wechsler's writings, with sections on brain damage and other neuropsychological conditions receiving more attention as the years progressed. His later writings discuss the advent of computers, and the differences in computer- and human-based models of intelligence (Wechsler, 1958, 1963, 1975), as well as contemporary advances in physics and biochemistry that he hoped could shed light on memory function (Wechsler, 1963).

In addition to reacting to the psychometric and research trends of his time, Wechsler was keenly aware of practical and societal issues in intelligence testing. Despite his acknowledgment that additional cognitive factors comprised intelligence, he noted the impracticality of measuring numerous, narrow cognitive abilities, because their inclusion did not explain a sufficient amount of additional variance in intelligence to warrant their measurement (Wechsler, 1958). He instead focused on the measurement of broader domains of cognitive ability. He realized that the expanded use of intelligence testing in neuropsychological, academic, vocational, and legal settings warranted ongoing evidence of the scale's validity when used for different purposes, and he incorporated additional clinical studies and sections in his writings to address these new areas. In short, the scale revisions made during Wechsler's lifetime were based on psychometric and theoretical advances, as well as clinical research and practical need. They were not based on fundamental changes to his definition or theory of intelligence. These forces continue to be the primary impetus for more recent changes to the Wechsler intelligence scales, including the changes made to the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) as part of the latest revision, the WAIS-IV.

The following sections describe the structure and content of the WAIS-IV, including subtest descriptions and scores. Much of the information pertaining to the WAIS-IV structure is adapted from Chapter 2 in the *WAIS-IV Technical and Interpretive Manual*, which includes additional information regarding the scale's structure, as well as is information on the rationale for changes between the WAIS-III and WAIS-IV.

STRUCTURE AND CONTENT OF THE WAIS-IV

The basic structure of the WAIS-IV is depicted in Figure 1.1. The 15 subtests (12 subtests for adults over 69 years of age) are organized into 4 index scales representing different cognitive domains: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. The index scales comprise the full scale. Core subtests are typically used to derive the composite scores (i.e., the index scores and FSIQ). Supplemental subtests (shown in parentheses) may be administered in addition to the core subtests to provide additional clinical information, or they may be administered in place of core subtests should one be spoiled or invalid.

Subtest descriptions

Verbal Comprehension subtests

The core Verbal Comprehension subtests are Similarities (SI), Vocabulary (VC), and Information (IN). Comprehension (CO) serves as

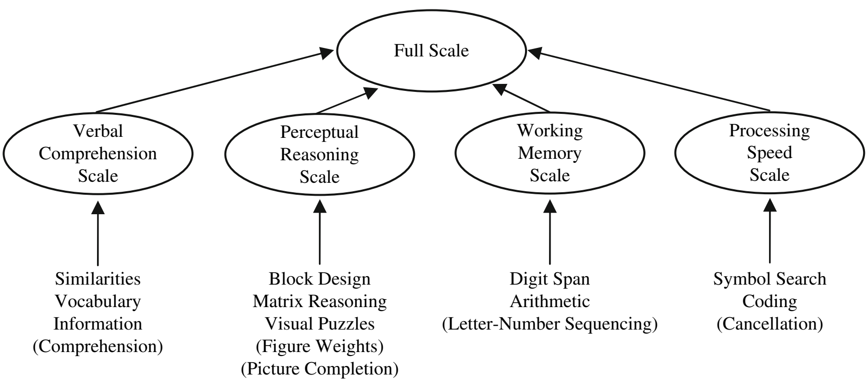

FIGURE 1.1 WAIS-IV structure.

a supplemental subtest. All of these subtests have appeared on previous versions of the Wechsler intelligence scales, and the items within the subtests are not timed.

Items on the Similarities subtest require that the individual describes how two common objects or concepts are similar. This subtest measures verbal concept formation, abstract verbal reasoning, categorical thinking, and the ability to distinguish between non-essential and essential features (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

The Vocabulary subtest is primarily composed of verbal items, but picture items are also included to extend the floor of the subtest. For picture items, the examinee names pictured objects; for verbal items, the individual defines words that are presented and read aloud by the examiner. This subtest measures verbal concept formation, language development, and word knowledge, and also requires long-term memory (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Information items are posed as questions addressing a broad range of general knowledge. It measures fund of knowledge, long-term memory and retrieval, verbal comprehension, and crystallized intelligence (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Similar to Information, items on the Comprehension subtest are posed as questions to the individual, but the content of the questions is based on an understanding of basic principles and social situations, rather than factual knowledge. This subtest measures verbal conceptualization, verbal expression, practical knowledge, social judgment, crystallized intelligence, and common sense (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Perceptual Reasoning subtests

The core Perceptual Reasoning subtests are Block Design (BD), Matrix Reasoning (MR), and Visual Puzzles (VP). Figure Weights (FW) serves as a supplemental subtest for individuals aged 16–69 years, and Picture Completion (PCm) serves as a supplemental subtest for individuals aged 16–90 years. Block Design, Matrix Reasoning, and Picture Completion have appeared on previous versions of the Wechsler intelligence scales; Visual Puzzles and Figure Weights are new to the WAIS-IV.

Block Design items require that the individual reproduces pictured designs using specially designed blocks. The block faces vary, with some sides being red, some white, and others having a half-red and half-white pattern on the diagonal. The subtest items are timed. Block Design measures non-verbal reasoning; analysis and synthesis; visual perception and organization; and visual–motor coordination (Carroll, 1993; Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

For items on Matrix Reasoning, the individual completes a matrix or serial reasoning problem by selecting the missing section from five response choices. Items are not timed. Matrix Reasoning measures fluid intelligence, visuospatial ability, simultaneous processing, and perceptual organization (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

To complete each Visual Puzzles item, the individual selects the three response options (from six) that could be combined to reproduce a geometric image. Items are timed. It was designed to be a non-motor task that would measure similar constructs to those measured by the WAIS-III Object Assembly subtest. It was devised to measure perceptual reasoning, visuospatial ability, analysis and synthesis, and simultaneous processing (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

For each Figure Weights item, the individual selects the response option (from five) that would keep a pictured scale in balance. The weights are represented by geometric shapes of different colors, and more difficult items require the individual to view more than one scale with established weight relationships to determine the response choice that keeps the scale balanced. Items are timed. It was designed to measure fluid reasoning; more specifically, quantitative and analogical reasoning (Wechsler, 2008a).

Picture Completion items consist of a pictured object or scene with a missing part. The individual must identify the missing part within 20 seconds. The subtest measures visual perception, perceptual organization, and attention to visual detail (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Working Memory subtests

The core Working Memory subtests are Digit Span (DS) and Arithmetic (AR). Letter–Number Sequencing (LN) serves as a supplemental subtest for individuals aged 16–69 years.

Digit Span includes three tasks: Forward, Backward, and Sequencing. For the Forward task, the individual repeats numbers spoken by the examiner. The Backward task requires the individual to repeat numbers in the reverse order of that presented, and the Sequencing task requires the individual to sequence numbers from the lowest to highest number. Although there is no time limit for the individual to respond, the examiner reads each number out at the rate of one number per second. The working memory demands for the Backward and Sequencing tasks are greater than those of the Forward task, but all three tasks are designed to measure working memory. Digit Span also measures attention, auditory processing, and mental manipulation (Reynolds, 1997; Groth-Marnat, 2009; Sattler & Ryan, 2009). All three tasks are administered to each individual.

Arithmetic items require the individual to mentally solve arithmetical word problems within a time limit. The Arithmetic subtest measures working memory, mental manipulation, attention, concentration, sequential processing, and numerical reasoning (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

For Letter–Number Sequencing, the examiner reads a series of letters and numbers. The individual recalls the numbers first, in ascending order, and then the letters, in alphabetical order. Although there is no time limit for the individual to respond, the examiner reads each number or letter out at the rate of one number per second. Letter–Number Sequencing measures working memory, mental manipulation, attention, concentration, and short-term auditory memory (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Processing Speed subtests

The core Processing Speed subtests include Symbol Search (SS) and Coding (CD). Cancellation (CA) serves as a supplemental subtest for individuals aged 16–69 years.

Symbol Search requires the individual to search for two target symbols within a row of symbols. Individuals use a pencil to mark either the matching symbol or a "no" box to indicate responses, and have 120 seconds to complete as many rows (items) as possible. Symbol Search measures visuomotor processing speed, short-term visual memory, visual discrimination, attention, and concentration (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

Coding requires that the individual copies simple symbols as quickly as possible, based on a key that pairs numbers with the symbols. Like Symbol Search, the individual is given 120 seconds to complete the subtest. Coding measures visuomotor processing speed, short-term visual memory, learning ability, cognitive flexibility, attention, concentration, and motivation (Kaufman & Lichtenberger, 1999, 2006; Groth-Marnat, 2009; Lichtenberger & Kaufman, 2009; Sattler & Ryan, 2009).

For Cancellation, the individual searches for specific colored shapes within a larger array of colored shapes, marking only the specified shapes. There are two items with different colors and shapes. Both items are administered to an individual, and each item has a time limit of 45 seconds. Although designed to measure the same construct as the Cancellation subtest of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003), the WAIS-IV Cancellation subtest uses abstract shapes rather than animals. Cancellation tasks are used to measure visuomotor processing speed, visual selective attention, and visual neglect (Geldmacher, Fritsch, & Riedel, 2000; Bate, Mathias, & Crawford, 2001; Wojciulik, Husain, Clarke, & Driver, 2001; Sattler & Ryan, 2009).

Score descriptions

A number of scores can be derived as part of a WAIS-IV administration, including scores at the subtest-, index-, and full-scale levels. Each subtest provides a score that is scaled to a metric with a mean of 10 and a standard deviation of 3. The sum of scaled scores for the subtests within a domain is used to derive the corresponding index score. For example, the sum of scaled scores for Similarities, Vocabulary, and Information is used in most situations to derive the VCI. Index scores include the Verbal Comprehension Index (VCI), the Perceptual Reasoning Index (PRI), the Working Memory Index (WMI), and the Processing Speed Index (PSI). A Full Scale IQ (FSIQ) is derived from the sum of subtest-scaled scores for all four domains. All of the composite scores, including the index scores and the FSIQ, are scaled to a metric with a mean of 100 and a standard deviation of 15.

In addition to the primary scores noted above, the WAIS-IV offers a number of optional scores. At the subtest level, the optional scores are designed to provide additional information related to the individual's performance on specific subtests. This process approach to assessment has its historical roots in the work of Edith Kaplan and her colleagues, who devised a number of process measures to further evaluate performance on the Wechsler intelligence scales. These measures provide a systematic and quantitative approach to the analysis of qualitative aspects of subtest performance. The WAIS-IV includes optional process scores for two subtests: Block Design and Digit Span. The Block Design No Time Bonus score (BDN) is based on the individual's Block Design performance without additional time-bonus points. Separate, optional scores are also available for the three Digit Span tasks: Forward, Backward, and Sequencing.

At the index level, the General Ability Index (GAI) is included as an optional index score. It is derived from the sum of scaled scores for the core Verbal Comprehension and Perceptual Reasoning subtests, thus resulting in a composite that is less influenced by the demands of working memory and processing speed than the FSIQ. The GAI was first introduced by Prifitera, Weiss, and Saklofske (1998) as an optional composite score for the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991). Tulsky, Saklofske, Wilkins, and Weiss (2001) developed a WAIS-III GAI subsequent to the scale's publication in 1997. Based on the increased clinical usage of this composite, information regarding the WAIS-IV GAI appears in the test manuals. Additional information regarding the history and interpretation of the GAI, as well as its counterpart, the Cognitive Proficiency Index (CPI), appears in Chapter 3 of this volume.

WAIS-III TO WAIS-IV: WHAT'S NEW?

Changes to structure and content

The most notable change between the WAIS-III and WAIS-IV structures involves the elimination of the traditional Verbal IQ (VIQ) and Performance IQ (PIQ) scores in favor of the four, factor-based index scores – a change that was foreshadowed by similar modifications to the structure of the WISC-IV. The third editions of the WISC and WAIS included a dual IQ/index score structure, in which the traditional FSIQ, VIQ, and PIQ scores remained the primary level of interpretation, and the index scores provided an alternative method for evaluating the individual's performance in more discrete domains of cognitive functioning. The dual IQ/index score structure served as a transition for those users who were accustomed to the traditional VIQ/PIQ split that had characterized the Wechsler intelligence scale since the publication of the Wechsler-Bellevue Intelligence Test – Form I (WB-I; Wechsler, 1939).

In part, the evolution of the index scores was based on an expanding base of factor-analytic evidence supporting the existence of additional factors within the Wechsler intelligence scales (Cohen, 1957a, 1957b, 1959; Kaufman, 1975, 1979). The emergence of the four-factor structure can be traced to the WISC-III. Prior to the WISC-III, both the adult and child versions of the Wechsler intelligence scales were commonly viewed as having three factors, based on numerous factor analytic investigations of the Wechsler scales (Cohen, 1957a, 1959; Kaufman, 1975). The first two factors represented verbal and performance abilities, and the third factor, termed the Freedom from Distractibility factor (FD), was composed of the Arithmetic, Digit Span, and Digit Symbol (now referred to as Coding) subtests. Interpretation of the FD factor varied, with some proposing it as a measure of attention and concentration (Kaufman, 1975), others describing it as a measure of memory (Cohen, 1957a), and still others contending that it measures sequencing ability (Bannatyne, 1974). Researchers working on the WISC-III revision developed the then-new Symbol Search subtest in an attempt to clarify the nature of the third factor, and the now familiar, four-factor structure emerged. The WAIS-III followed suit with the addition of a Symbol Search subtest, and the four-factor structure of the scale was again confirmed. The WISC-III Freedom from Distractibility Index was renamed as the Working Memory Index on the WAIS-III.

The primary impetus behind the rise of the index scores was borne from the clinical research literature suggesting that performance in more discrete domains of cognitive ability provided useful information for differential diagnosis (Wechsler, 1997). For example, individuals with Reading and Mathematics Disorder often have difficulties with tasks requiring working memory (Gathercole, Hitch, Service, & Martin, 1997; Wechsler, 2003), and individuals with traumatic brain injury (TBI) often have difficulty with tasks requiring processing speed (Mathias & Wheaton, 2007). Although diagnosis should never be based on a single score, the refined nature of the index scores enhances the interpretability of group and individual differences (see also Weiss, Saklofske, Prifitera, & Holdnack, 2006).

Although the structural changes between the WAIS-III and WAIS-IV are substantial, the scales measure very similar constructs, as indicated by the strength of the correlations between the WAIS-III and WAIS-IV composites provided in the manual (Wechsler, 2008a) and reproduced in Table 1.1.

Table 1.2 includes a comparison of subtests contributing to corresponding scores on the WAIS-III and WAIS-IV. The subtest comparisons are based on administration of core subtests in both measures.

As expected, the greatest difference in subtest contribution to composite scores is noted in the comparisons between corresponding IQ and Index scores. The WAIS-III VIQ included three subtests that do not appear in the WAIS-IV VCI: Comprehension, Arithmetic, and Digit Span. Inclusion of Arithmetic and Digit Span in the WAIS-III VIQ created a mixture of verbal and working memory tasks, making interpretation of the VIQ more difficult when performance across these domains varied. The WAIS-III PIQ included three subtests that do not appear in the WAIS-IV PRI: Picture Completion, Picture Arrangement (PA), and Coding. Unusual performance on the Coding subtest relative to the other PIQ subtests made interpretation of the PIQ problematic. The WAIS-IV VCI and PRI represent

TABLE 1.1 Correlations between WAIS-III and WAIS-IV composites

Composite	Correlation
WAIS–III VIQ/WAIS-IV VCI	0.89
WAIS–III VCI/WAIS-IV VCI	0.91
WAIS–III PIQ/WAIS-IV PRI	0.83
WAIS–III POI/WAIS-IV PRI	0.84
WAIS–III WMI/WAIS-IV WMI	0.87
WAIS–III PSI/WAIS-IV PSI	0.86
WAIS–III FSIQ/WAIS-IV FSIQ	0.94

TABLE 1.2 Subtest contribution to composite scores on the WAIS-III and WAIS-IV

Composite	WAIS-III subtests	WAIS-IV subtests
VIQ/VCI	VC, SI, IN, CO, AR, DS	VC, SI, IN
PIQ/PRI	BD, MR, PCm, PA, CD	BD, MR, VP
VCI/VCI	VC, SI, IN	VC, SI, IN
POI/PRI	BD, MR, PCm	BD, MR, VP
WMI/WMI	AR, DS, LN	AR, DS
PSI/PSI	CD, SS	CD, SS
GAI/GAI	VC, SI, IN, BD, MR, PCm	VC, SI, IN, BD, MR, VP
FSIQ/FSIQ	VC, SI, IN, CO, BD, MR, PCm, PA, AR, DS, CD	VC, SI, IN, BD, MR, VP, AR, DS, CD, SS

purer measures of their corresponding cognitive domains than the WAIS-III VIQ and PIQ, thus improving interpretability when variable performance across cognitive domains is present.

The three subtests that contribute to the VCI are the same across the WAIS-III and the WAIS-IV, and include Vocabulary, Similarities, and Information. Two of the three subtests contributing to the WAIS-III POI are the same as those that contribute to the WAIS-IV PRI (Block Design and Matrix Reasoning). The third subtest on the WAIS-IV PRI is a new subtest, Visual Puzzles. It replaces Picture Completion as the third subtest comprising the WAIS-IV PRI. The WAIS-III WMI was composed of three subtests (Arithmetic, Digit Span, and Letter–Number Sequencing), whereas the WAIS-IV WMI is composed of only two subtests (Arithmetic and Digit Span). The subtests contributing to the WAIS-III and WAIS-IV PSI are the same, and include Coding and Symbol Search. Taken together, the subtest changes for the WAIS-IV Index scores are minimal, and should not result in major interpretive differences.

Table 1.3 includes the percentages of index-score contribution to the FSIQ in the WAIS-III and WAIS-IV. The proportions are similar across the two measures with the exception of the Processing Speed Index, which comprises 20 percent of the subtests in the WAIS-IV FSIQ versus only

TABLE 1.3 Index-score contribution to FSIQ for the WAIS-III and WAIS-IV

	VCI	PRI	WMI	PSI
WAIS-III	36.4%	36.4%	18.2%	9%
WAIS-IV	30%	30%	20%	20%

9 percent of subtests in the WAIS-III FSIQ. Thus, the contribution of the PSI to the FSIQ has more than doubled in the WAIS-IV relative to the WAIS-III.

Increased emphasis on the measurement of processing speed has been evident in recent revisions to both the child and adult versions of the Wechsler intelligence scales (e.g., WISC-III, WISC-IV, WAIS-III, and WAIS-IV). The addition of the Symbol Search subtest to the WISC-III and WAIS-III allowed the PSI factor to emerge. Subsequent research indicates that the PSI is sensitive to a variety of neuropsychological conditions, including traumatic brain injury (Kennedy, Clement, & Curtiss, 2003), epilepsy (Berg *et al.*, 2008), multiple sclerosis (Forn, Belenguer, Parcet-Ibars, & Ávila, 2008) and Attention Deficit/Hyperacticity Disorder (Schwean & Saklofske, 2005). Research also indicates that processing speed may play a central role in age-related changes in intellectual ability (Salthouse, 2000).

The Cancellation subtest was added to the WISC-IV as a supplemental measure of processing speed that required less fine motor demands than Coding. The WAIS-IV includes a version of the Cancellation subtest for similar reasons. These measures have been extensively used in neuropsychological settings as measures of visual neglect, response inhibition, and motor perseveration (Adair, Na, Schwartz, & Heilman, 1998; Geldmacher *et al.*, 2000; Lezak, Howieson, Loring, Hannay, & Fischer, 2004).

Also evident in recent revisions is an increased emphasis on working memory content. The roots of working memory lie in the field of cognitive psychology, and date back to investigations by Baddeley and Hitch (1974). Although there is some disagreement as to the definition of working memory, it is generally considered to be an active form of memory, in which information is stored temporarily for further processing. Baddeley's (2003) model of working memory is the most comprehensive and accepted model at the current time. In this model, auditory (verbal) and visual information are stored and refreshed in separate systems, and a central executive controls the allocation of resources to these systems (see Chapter 3 for additional details of Baddeley's working memory model). Accordingly, the auditory and visual working memory tasks appear separately in the WAIS-IV and Wechsler Memory Scale – Fourth Edition (WMS-IV; Wechsler, 2009), respectively. Although the WAIS-III WMI was composed of only auditory tasks (Digit Span and Letter–Number Sequencing), the WMS-III WMI included one auditory (Letter–Number Sequencing) and one visual (Spatial Span) working memory task. Subsequent research indicates that the mixture of auditory and visual tasks on the WMS-III could lead to interpretive difficulties, especially when the WMIs of the two scales were discrepant (Wilde, Strauss, & Tulsky, 2004). The WAIS-IV WMI is derived from the scaled scores on the Digit Span and Arithmetic subtests, both of which are auditory measures. The supplemental subtest, Letter–Number Sequencing, is also an auditory measure. The WMS-IV Visual Working Memory Index (VWMI) is composed of new visual working memory tasks, including Spatial Addition and Symbol Span (see Chapter 9 for additional details about the WMS-IV VWMI).

Other content-related changes were made at the subtest level to enhance the measurement of working memory on Arithmetic and Digit Span. Arithmetic items were revised to decrease demands on verbal comprehension and mathematical knowledge, thus increasing demands on working memory. For example, excess verbiage was eliminated, and single-syllable names were chosen for the word problems. Increased item difficulty is obtained by increasing the number of sequential, simple calculations, rather than requiring the solution of more complex calculations. Based on research indicating that the Forward and Backward tasks of Digit Span had different cognitive demands (see, for example, Banken, 1985; Reynolds, 1997), Digit Span Sequencing was added as a third Digit Span task. Like the Backward task, the Sequencing task places greater demands on working memory than the Forward task, thus increasing the working memory load of the Digit Span subtest as a whole. Separate scaled scores are available for Digit Span Forward, Backward, and Sequencing, enabling the clinician to compare performance across the three tasks. It is interesting to note that the researchers working on the WAIS-IV revision considered eliminating the Forward task, but Pilot data indicated its elimination resulted in lower scores on the Backward task, perhaps resulting from a loss of progressive instruction. In addition, retention of the Forward task ensured that the floor of the subtest was sufficient for individuals with suspected or confirmed intellectual disability (Wechsler, 2008a).

Fluid reasoning has been noted as a key aspect of cognitive functioning in many contemporary models of cognitive ability (Cattell & Horn, 1978; Carroll, 1997; Sternberg, 2000). According to Carroll (1993: 583), tasks that require fluid reasoning involve "manipulating abstractions, rules, generalizations, and logical relationships." The addition of the Matrix Reasoning subtest to the WAIS-III, Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III; Wechsler, 2002), and WISC-IV was aimed at increasing the direct measurement of fluid reasoning. The increased emphasis on fluid reasoning was also represented by renaming of the WISC-III Perceptual Organization Index as the Perceptual Reasoning Index in the WISC-IV. The WAIS-IV follows this lead in nomenclature change, and also introduces a new subtest to measure fluid reasoning: Figure Weights.

The Figure Weights subtest was developed to measure a specific aspect of fluid reasoning, quantitative reasoning. Quantitative reasoning tasks involve reasoning processes that can be expressed mathematically, emphasizing inductive or deductive logic (Carroll, 1993). The subtest does not use traditional mathematical content, but instead uses the concept of balancing weights on two sides of a scale. The Figure Weights subtest also involves working memory, as indicated by results of factor analyses (Wechsler, 2008a). The involvement of working memory increases with item difficulty, as more difficult items require that a greater number of shape–weight relationships be retained and evaluated to find the correct solution. This relationship between reasoning and working memory is not surprising, based on related research suggesting a dynamic interplay between fluid reasoning, working memory, and processing speed (Kyllonen & Christal, 1990; de Ribaupierre & Lecerf, 2006; Unsworth & Engle, 2007; Salthouse & Pink, 2008). The dynamic relationship between fluid reasoning, working memory, and processing speed, as well as its importance in learning and memory, is discussed in more detail in Chapter 3.

Other structural and content-related changes in the WAIS-IV include the addition of the Visual Puzzles subtest, and the deletion of several WAIS-III subtests and optional procedures. The Visual Puzzles subtest was created to measure constructs similar to those assessed by the Object Assembly subtest, including perceptual organization, spatial reasoning, and analysis and synthesis of part–whole relationships. This development was planned due to several limitations of Object Assembly. Although the Object Assembly subtest provided a good measure of perceptual organization (Larrabee, 2004), limitations impacting its use included age-appropriateness, ease of administration, testing time, reliability, and motor demands. Thus, development efforts were aimed at finding a replacement or new measure that tapped similar constructs. Psychometric results support the improved reliability of Visual Puzzles relative to Object Assembly, as well as the relationship of this subtest to other measures on the Perceptual Reasoning scale. Future research is needed with this new subtest to determine if it shows evidence of the same clinical utility as the Object Assembly subtest.

In addition to Object Assembly, the Picture Arrangement subtest was dropped from the WAIS-IV. Elimination of these subtests aided in accomplishing several research goals, including the reduction of overall administration time and the need for time-bonus points on perceptual reasoning measures. Both of these subtests had relatively poorer psychometric properties than other subtests (e.g., reliability), and the Picture Arrangement subtest was frequently "overinterpreted" as a measure of social judgment or sequencing ability.

A more difficult decision involved the removal of optional procedures for the Coding subtest. The Coding subtest, called Digit Symbol–Coding on the WAIS-III, included two optional procedures, Digit Symbol–Incidental Learning and Digit Symbol–Copy. These tasks were designed to further evaluate an individual's performance of the Digit Symbol–Coding subtest, by teasing apart the possible effects of incidental learning and graphomotor speed on subtest performance. One of the primary goals of WAIS-IV revision was to add new measures of fluid reasoning, working memory, and processing speed, while reducing or maintaining administration time. Extensive market research with WAIS-IIII users indicated that the incidence of usage for these subtests was low, so the decision was made to eliminate them from the standardization edition. The WAIS-III Digit Symbol–Copy procedure can still be used as a measure of graphomotor speed, but comparisons between this score and scores from the WAIS-IV Coding subtest are not supported. For those who are interested in obtaining additional information about the incidental learning and graphomotor speed aspects of the Coding subtest, Sattler and Ryan (2009) have included recall and copy tasks for use with the WAIS-IV in their text, *Assessment with the WAIS-IV*.

Twelve WAIS-III subtests were retained on the WAIS-IV, but the item content, administration procedures, or scoring has changed. Chapter 2 (see Appendix) includes a detailed description of the administration and scoring changes made to retained subtests on the WAIS-IV. This information should be especially helpful to those practitioners who are making the transition from the WAIS-III to the WAIS-IV. The *WAIS-IV Technical and Interpretive Manual* (Wechsler, 2008b) includes an item-level analysis of changes between the WAIS-III and WAIS-IV (e.g., how many items were dropped, retained, or modified), and the reader is referred to those sections for additional information.

Other changes

Other improvements were made on the WAIS-IV that are not necessarily related to changes in structure or content. A number of changes were based on increasing the developmental appropriateness of the scale for older adults, based on sensory and psychomotor changes related to normal aging (Storandt, 1994; Kaufman & Lichtenberger, 1999, 2006; Lezak *et al.*, 2004). Although these changes were based primarily on the needs of older adults, they should also make the WAIS-IV a more appropriate measure for individuals of all ages with similar difficulties. Based on the decline of processing speed with increasing age (see, for example, Lee, Gorsuch, Saklofske, & Patterson, 2008), the use of time-bonus points on the perceptual reasoning subtests has been drastically reduced. Time-bonus points were eliminated entirely on Arithmetic, and limited to six ceiling items on Block Design. Based on possible issues with auditory discrimination, the occurrence of rhyming letters and numbers within a trial was virtually eliminated on Digit Span and Letter–Number Sequencing. Similarly, concerns with possible deficits in visual acuity prompted enlargement of all visual stimuli. As mentioned previously, a reduction in motor demands was also desired. Cancellation provides an alternative processing speed measure with reduced fine motor demands compared to Coding, and the addition of Visual Puzzles similarly reduces the motor demands of subtests in the perceptual reasoning domain relative to the WAIS-III.

Although not specifically intended for older adults, the WAIS-IV instructions emphasize teaching to a greater degree than the WAIS-III, with all examinees receiving instruction regarding the demands of the subtest task. This differs from previous versions, in which corrective feedback was provided only when the examinee provided an incorrect response. By teaching all examinees in the same manner, the possible effects of differential teaching are minimized while further ensuring that low scores are not due to an examinee misunderstanding the task at hand. This is especially important for older individuals who may be unfamiliar with the types of items included on a subtest (e.g., matrix problems), or individuals with less educational opportunity. Taken together with the reduced number of core subtests, the average testing time of 80 minutes for the WAIS-III has been reduced to 67 minutes on the WAIS-IV – a time saving of over 15 percent. The reduced testing time should result in benefits in terms of further limiting fatigue, as well as providing the practitioner with additional time to evaluate other aspects of cognitive functioning, such as adaptive behavior, memory, and executive function.

CONCLUSION

The WAIS-IV is the latest revision of Wechsler's adult intelligence scales, the most widely used tests of intelligence for adults. It represents a continuing tradition of change and innovation that has been most evident in recent revisions of the scale. The increasing rate of change mirrors a similar increase in productivity in related areas of research, including neuropsychology, cognitive psychology, cognitive neuroscience, and intelligence theory. It is likely that continuing advances in related fields will contribute to the revision goals of future editions.

One of the most promising areas for future research is functional brain imaging (Dingfelder, 2009). The use of intelligence measures in brain imaging studies is becoming more common, with evidence suggesting more localized activation of brain regions for specific cognitive abilities (e.g., spatial ability), and more diffuse activation of brain areas for general intellectual ability (Colom *et al.*, 2009; Haier *et al.*, 2009). Other studies indicate a positive correlation between cortical thickness and general intelligence (Karama *et al.*, 2009). Even more relevant is a recent study employing lesion-mapping techniques for an evaluation of WAIS-III index scores, with results indicating more localized regions for the VCI, POI, and WMI than the PSI, which appears to be more diffuse in nature (Gläscher *et al.*, 2009). Based on the rate of progress in the field of brain imaging, psychologists and educators alike should re-examine their current knowledge about intelligence to include relevant literature on the neural basis of intelligence (Haier & Jung, 2008).

The WAIS-IV is the product of progressive innovations over the last 70 years. The authors would like to express their respect and appreciation to Dr Wechsler for his remarkable contributions to the field of intelligence assessment, and for modeling a method of test development that strives for psychometric, clinical, and practical excellence on the basis of research from a wide variety of disciplines. It is this foundation that has allowed the Wechsler scales to stand the test of time, as they adapt to the ever-changing world around them.

References

Adair, J. C., Na, D. L., Schwartz, R. L., & Heilman, K. M. (1998). Analysis of primary and secondary influences on spatial neglect. *Brain and Cognition, 37*, 351–367.

Baddeley, A. D. (2003). Working memory: looking back and looking forward. *Nature Reviews Neuroscience, 4*(10), 829–839.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation, Vol. 8, Advances in Research and Theory* (pp. 47–89). New York, NY: Academic Press.

Banken, J. A. (1985). Clinical utility of considering Digits Forward and Digits Backward as separate components of the Wechsler Adult Intelligence Scale – Revised. *Journal of Clinical Psychology, 41*(5), 686–691.

Bannatyne, A. (1974). Diagnosis: A note on recategorization of the WISC scaled scores. *Journal of Learning Disabilities, 7*, 272–274.

Bate, A. J., Mathias, J. L., & Crawford, J. R. (2001). Performance on the Test of Everyday Attention and standard tests of attention following severe traumatic brain injury. *Clinical Neuropsychologist, 15*(3), 405–422.

Berg, A. T., Langfitt, J. T., Testa, F. M., DiMario, F., Kulas, J., Westerveld, M., & Levy, S. R. (2008). Residual cognitive effects of uncomplicated idiopathic and cryptogenic epilepsy. *Epilepsy and Behavior, 13*(4), 614–619.

Carroll, J. B. (1993). *Human Cognitive Abilities: A Survey of Factor-analytic Studies*. Cambridge: Cambridge University Press.

Carroll, J. B. (1997). The three-stratum theory of cognitive abilities. Contemporary intellectual assessment: theories, tests, and issues. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (pp. 122–130). New York, NY: Guilford Press.

Cattell, R. B., & Horn, J. L. (1978). A check on the theory of fluid and crystallized intelligence with description of new subtest designs. *Journal of Educational Measurement, 15*, 139–164.

Cohen, J. (1957a). The factorial structure of the WAIS between early adulthood and old age. *Journal of Consulting Psychology, 21*(4), 283–290.

Cohen, J. (1957b). A factor-analytically based rationale for the Wechsler Adult Intelligence Scale. *Journal of Consulting Psychology, 21*(6), 451–457.

Cohen, J. (1959). The factorial structure of the WISC at ages 7–6, 10–6, and 13–6. *Journal of Consulting Psychology, 23*(4), 285–299.

Colom, R., Haier, R. J., Head, R., Álvarez-Linera, J., Quiroga, M. Á., Shih, P. C., & Jung, R. E. (2009). Gray matter correlates of fluid, crystallized, and spatial intelligence: Testing the P-FIT model. *Intelligence, 37*, 124–135.

Deary, I. J. (2009). Introduction to the special issue on cognitive epidemiology. *Intelligence, 37*(6), 517–519.

de Ribaupierre, A., & Lecerf, T. (2006). Relationships between working memory and intelligence from a developmental perspective: Convergent evidence from a neo-Piagetian and a psychometric approach. *European Journal of Cognitive Psychology, 18*, 109–137.

Dingfelder, S. F. (2009). From the research lab to the operating room. *Monitor on Psychology, 40*, 4043.

Flanagan, D. P., & Kaufman, A. S. (2004). *Essentials of WISC-IV Assessment*. Hoboken, NJ: Wiley.

Flanagan, D. P., & Kaufman, A. S. (2009). *Essentials of WISC-IV Assessment* (2nd ed.). Hoboken, NJ: Wiley.

Forn, C., Belenguer, A., Parcet-Ibars, M. A., & Ávila, C. (2008). Information-processing speed is the primary deficit underlying the poor performance of multiple sclerosis patients in the Paced Auditory Serial Addition Test (PASAT). *Journal of Clinical and Experimental Neuropsychology, 30*(7), 789–796.

Gathercole, S. E., Hitch, G. J., Service, E., & Martin, A. J. (1997). Phonological short-term memory and new word learning in children. *Developmental Psychology, 33*(6), 966–979.

Geldmacher, D. S., Fritsch, T., & Riedel, T. M. (2000). Effects of stimulus properties and age on random-array letter cancellation tasks. *Aging, Neuropsychology, and Cognition, 7*(3), 194–204.

Georgas, J., Weiss, L. G., van de Vijver, F. J. R., & Saklofske, D. H. (Eds.). (2003). *Culture and Children's Intelligence: Cross-cultural Analysis of the WISC-III*. San Diego, CA: Academic Press.

Gläscher, J., Tranel, D., Paul, L. K., Rudrauf, D., Rorden, C., Hornaday, A., Grabowski, T., Damasio, H., & Adolphs, R. (2009). Lesion mapping of cognitive abilities linked to intelligence. *Neuron, 61*, 681–691.

Goldstein, G., & Beers, S. R. (Eds.). (2003). *Comprehensive Handbook of Psychological Assessment*, Vol. 1, *Intellectual and Neuropsychological Assessment*. Hoboken, NJ: Wiley.

Gottfredson, L. S. (2009). Logical fallacies used to dismiss the evidence on intelligence testing. In R. P. Phelps (Ed.), *Correcting Fallacies about Educational and Psychological Testing* (pp. 11–65). Washington, DC: American Psychological Association.

Gottfredson, L., & Saklofske, D. H. (2009). Intelligence: Foundations and issues in assessment. *Canadian Psychology, 50*, 183–195.

Groth-Marnat, G. (2009). *Handbook of psychological assessment* (5th ed.). Hoboken, NJ: Wiley.

Haier, R. J., Colom, R., Schroeder, D. H., Condon, C. A., Tang, C., Eaves, E., & Head, K. (2009). Gray matter and intelligence factors: is there a neuro-g? *Intelligence, 37*, 136–144.

Haier, R. J., & Jung, R. E. (2008). Brain imaging studies of intelligence and creativity: What is the picture for education? *Roeper Review, 30*, 171–180.

Horn, J. L., & Noll, J. (1997). Human cognitive capabilities: Gf–Gc theory. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (pp. 53–91). New York, NY: Guilford Press.

Kamphaus, R. W. (1993). *Clinical Assessment of Children's Intelligence: A Handbook for Professional Practice*. Needham Heights, MA: Allyn and Bacon.

Karama, S., Ad-Dab'bagh, Y., Haier, R. J., Deary, I. J., Lyttelton, O. C., Lepage, C., Evans, A. C., & The Brain Development Cooperative Group. (2009). Positive association between cognitive ability and cortical thickness in a representative US sample of healthy 6- to 18-year-olds. *Intelligence, 37*, 145–155.

Kaufman, A. S. (1975). Factor analysis of the WISC-R at 11 age levels between 6½ to 16½ years. *Journal of Consulting and Clinical Psychology, 43*(2), 135–147.

Kaufman, A. S. (1979). WISC-R research: Implications for interpretation. *School Psychology Review, 8*(1), 5–27.

Kaufman, A. S., & Lichtenberger, E. O. (1999). *Essentials of WAIS-III Assessment*. New York, NY: Wiley.

Kaufman, A. S., & Lichtenberger, E. O. (2006). *Assessing Adolescent and Adult Intelligence* (3rd ed.). Hoboken, NJ: Wiley.

Kennedy, J. E., Clement, P. F., & Curtiss, G. (2003). WAIS-III Processing Speed Index scores after TBI: The influence of working memory, psychomotor speed and perceptual processing. *Clinical Neuropsychologist, 17*(3), 303–307.

Kyllonen, P. C., & Christal, R. E. (1990). Reasoning ability is (little more than) working memory capacity? *Intelligence, 14*(4), 389–433.

Larrabee, G. (2004). A review of clinical interpretation of the WAIS-III and WMS-III: Where do we go from here and what should we do with the WAIS-IV and WMS-IV? *Journal of Clinical and Experimental Psychology, 26*(5), 706–717.

Lee, H. F., Gorsuch, R., Saklofske, D. H., & Patterson, C. (2008). Cognitive differences for ages 16 to 89 (Canadian WAIS-III): Curvilinear with Flynn and Processing Speed Corrections. *Journal of Psychoeducational Assessment, 26*(4), 382–394.

Lezak, M. D., Howieson, D. B., Loring, D. W., Hannay, H. J., & Fischer, J. S. (2004). *Neuropsychological Assessment* (4th ed.). New York, NY: Oxford University Press.

Lichtenberger, E. O., & Kaufman, A. S. (2009). *Essentials of WAIS-IV Assessment*. New York, NY: Wiley.

Mathias, J. L., & Wheaton, P. (2007). Changes in attention and information-processing speed following severe traumatic brain injury: A meta-analytic review. *Neuropsychology, 21*(2), 212–223.

Prifitera, A., & Saklofske, D. H. (Eds.). (1998). *WISC-III Clinical Use and Interpretation: Scientist–Practitioner Perspectives*. San Diego, CA: Academic Press.

Prifitera, A., Weiss, L. G., & Saklofske, D. H. (1998). The WISC-III in context. In A. Prifitera, & D. H. Saklofske (Eds.), *WISC-III Clinical Use and Interpretation: Scientist–Practitioner Perspectives* (pp. 1–38). San Diego, CA: Academic Press.

Reynolds, C. R. (1997). Forward and backward memory span should not be combined for clinical analysis. *Archives of Clinical Neuropsychology, 12*(1), 29–40.

Salthouse, T. A. (2000). Aging and measures of processing speed. *Biological Psychology, 54*, 35–54.

Salthouse, T. A., & Pink, J. E. (2008). Why is working memory related to intelligence? *Psychonomic Bulletin and Review, 15*(2), 364–371.

Sattler, J. M., & Ryan, J. J. (2009). *Assessment with the WAIS-IV*. San Diego, CA: Author.

Schwean, V., & Saklofske, D. H. (2005). Assessment of attention deficit hyperactivity disorder with the WISC-IV. In A. Prifitera, D. Saklofske, & L. G. Weiss (Eds.), *WISC-IV Clinical Use and Interpretation: Scientist–Practitioner Perspectives* (pp. 235–280). San Diego, CA: Elsevier Academic Press.

Shaw, S.R., Swerdlik, M.E., & Laurent, J. (1993). Review of the *WISC-III Intelligence Scale for Children* (3rd ed.). *Journal of Psychoeducational Assessment*, 151–160.

Spearman, C. (1904). "General Intelligence," objectively determined and measured. *American Journal of Psychology, 15*, 201–293.

Sternberg, R. J. (2000). *Handbook of Intelligence.* New York, NY: Cambridge University Press.

Storandt, M. (1994). General principles of assessment of older adults. In M. Storandt, & G. R. VandenBos (Eds.), *Neuropsychological Assessment of Dementia and Depression in Older Adults: A Clinician's Guide* (pp. 7–32). Washington, DC: American Psychological Association.

Thorndike, R. M. (1990). Origins of intelligence and its measurement. *Journal of Psychoeducational Assessment, 8*(3), 223–230.

Tulsky, D. S., Saklofske, D. H., Chelune, G. J., Heaton, R. K., Ivnik, R. J., Bornstein, R., Prifitera, A., & Ledbetter, M. F. (Eds.). (2003). *Clinical Interpretation of the WAIS-III and WMS-III*. San Diego, CA: Academic Press.

Tulsky, D. S., Saklofske, D. H., Wilkins, C., & Weiss, L. G. (2001). Development of a General Ability Index for the Wechsler Adult Intelligence Scale (3rd ed.). *Psychological Assessment, 13*(4), 566–571.

Unsworth, N., & Engle, R. W. (2007). On the division of short-term and working memory: An examination of simple and complex span and their relation to higher order abilities. *Psychological Bulletin, 133*(6), 1038–1066.

Wechsler, D. (1939). *The Measurement of Adult Intelligence*. Baltimore, MD: Williams & Wilkins.

Wechsler, D. (1941). *The Measurement of Adult Intelligence* (2nd ed.). Baltimore, MD: Williams & Wilkins.

Wechsler, D. (1944). *The Measurement of Adult Intelligence* (3rd ed.). Baltimore, MD: Williams & Wilkins.

Wechsler, D. (1950). Cognitive, conative, and non-intellective intelligence. *American Psychologist, 5*, 78–83.

Wechsler, D. (1958). *The Measurement and Appraisal of Adult Intelligence* (4th ed.). Oxford: Williams & Wilkins.

Wechsler, D. (1963). Engrams, memory storage, and mnemonic coding. *American Psychologist, 18*(3), 149–153.

Wechsler, D. (1975). Intelligence defined and undefined: a relativistic appraisal. *American Psychologist, 30*(2), 135–139.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children* (3rd ed.). San Antonio, TX: Psychological Corporation.

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale* (3rd ed.). San Antonio, TX: Psychological Corporation.

Wechsler, D. (2002). *Wechsler Preschool and Primary Scale of Intelligence* (3rd ed.). San Antonio, TX: Psychological Corporation.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children* (4th ed.). San Antonio, TX: Psychological Corporation.

Wechsler, D. (2008a). *Wechsler Adult Intelligence Scale* (4th ed.). San Antonio, TX: Pearson.

Wechsler, D. (2008b). *WAIS-IV Technical and Interpretive Manual*. San Antonio, TX: Pearson.

Wechsler, D. (2009). *Wechsler Memory Scale* (4th ed.). San Antonio, TX: Pearson.

Weiss, L. G., Saklofske, D. H., Prifitera, A., & Holdnack, J. (2006). *WISC-IV Advanced Clinical Interpretation*. San Diego, CA: Elsevier.

Wilde, N. J., Strauss, E., & Tulsky, D. S. (2004). Memory span on the Wechsler scales. *Journal of Clinical and Experimental Neuropsychology, 26*(4), 539–549.

Wojciulik, E., Husain, M., Clarke, K., & Driver, J. (2001). Spatial working memory deficit in unilateral neglect. *Neuropsychologia, 39*(4), 390–396.