Difference score reliabilities within the RIAS-2 and WISC-V

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Abstract

Many prominent intelligence tests (e.g., WISC-V & RIAS-2) offer methods for computing subtest- and composite-level difference scores. This current study uses data provided in the technical manual of the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V) and Reynolds Intellectual Abilities Scale, Second Edition (RIAS-2) to calculate reliability coefficients for difference scores. Subtest-level difference score reliabilities range from 0.59 to 0.99 for the RIAS-2 and from 0.53 to 0.87 for the WISC-V. Composite-level difference score reliabilities range from 0.23 to 0.95 for the RIAS-2 and from 0.36 to 0.87 for the WISC-V, with the exception of the FSIQ > GAI comparison, which resulted in a reliability of 0.00. Emphasis is placed on comparisons recommended by test publishers and a discussion of minimum requirements for interpretation of differences scores is provided.

Keywords: intelligence test; difference score; reliability; evidence based assessment

Difference score reliabilities within the RIAS-2 and WISC-V

Despite the enduring use of cognitive measures, researchers continue to debate how they should be interpreted (Fiorello, Flanagan, & Hale, 2014; Fiorello et al., 2007; McGill, Dombrowski, & Canivez, 2018; Watkins, 2000). While several researchers have argued that interpretation should be isolated to the general intelligence composite (Canivez, 2013; Dombrowski, 2015; J. H. Kranzler & Floyd, 2013), alternative interpretive frameworks emphasize more specific cognitive abilities (e.g., Comprehension Knowledge) and how they compare to other specific cognitive abilities (e.g., Fiorello et al., 2014; Flanagan & Alfonso, 2017; Flanagan, Ortiz, & Alfonso, 2013; Kaufman, Raiford, & Coalson, 2015). The latter perspective has long been a significant component of the *Intelligent Testing* (Kaufman, 1979) approach to interpretation (cf. Sattler, 2018), which has intuitive and social appeal (Bray, Kehle, & Hintze, 1998) and continues to have both implicit or explicit endorsement by test authors (e.g., Reynolds & Kamphaus, 2015a; Wechsler, 2014a). Regarding the latter point, several test manuals (e.g., Reynolds & Kamphaus, 2015b, pp. 51-52; Wechsler, 2014b, pp. 62-76) provide interpretive instructions that mirror the contemporary intelligent testing framework (Kaufman et al., 2015). Moreover, test authors provide dedicated worksheets as part of their record forms for the calculation of differences between specific cognitive ability composites and between subtests. Likely due to a constellation of these factors, as much as 65% and 33% of instructors teach students to interpret comparisons between composite scores and between subtests, respectively (Lockwood & Farmer, 2019). It is then no surprise that practitioners report interpreting score comparisons in practice (Benson et al., 2019; Kranzler et al., 2020; Sotelo-Dynega & Dixon, 2014).

Conceptually, difference scores serve to quantify whether there are notable strengths and weaknesses between a student's specific cognitive abilities (Canivez, 2013); these differences are said to be characteristic of an underlying learning or processing disorder (Flanagan et al., 2013; McGill et al., 2018; Watkins, 2003). Contemporary approaches have minimized emphasis of comparisons between subtests and have instead focused on comparisons between composites representing Cattell-Horn-Carroll broad abilities (McGill et al., 2018). These types of comparisons are regarded as intra-cognitive (Flanagan & Ortiz, 2001) as they are neither true normative comparisons (i.e., scores are not interpreted based solely on a comparison with a standardized sample) nor are they true ipsative comparisons (i.e., difference scores are not calculated using an anchor score, such as an average composite score). The distinction between intra-cognitive and ipsative comparison as well as the focus on composite scores rather than subtests marks a subtle distinction between modern interpretive approaches and those cognitive profile analysis of the 1980s and 1990s (Bray et al., 1998; Macmann & Barnett, 1997; McDermott, Fantuzzo, & Glutting, 1990; McDermott, Fantuzzo, Glutting, Watkins, & Baggaley, 1992; Watkins, 2000, 2003). That said, intra-cognitive comparisons, now as a significant underlying component of various patterns of strengths and weaknesses (PSW) approaches (e.g., Fiorello et al., 2014; Flanagan et al., 2013; Naglieri & Feifer, 2018), have been challenged due to their inadequate psychometric properties and poor predictive validity (Canivez, 2013; McGill et al., 2018; McGrew & Knopik, 1996). On the other hand, proponents have argued for the use of such scores in the context of other clinical data (i.e., interviews, rating scales, and other standardized scores; e.g., Sattler, 2018). This recommendation is not unique to difference scores and evokes the "alchemist's fantasy" (Lilienfeld, Wood, & Garb, 2006; see Kranzler et al., 2020 for review) in the absence of clear incremental validity for difference scores.

Often, the first step in establishing that a score is useful is to evaluate whether it is reliable at a single time point; this basic expectation is included in ethical and professional guidelines (American Educational Research Association [AERA], APA, & National Council on Measurement in Education [NCME], 2014; American Psychological Association [APA], 2010; Hunsley & Mash, 2018; National Association of School Psychologists [NASP], 2010). However, to adequately explore what is “good enough” (Hunsley & Mash, 2018) reliability, both reliability and its implications for practice must be discussed. Reliability is conceptually defined as “...the degree to which scores are free from errors of measurement” (Price, 2016, p. 203) and is defined as the ratio of true score variance to observed score variance (Nunnally & Bernstein, 1994, p. 212). We will explore this issue primarily in relation to internal consistency reliability (ICR; Cronbach, 1947; R. M. Thorndike & Thorndike-Christ, 2010). In school psychology, the most salient uses of reliability are the confidence intervals generated to help describe scores from various instruments. As such, observing the impact of adequate and inadequate reliability on obtained test scores can be done by reviewing the widths of the confidence intervals for those scores. Confidence interval widths (CI widths) are the range between the confidence limits. For confidence intervals that are already generated, users of these instruments can take the difference between the upper-bound confidence limit and the lower-bound confidence limit. For example, a standard score of 100 ($m = 100$, $sd = 15$) with reliability of 0.90, the 95% confidence interval ranges between 91 and 109; $109 - 91$ results in a CI width of 18 points. The standard deviation and reliability of the score, as well as the desired confidence level (e.g., 95%, 90%, 68%) all play an integral role in the calculation of confidence intervals. The importance of reliability on obtained scores can be seen through its impact on CI widths at various levels of (Schneider, 2014). Figure 1 represents such a comparison, with reliability coefficients ranging between 0.70

and 1.00 on the x-axis, CI width along the y-axis, and then separate lines representing common confidence levels, from 68% through 99%. Points along each path indicate the calculated CI width at 0.70, 0.80, and 0.90 reliability; the standard deviation is held constant at 15 for all calculations.

Figure 1. Confidence interval widths as a function of reliability coefficient and confidence level when standard deviation is held constant at 15.

Given these data, the relationship between a particular confidence level (e.g., 95%) curve to gauge the degree of uncertainty associated with each level of reliability. This is especially informative when considering high-stakes clinical decisions such as classification and diagnosis.

Experts have argued that to use an instrument for clinical purposes, its ICR, typically calculated using Cronbach's Alpha (α ; Cronbach, 1951), should be equal to or higher than 0.90 (e.g., Aiken & Groth-Marnat, 2005; Nunnally & Bernstein, 1994). The justification for such a high standard can be understood when considering that lower reliability levels can lead to large confidence intervals. Clinical decisions often rest, in part, on the distinction between an observed score and a cut-score, and small differences in the observed score can greatly influence the decisions to be made. In clinical practice, it is difficult to accept any degree of uncertainty, and so the argument is that a reliability estimate of 0.90—and ideally, of 0.95—should be the minimum acceptable standard (Aiken & Groth-Marnat, 2005; Nunnally & Bernstein, 1994). Even when requiring a reliability estimate of 0.90 or 0.95, the 95% CI widths are ~19 points and ~13 points, respectively. Thus, even with a small change in level of reliability (i.e., from 0.95 to 0.90, the risk of false positives and negatives do increase noticeably.

Depending upon the purpose of the assessment, a practitioner may be more or less comfortable with uncertainty—and thus more or less willing to rely on a wider or narrower CI width. Hunsley and Mash (2018) developed a tripartite model recognizing that a single guideline (e.g., instruments used for clinical decision making should have an internal consistency reliability of 0.90; Nunnally & Bernstein, 1994) fails to recognize the variety of reasons for which a clinician may be using a test score; see table 1. For instance, it would be inaccurate to suggest that the same level of certainty is necessary when (a) making a diagnosis of specific learning disability (SLD) and when (b) assessing digits correct per minute during treatment. SLD relies on test scores (e.g., achievement test scores) that are obtained at a fixed point in time while digits correct per minute relies on measurement repeated over time. Moreover, the stakes of making an error across these uses are different; making a change to educational placement or

diagnosis can be complex where as the modification of treatment is a simpler procedure. As a result, it may be reasonable to make a decision about treatment response when the CI width is large, but it would be challenging to justify making a diagnosis given such uncertain data.

What Makes a Difference Score Reliable?

As with any score from a psychological instrument, difference scores are clinically useful when they provide meaningful, reliable information that aids in the decision-making process (AERA, APA, & NCME, 2014; Hunsley & Mash, 2018). Before interpreting a difference score, practitioners should first consider the reliability of the information provided by the score as well as its usefulness in guiding a decision. Any intelligence test score used in the diagnostic or educational classification decision-making process should have the smallest CI width possible. As such, the 0.90 criteria first established by Nunnally and Bernstein (1994) and more recently described as “excellent” by Hunsley and Mash (2018) will be used in the current study. However, given that test publishers do not provide the standard deviation and reliability of all scores—especially difference scores—from their instruments, estimating an appropriate CI width for difference scores is challenging

As difference scores are typically established through a simple-difference procedure (i.e., subtracting one score from another), the errors of both scores (i.e., the contrast scores) will have a cumulative effect (Glass, Ryan, & Charter, 2010; McGill et al., 2018). Two essential components of a good difference score are (1) high contrast score reliability and (2) low-to-moderate intercorrelation between the contrasted scores. To illustrate, two contrast scores with reliability 0.94 and 0.95 will result in a difference score reliability of 0.91 when their correlation is 0.30. However, the difference score reliability will be 0.35 when their correlation is 0.90, far below the 0.90 threshold for clinical decision making. Conversely, when contrast score

reliabilities are low (e.g., 0.20) to moderate (e.g., 0.40), the difference score reliability approaches 0.00. Conceptually, variability within all intelligence test scores stem from (a) general intelligence, (b) specific cognitive abilities, and (c) error (Carroll, 1993); when the simple-difference between comparison scores are calculated, the sources or portions of variance that are removed cannot be controlled for, ultimately resulting in a score that has greater error than either of its parts. Thus, if practitioners continue to use difference scores, they should have access and be aware of the reliabilities of these scores, and likely interpret them in light of their CI (Charter & Feldt, 2009).

Interpreting CI Width of Difference Scores

Charter (1999) and Charter and Feldt (2009) argued for the interpretation of difference scores based on their confidence intervals, and suggest there are four distinct possibilities and recommended outcomes. These types are depicted in figure 2 with a hypothetical CI width of 12 and difference scores selected for clarity.

Figure 2. Four possible outcomes when interpreting confidence intervals of difference scores.

Type 1 = the CI includes zero; Type 2 = The CI does not include zero, but the CI is entirely below the critical value; Type 3 = The CI is entirely above zero and includes the critical value; Type 4 = The CI is entirely above the critical value.

In type 1, we would conclude that the difference between the comparison scores is not different from zero, while we might conclude that the differences in types 2, 3, and 4 are all above zero; we would not interpret this as a true difference. In type 2, we would conclude that while the difference is greater than zero, it is entirely below the critical value; we would not interpret this as a meaningful difference. In type 3, we could conclude that either (a) there is no meaningful difference because a portion of the CI falls below the critical value or that (b) there is a meaningful difference and cautiously interpret that difference. In the final condition, type 4, we

would conclude that the difference is entirely above the critical value and interpretation is warranted.

Difference Score Reliability to Date

The issue of poor difference score reliability in making clinical decisions is not a new problem facing the field (e.g., Brown & Ryan, 2004; Charter, 2001, 2002; Charter & Feldt, 2009; Glass et al., 2010; Glass, Ryan, Charter, & Bartels, 2009; Ryan & Brown, 2005). Difference score reliability coefficients were calculated for subtest and composite comparisons available from the Wechsler Adult Intelligence Scales, Third Edition (WAIS-III; Wechsler, 1997a) across two studies (Brown & Ryan, 2004; Charter, 2001). Charter (2001) used data available from the technical manual and found that only a small fraction (i.e., 12%) of potential subtest comparisons had difference score reliability coefficients ≥ 0.80 , with coefficients ranging between 0.44 and 0.85. The majority (i.e., 84%) of composite level comparisons (e.g., Verbal IQ > Performance IQ across all ages) had difference score reliability coefficients ≥ 0.80 , with coefficients ranging between 0.77 and 0.88; however, none met the .90 criteria.

Brown and Ryan (2004) accessed a clinical sample of men from a substance abuse disorders program and computed split-half reliability coefficients for difference scores stemming from subtests and composites for the total sample. Brown and Ryan found similarly small fraction (i.e., 13%) of potential subtest comparisons had difference score reliability coefficients ≥ 0.80 , with coefficients ranging between 0.34 and 0.85. Two of the four composite score comparisons had difference score reliability coefficients ≥ 0.80 , with coefficients ranging between 0.79 and 0.87. These data were largely consistent with the data from the technical manual (Charter, 2001).

Similarly, Charter (2002) calculated difference score reliabilities for the Wechsler Memory Scale, Third Edition (Wechsler, 1997b), using data available from the technical manual, and found another small fraction (i.e., 18%) of composite score comparisons had difference score reliability coefficients ≥ 0.80 , with coefficients ranging between 0.00 and 0.87. Ryan and Brown (2005) completed a similar analysis for the Wechsler Abbreviated Scales of Intelligence (Wechsler, 1999) using data from the technical manual. Ryan and Brown found that nine of the 12 (75%) potential subtest comparisons and 21 of the 22 (95%) of potential composite comparisons had difference score reliability coefficients ≥ 0.80 . The subtest-level difference score reliability coefficients ranged from 0.59 to 0.85, and the composite-level difference score reliability coefficients ranged from 0.78 to 0.91. Despite this noticeable improvement in reliability coefficients, only two potential composite comparisons met the 0.90 criteria for clinical decision-making.

More recently, Glass and colleagues (Glass et al., 2010; Glass et al., 2009) computed difference score reliability coefficients using the technical manuals for the Wechsler Intelligence Scale for Children, Fourth Edition (Wechsler, 2003) and the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV; Wechsler, 2008). Glass et al. (2010) found that 36% (i.e., 24 of the 66) of the potential WAIS-IV subtest comparisons and all 39 of the potential composite comparisons had difference score reliability coefficients ≥ 0.80 . Moreover, the VCI > PRI comparison score reliability coefficient met the 0.90 criteria at four different age ranges, but failed to do so across all ages. On the WISC-IV, however, only 8% (i.e., five of the 66) of the potential subtest comparisons had difference score reliability coefficients ≥ 0.80 , with scores ranging between 0.50 and 0.82. Glass et al. (2009) found that 91% (i.e., 33 of the 36) potential WISC-IV composite comparisons had difference score reliability coefficients ≥ 0.80 ; however,

no composite or subtest comparison resulted in a reliability coefficient that met the 0.90 criteria for clinical decision-making.

The research to date has shown that a majority of difference scores stemming from composites had reliability coefficients ≥ 0.80 , but very few met the 0.90 criteria. Those that did meet the 0.90 criteria failed to meet it consistently across all age ranges. Difference scores stemming from subtest comparisons frequently had reliability coefficients below the 0.80 criteria, and never met the 0.90 criteria for any age range. However, difference score reliability analyses have not been conducted for the recent editions of popular intelligence tests (e.g., Wechsler, 2014a), and the research has extensively assessed instruments from the Wechsler series. The purpose of this manuscript is to extend previous research by computing difference score reliabilities for available scores on the WISC-V (Wechsler, 2014a) and to extend this analysis to another popular test, the Reynolds Intellectual Assessment Scale, Second Edition (RIAS-2; Reynolds & Kamphaus, 2015a). Additionally, emphasis will be placed on those difference scores that are specifically indicated for interpretation by test manuals and protocols.

Methods

All analyses are based on archival data obtained from the supporting materials of the RIAS-2 (Reynolds & Kamphaus, 2015a) and the WISC-V (Wechsler, 2014c; Wechsler, Raiford, & Holdnack, 2014a, 2014b). The formula for difference score reliability (see R. L. Thorndike & Hagen, 1969) requires a reliability estimate of each of the scores to be compared as well as the correlation between those two scores. All test score reliabilities and intercorrelations were double-coded by the author and a research assistant. The agreement found for all coded variables was 99%, and disagreements were corrected by retrieving data from the respective test manual until 100% agreement was established. Reliabilities were computed across all available age-

ranges. Internal review board approval to code and analyze the archival data was obtained from the first author's university. No data were excluded and all analyses and measures are reported.

Measures

The RIAS-2 (Reynolds & Kamphaus, 2015a) is an intelligence test consisting of eight subtests. The standardization sample included 2,154 individuals across ages 3 to 94; the sample was stratified based upon the 2012 United States Census. For the RIAS-2 (Reynolds & Kamphaus, 2015a), the internal consistency reliabilities are Cronbach's (1951) coefficient alpha calculated based on the standardization sample, and were retrieved from the RIAS-2 (Reynolds & Kamphaus, 2015a) manual tables 5.1 and 5.2; intercorrelations were retrieved from tables N.1 through N.5. The following RIAS-2 subtests were included in the analysis: Guess What (GWH), Verbal Reasoning (VRZ), Odd-Item Out (OIO), Verbal Memory (VRM), Nonverbal Memory (VRM), Speeded Naming Task (SNT), and Speeded Picture Search (SPS); subtest reliability coefficients ranged between 0.80 and 0.99 across all age ranges. The following RIAS-2 composites were included: Verbal Intelligence Index (VIX), Nonverbal Intelligence Index (NIX), Composite Memory Index (CMX), Speeded Processing Index (SPI), and Composite Intelligence Index (CIX). Composite reliability coefficients ranged between 0.86 and 0.97. The RIAS-2 (Reynolds & Kamphaus, 2015a) reports subtest and composite reliability according to nine distinct age-ranges (see Supplemental Table 1) and reports subtest and composite intercorrelations according to four age-ranges (i.e., 3 to 5, 6 to 17, 18 to 30, and 31 to 94). As a result, some age-ranges have differing boundaries (i.e., at age-ranges 3 to 6, 15 to 18, and 25 to 34). When overlap occurred between age-ranges, reliabilities were calculated using both available intercorrelations and reported as a range. Difference score reliability coefficients were calculated for the total standardization sample and at each age-range.

The WISC-V (Wechsler, 2014a) is an intelligence test consisting of 16 subtests. The standardization sample included 2,200 children between the ages of 6 and 16 years; the sample was stratified based upon the 2012 United States Census. For the WISC-V (Wechsler, 2014a), the internal consistency reliabilities are split-half coefficients calculated based on the standardization sample, and were retrieved from the WISC-V Technical and Interpretive Manual (Wechsler et al., 2014a), table 4.1; intercorrelations were retrieved from the WISC-V Technical and Interpretive Manual Supplement (Wechsler et al., 2014b), tables G.1 through G.21. Primary subtests—that is, the core 16 subtests necessary for calculating the Full Scale IQ (FSIQ), primary second-order composites (e.g. Verbal Comprehension Index), and pseudo-composites—were included in the analysis. Process scores—those scores, such as Block Design No Time Bonus, that can be calculated from portions of subtests—and non-primary subtests, such as Naming Speed Literacy, Naming Speed Quantity, Immediate Symbol Translation, Delayed Symbol Translation, and Recognition Symbol Translation were not included in the analysis. Similarly, the second-order and pseudo-composites were included while Naming Speed, Symbol Translation, and Storage and Retrieval composites were excluded. The following WISC-V subtests were included in the analysis: Similarities (SI), Vocabulary (VO), Information (IN), Comprehension (CO), Block Design (BD), Visual Puzzles (VP), Matrix Reasoning (MR), Figure weights (FW), Picture Completion (PC), Arithmetic (AR), Digit Span (DS), Picture Span (PS), Letter Number Sequences (LN), Coding (CD), Symbol Search (SS), and Cancellation (CA); subtest reliability coefficients ranged between .67 to .96. The following WISC-V composites were included in the analysis: Verbal Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), Processing Speed Index (PSI), Quantitative Reasoning Index (QRI), Auditory Working Memory Index (AWMI), Nonverbal

Index (NVI), Cognitive Proficiency Index (CPI), General Ability Index (GAI), and Full Scale IQ (FSIQ). Difference score reliability coefficients were calculated for the total standardization sample and at each age-range; aggregate data presented are from the total standardization sample.

Both the RIAS-2 (Reynolds & Kamphaus, 2015a) and WISC-V (Wechsler, 2014a) feature *recommended comparisons* by providing tables on their respective protocols for the calculation of specific difference scores. Because these tables are likely to be used by practitioners related to their immediate availability on the protocol, difference score reliability coefficients for these comparisons are highlighted at the subtest and composite level.

Analysis

The formula from R. L. Thorndike and Hagen (1969), used in the literature to date, provides a difference score reliability estimate for when the two contrast scores have equal standard deviations:

$$r = \frac{\left[\frac{(r_a + r_b)}{2} - r_{ab} \right]}{(1 - r_{ab})}$$

Where r is the reliability; r_a and r_b are measures of score reliability for the two contrast scores; and r_{ab} is the correlation between contrast scores a and b . Of note, the formula from R. L. Thorndike and Hagen (1969) may result in an anomalous negative reliability coefficient when the average reliability of the contrast scores (e.g. $r_a = .95$ and $r_b = .96$; mean = .96) is less than the intercorrelation between the contrast scores (e.g., $r_{ab} = .97$). Using the difference score reliability formula, the numerator produces a negative value (e.g., -.015) while the denominator remains positive (e.g., .03). Given that reliability is a theoretical construct ranging between 0.00

and 1.00, all such computed reliability coefficients were recorded as 0.00. In addition to calculating the reliability of each difference score, the CI width of each type of difference score was calculated using the formula from Schneider (2014):

$$CI\ Width = 2z_{CI\%}\sigma_x\sqrt{r_{xx} - r_{xx}^2}$$

where $z_{CI\%}$ is the z-score associated with the desired confidence level (e.g., the $z_{CI\%}$ for 95% CI is 1.96), σ_x is the standard deviation of the observed score, and r_{xx} is the reliability of the difference score. In order to better understand the practical impact of the reliabilities obtained, we calculated the 95% CI widths of the average RIAS-2 and WISC-V (a) subtest difference score, (b) recommended subtest difference score, (c) composite difference score, and (d) recommended composite difference score. However, because neither the RIAS-2 (Reynolds & Kamphaus, 2015a) nor the WISC-V (Wechsler, 2014a) test authors provide psychometric properties for these score types and we do not have standardization data to perform these calculations, we are uncertain of the standard deviations that should be used in the formula. To compensate with this, we provide 95% CI widths at standard deviations of 3, 10, and 15 to reflect the standard deviations from which these scores are derived.

Results

Subtest-Level Comparisons

Subtest difference score reliability coefficients for the RIAS-2 (Reynolds & Kamphaus, 2015a) subtest difference scores are displayed in Table 2. The RIAS-2 subtest difference score reliability coefficients ranged between 0.59 and 0.99 (median = 0.85; mean = 0.81; SD = 0.10), with the GWH > VRZ comparison at the low-end and SNT > SPS comparison at the high-end of the range. Of the 28 potential comparisons, 15 had reliability coefficients between 0.80 and 0.90,

and three had reliability coefficients of 0.90 or higher. Only three comparisons, VRM > SNT, VRM > SPS, and SNT > SPS, met the 0.90 criteria for all age-ranges while 10 comparisons met the 0.80 criteria for all age-ranges. Fifteen comparisons did not meet the 0.80 criteria.

Subtest difference score reliability coefficients for the WISC-V (Wechsler, 2014a) subtest difference scores are displayed in Table 3. The WISC-V subtest difference score reliability coefficients ranged between 0.53 and .87 (median = 0.77; mean = 0.77; SD = .06), with the VC > IN comparison at the low-end and FW > CA at the high-end of the range. Of the 120 potential comparisons, 32 had reliability coefficients between 0.80 and 0.90, and none had reliability coefficients of 0.90 or higher. Only five met the 0.80 criteria for all-age ranges, while the remaining 115 comparisons did not meet the 0.80 criteria for all age-ranges.

Recommended Comparisons. The RIAS-2 (Reynolds & Kamphaus, 2015a) protocol provides space for calculating four subtest comparisons: (1) GWH > VRZ, (2) OIO > WHM, (3) VRM > NVM, and (4) SNT > SPS. Reliability coefficients for these data ranged between 0.59 and 0.99 (median = 0.76; mean = 0.78; SD = 0.18) and are displayed in boldface in Table 2. Of these four recommended comparisons, only VRM > NVM and SNT > SPS met the 0.80 criteria for the total sample, and only SNT > SPS met the 0.90 reliability criteria at each age-range.

The WISC-V (Wechsler, 2014a) protocol provides space for calculating eight subtest-to-subtest comparisons: (1) SI > VC, (2) BD > VP, (3) MR > FW, (4) DS > PS, (5) CD > SS, (6) FW > AR, (7) DS > LN, and (8) CA > SS. Reliability coefficients for these data ranged between 0.56 and 0.84 (median = 0.70; mean = 0.70; SD = 0.10) are displayed in boldface in Table 3. Of these eight recommended comparisons, only MR > FW and FW > AR met the 0.80 criteria for the total sample; no recommended comparisons met the 0.90 or 0.80 criteria at each age-range.

Composite-Level Comparisons

Composite score reliabilities for the RIAS-2 (Reynolds & Kamphaus, 2015a) are displayed in Table 4. The RIAS-2 composite difference score reliability coefficients ranged between 0.23 and 0.95 (median = 0.80; mean = 0.75, SD = 0.26), with the NIX > CIX comparison at the low-end and the CIX > SPI comparison at the high-end of the range. Of the 10 potential comparisons, one had a reliability coefficient between 0.80 and 0.90, and four had reliability coefficients of 0.90 or higher.

Composite score reliabilities for the WISC-V (Wechsler, 2014a) are displayed in Table 5. The WISC-V composite difference score reliability coefficients ranged between 0.00 and 0.87 (median = 0.81, mean = 0.75, SD = 0.16), with the FSIQ > GAI comparison at the low-end and the PSI > QRI comparison at the high-end of the range. Of the 55 potential comparisons, 31 had reliability coefficients between 0.80 and 0.90, and none had a reliability coefficient of 0.90 or higher. Seventeen met the 0.80 criteria at all age-ranges.

Recommended Comparisons. The RIAS-2 (Reynolds & Kamphaus, 2015a) protocol provides space for calculating eight composite comparisons: (1) VIX > NIX, (2) VIX > CMX, (3) VIX > SPI, (4) NIX > CMX, (5) NIX > SPI, (6) CMX > SPI, (7) CIX > CMX, and (8) CIX > SPI. Reliability coefficients for these data ranged between 0.79 and 0.95 (median = 0.86; mean = 0.86; SD = 0.08) and are displayed in boldface in Table 4. Of the eight recommended comparisons, one met only the 0.80 criteria while four had a reliability coefficient of 0.90 or higher. All four that met the 0.90 criteria did so at all age-ranges. Of interest, only those comparisons that included the SPI met the 0.90 criteria.

The WISC-V (Wechsler, 2014a) protocol provides space for calculating 13 composite comparisons: (1) GAI > FSIQ, (2) GAI > CPI, (3) WMI > AWMI, (4) VCI > VSI, (5) VCI > FRI, (6) VCI > WMI, (7) VCI > PSI, (8) VSI > FRI, (9) VSI > WMI, (10) VSI > PSI, (11) FRI > WMI, (12) FRI > PSI, (13) WMI > PSI. Reliability coefficients for these data ranged between 0.00 and 0.86 including the FSIQ and GAI comparison, and 0.80 and 0.86 (median = 0.84; mean = 0.83; SD = 0.012); these data are displayed in boldface in Table 5. Of these 13 comparisons, 11 meet the 0.80 criteria while none meet the 0.90 criteria. Of those 11, only six (54%) meet the 0.80 criteria at all age-ranges.

95% CI Widths

The 95% CI widths for the average difference score by type are provided in table 6. When the standard deviation of the difference scores was held at 3, CI widths ranged between 4.08 to 5.39 (median = 4.91; *SD* = 0.42). The average CI widths for WISC-V subtests, which are scaled scores, were 4.95 overall and 5.39 for recommended subtest comparisons. When the standard deviation of the scores was held at 10, CI widths ranged between 13.60 and 17.96 (median = 16.37; *SD* = 2.11). The average CI widths for RIAS-2 subtests, which are T scores, were 15.38 overall and 16.24 for recommended subtest comparisons. Finally, when the standard deviation of the difference scores was held at 15, CI widths ranged between 20.40 and 26.95 (median = 24.55, *SD* = 2.11). The average CI widths for the RIAS-2 composites were 25.46 overall and 20.40 for recommended composite comparisons. Moreover, the average CI widths for the WISC-V composites were 25.46 overall and 22.09 for recommended composite comparisons.

Discussion

Guidelines regarding the clinical interpretation of psychological instruments have emphasized the need for measures to first be reliable, then valid and useful (APA, 2010; Beidas et al., 2015; Hunsley & Mash, 2018; NASP, 2010). While there is no standard for minimum reliability, we contend that when making high-stakes decisions (e.g., educational placement), only data with excellent reliability (i.e., $r \geq 0.90$) are appropriate. The reason for this is that systematic and random error do not carry useful information, and thus measurement errors should be minimized as much as possible (cf. signal detection theory; see McFall & Treat, 1999) when those data contribute to decisions that have long-term impact on the lives of children. Difference scores available from prominent intelligence tests are often used during the decision-making process often function as a sign of disorder or guide the interpretation of test scores used in educational classification and diagnosis. Despite authors' providing guidance on how difference scores might be interpreted and their use on test protocols (e.g., Reynolds & Kamphaus, 2015a; Wechsler et al., 2014a), test authors typically do not publish psychometric data, such as reliability estimates, of difference scores. That said, results of previous research have largely found that difference scores have lower reliability than desired for high-stakes decision making (Brown & Ryan, 2004; Charter, 2001; Charter, 2002; Glass et al., 2010; Glass, Charter, Ryan, & Bartels, 2009; Ryan & Brown, 2005).

At the subtest level, data from this analysis of the WISC-V and RIAS-2 were largely consistent with recommendations that subtest-level analysis be avoided in practice. Only one of the recommended comparisons—SNT > SPS from the RIAS-2—from either test met guidelines for clinical interpretation across all age ranges. At the composite level, only four of the recommended comparisons—all from the RIAS-2—available from either test met guidelines for clinical interpretation across all age ranges. Despite these few exceptions, the findings from this

analysis are generally consistent with the prior literature on the reliability of discrepancy scores. As such, practitioners would need to be cautious when using intra-cognitive difference scores. When reviewing the CI widths of difference scores, as noted in all cases, the CI width was larger than the standard deviation used in the formula.

Given the average CI width and the rules offered by Charter (1999) and Charter and Feldt (2009), the findings from this analysis support the view that high-stakes clinical decisions, including diagnostic or educational classification determinations, should not typically be informed by difference scores (Canivez, 2013; McGill, Styck, Palomares, & Hass, 2016). Moreover, subtest and composite discrepancies are not always adequately reliable, and further support research that indicates that convergence between component parts is an unnecessary criterion for interpreting composite scores (Canivez, 2013; McGill, 2016; Schneider & Roman, 2018). At best, clinicians would need to engage in cautious use of composite-level difference scores and forgo the interpretation of subtest-level difference scores for clinical decision-making. Finally, the contention that difference scores may be useful in the context of other data (e.g., Sattler, 2018) has not been empirically substantiated, and the reliability of such scores may render them nondiagnostic. Thus, using difference scores may result in a dilution effect in which diagnostic data are given less weight (Nisbett, Zukier, & Lemley, 1981).

Limitations & Future Research

This analysis of the WISC-V (Wechsler, 2014a) and RIAS-2 (Reynolds & Kamphaus, 2015a) uses established procedures to evaluate reliability coefficients of difference scores. However, the study is not without limitations. This study does not seek to investigate the reliability of profiles of score differences as often used in more nuanced cognitive profile analysis, though the stability of profiles has been investigated by others (e.g., Livingston,

Jennings, Reynolds, & Gray, 2003). Additionally, while this study may speak to the whether individual difference scores are tenable, the reliability of composites generated through the aggregation of multiple instruments was not investigated (e.g., Flanagan, Ortiz, & Alfonso, 2015). As difference scores are generated between composites stemming from score from multiple instruments (Benson et al., 2019; Flanagan et al., 2013; John H Kranzler, Benson, & Floyd, 2016). Finally, it is highly unlikely that the actual reliability of the FSIQ-to-GAI difference score was 0.00, and theoretically untenable that they were < 0.00 ; these estimates should be considered lower-bound reliability coefficients. This is generally true for all computations in this analysis.

Conclusion

As school psychologists, bringing data to the multidisciplinary team and advocating for their needs is an essential part of the profession. When that data is unreliable, there is a higher risk for data to suggest a false positive or false negative, potentially misinforming IEP teams during the decision making process. Due to inconsistencies across age ranges and across tests, the necessity to individually calculate the confidence interval of each difference score (Charter, 1999; Charter & Feldt, 2009), and the poor diagnostic and treatment utility offered by profile analysis methods in general (Canivez, 2013; John H Kranzler, Floyd, Benson, Zaboski, & Thibodaux, 2016; McGill, 2018; McGill et al., 2018; McGill et al., 2016; Miciak, Fletcher, Stuebing, Vaughn, & Tolar, 2014; Watkins, 2003), clinicians will likely make more reliable clinical decisions if they avoid the use of difference scores. That said, difference scores, when used, should be interpreted with caution and only under the circumstances prescribed by Charter and colleagues (1999; 2009). Finally, given the questionable reliability of these methods, school

psychology faculty should reevaluate whether teaching graduate students these interpretive strategies is consistent with evidence-based assessment practices.

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Table 1.

Hunsley and Mash's Tripartite Model for ICR Reliability

Rating	Reliability Criteria	95% CI Width with SD = 15
Adequate	0.70 to 0.79	32.21 to 26.95
Good	0.80 to 0.89	26.30 to 19.50
Excellent	≥ 0.90	≤ 18.59

Criteria adapted from J. Hunsley & E. J. Mash (2019). CI Width = confidence interval

width; SD = standard deviation.

Table 2.

RIAS-2 Subtest Discrepancy Score Reliabilities

Subtest	1	2	3	4	5	6	7
1. Guess What							
2. Verbal Reasoning	0.59						
3. Odd-Item Out	0.69	0.69					
4. What's Missing	0.70	0.74	0.68				
5. Verbal Memory	0.85	0.81	0.83	0.87			
6. Nonverbal Memory	0.74	0.76	0.65	0.67	0.84		
7. Speeded Naming Task	0.89	0.89	0.87	0.88	0.96	0.86	
8. Speeded Picture Search	0.89	0.87	0.84	0.88	0.96	0.87	0.99

Note. Comparisons that can be calculated directly via the test record are shown in boldface.

Table 3.

WISC-V Subtest Discrepancy Score Reliabilities

Subtest	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Similarities															
2. Vocabulary	0.59														
3. Information	0.61	0.53													
4. Comprehension	0.63	0.63	0.65												
5. Block Design	0.73	0.73	0.72	0.73											
6. Visual Puzzles	0.77	0.76	0.76	0.77	0.66										
7. Matrix Reasoning	0.76	0.76	0.75	0.75	0.73	0.77									
8. Figure Weights	0.82	0.81	0.81	0.81	0.79	0.83	0.82								
9. Picture Completion	0.75	0.74	0.74	0.74	0.75	0.77	0.77	0.83							
10. Arithmetic	0.75	0.76	0.73	0.75	0.76	0.81	0.79	0.84	0.79						
11. Digit Span	0.79	0.80	0.79	0.78	0.78	0.83	0.80	0.87	0.80	0.79					
12. Picture Span	0.77	0.77	0.77	0.75	0.76	0.80	0.77	0.84	0.77	0.78	0.76				
13. Letter-Number Seq.	0.74	0.74	0.74	0.73	0.76	0.80	0.76	0.83	0.77	0.74	0.67	0.72			
14. Coding	0.80	0.80	0.80	0.77	0.75	0.82	0.80	0.85	0.78	0.80	0.81	0.78	0.77		
15. Symbol Search	0.78	0.79	0.77	0.76	0.73	0.79	0.77	0.84	0.77	0.79	0.79	0.77	0.77	0.56	
16. Cancellation	0.83	0.83	0.82	0.80	0.79	0.83	0.82	0.87	0.80	0.84	0.85	0.82	0.82	0.74	0.72

Note. Seq = Sequencing. Comparisons that can be calculated directly via the test record are shown in boldface.

Table 4.

RIAS-2 Composite Discrepancy Score Reliabilities

Subtest	1	2	3	4
1. Verbal Intelligence Index				
2. Nonverbal Intelligence Index	0.79			
3. Composite Memory Index	0.80	0.79		
4. Speeded Processing Index	0.94	0.93	0.92	
5. Composite Intelligence Index	0.32	0.23	0.79	0.95

Note. Comparisons that can be calculated directly via the test record are shown in boldface.

Table 5.

WISC-V Composite Discrepancy Score Reliabilities

Subtest	1	2	3	4	5	6	7	8	9	10
1. Verbal Comprehension Index										
2. Visual Spatial Index	0.80									
3. Fluid Reasoning Index	0.82	0.80								
4. Working Memory Index	0.83	0.84	0.84							
5. Processing Speed index	0.86	0.84	0.86	0.84						
6. Quantitative Reasoning Index	0.65	0.74	0.66	0.79	0.83					
7. Auditory Working Memory Index	0.82	0.83	0.67	0.84	0.87	0.85				
8. Nonverbal Index	0.83	0.85	0.84	0.53	0.85	0.77	0.83			
9. Cognitive Proficiency Index	0.81	0.57	0.60	0.77	0.80	0.86	0.74	0.73		
10. General Ability Index	0.54	0.71	0.58	0.85	0.87	0.76	0.85	0.59	0.86	
11. Full Scale IQ	0.85	0.84	0.86	0.58	0.44	0.76	0.79	0.36	0.77	0.00

Note. Comparisons that can be calculated directly via the test record are shown in boldface.

Table 6.

95% CI Widths for Average Discrepancy Scores by Type

Discrepancy Score Type	Average r	Standard Deviation		
		3	10	15
RIAS-2 subtests	0.81	4.61	15.38	23.07
RIAS-2 subtests, Rec.	0.78	4.87	16.24	24.36
WISC-V subtests	0.77	4.95	16.50	24.74
WISC-V subtests, Rec.	0.70	5.39	17.96	26.95
RIAS-2 composites	0.75	5.09	16.97	25.46
RIAS-2 composites, Rec.	0.86	4.08	13.60	20.40
WISC-V composites	0.75	5.09	16.97	25.46
WISC-V composites, Rec	0.83	4.42	14.72	22.09

Note. CI = confidence interval. r = computed discrepancy score reliability. Rec. = publisher recommended comparisons.