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REVIEW

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Literature Review of the Herrmann Brain Dominance Instrument® (HBDI®)

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Abstract

A substantial amount of literature relating to the Herrmann Brain Dominance Instrument® (HBDI®) was found, references for which are to be made available by Herrmann International to assist interested researchers and practitioners. This literature review contains some of the more important and current studies located. These studies are discussed in terms of (a) usability, appeal, and positive expectations; and (b) the validity of the HBDI®, according to the six aspects of construct validity proposed by Messick (1995, 1998). Validity is discussed in terms of internal and external evidence. Internal evidence of validity includes discussion of content validity, score structural validity, and substantive process validity. External evidence of validity includes discussion of generalizability, external relationships, and testing consequences. Despite the fact that studies critical of the HBDI® were included in the review, the vast majority of studies supported the four quadrant preference theory underlying the HBDI®. Ideas for further research are indicated in the review.

Literature Review of the Herrmann Brain Dominance Instrument® (HBDI®)

The purpose of this literature review is to sample and summarize significant literature relating to the validity of the Herrmann Brain Dominance Instrument (HBDI®). First, I will describe the methodology used in conducting this review. This method resulted in collecting, organizing, and making available several data collections, the composition and availability of which I will discuss. Following a description of this methodology, I will review three main aspects of validity. First, I will address user-related aspects of validity by examining summaries of literature that relates to the usability, appeal, and positive expectations users have toward the HBDI®. In the next two sections, I review internal validity evidence and external validity evidence by examining literature that relates to the validity and reliability of the HBDI®. These two sections cover each of the six aspects of construct validity proposed by Messick (1995, 1998). Throughout this review, I attempt to be impartial, accurate, and comprehensive in summarizing the findings of the literature, and I include both literature that supports the validity of the HBDI® and literature that is critical of it.

Method

Initial research was done online through the Harold B. Lee Library at Brigham Young University. This research consisted of searching through all relevant topics and all databases available within each topic. Terms searched included *brain dominance*, *hemisphericity*, *Herrmann Brain Dominance Instrument*, *Hermann Brain Dominance Instrument*, *Herrman Brain Dominance Instrument*, and *Herman Brain Dominance Instrument*. All relevant hits were recorded in a Citation database.[1] Full texts of all references were printed out when available online, obtained through Interlibrary Loan, or photocopied from hardbound volumes in the

[1] Citation is bibliographic and research note software published and distributed by Oberon Development, Columbus, Ohio.

Harold B. Lee Library. Searches were also performed on Google and Google Scholar with the same search terms. All relevant hits were similarly recorded in the database and hard copies were printed, with the exception of hundreds of websites advertising HBDI® assessment services. The more recent dissertations and journal articles were also scanned for relevant citations, which were then located online or physically in the Harold B. Lee Library. These references were also entered into the Citation database and full texts were obtained.

This literature review consists of a sampling of the more recent and significant sources. Many significant sources remain to be included in subsequent, more specialized reviews. The collection of references and documents relating to the HBDI® should continue to expand, and should thus become a valuable resource for researchers and practitioners interested in the HBDI® for a variety of reasons and applications. The resulting compendium is to be made available by Herrmann International in order to assist interested researchers and practitioners. For information, contact Herrmann International at info@hbdi.com. The aforementioned files and resources involve annotated and unannotated bibliographies in the following categories:

- *General*, which includes publications that refer to the HBDI®, hemisphericity (left- and right-brain), and brain physiology;
- *HBDI®*, which is limited to publications that refer to HBDI®;
- *Hemisphericity*, which is limited to publications that refer to the HBDI® and hemisphericity;
- *Journal articles*; and
- *Dissertations*.

User-Centered Aspects of Validity: Usability, Appeal, and Positive Expectations

This section deals with literature relating to the overall appeal of the HBDI®, as well as its perceived value, usability, proper (and improper) use, and weaknesses. Over the last 25 years, throughout globalization and expanded use of the HBDI® internationally, Herrmann International has made continuous efforts to improve the appeal and usability of the instrument for different audiences, including increased interpretability of HBDI® results and enhanced appeal of the reports and scoring sheets. While a report of this work is needed to present a complete picture of usability, this section is restricted to published works found in the literature. A thorough review of the literature revealed an absence of published studies that referenced the usability of the instrument and that referenced the usability of the interpretation sheets and materials; however, reports on the appeal and perceived value of the HBDI® were frequent.

Overall Appeal and Perceived Value

Overall appeal and perceived value concern the manner in which people consider the HBDI® to be appealing and useful, and whether it can be used to address various problems. Coffield, Mosely, Hall, and Ecclestone (2004) addressed the appeal and perceived value of the HBDI® in their major review of 13 different instruments that measure learning styles. They stated that a reliable and valid instrument that measures learning styles and approaches can be used as a tool to encourage self-development "not only by diagnosing how people learn, but by showing them how to enhance their learning" (Coffield et al., 2004, p. 50). They evaluated the HBDI® and 12 other learning styles instruments on the basis of four criteria: (a) internal consistency, (b) test-retest reliability, (c) construct validity, and (d) predictive validity. According to the results of their analysis, the HBDI® compared favorably with the other instruments, especially in regard to test-retest reliability and construct validity. Conversely,

Coffield et al. (2004) determined that the HBDI® failed to demonstrate evidence of internal consistency and predictive validity; however, this was due to a lack of research evidence in these areas rather than negative research findings. Only one of the 13 instruments met all four criteria, two of the instruments met three of the criteria, three of the instruments (including the HBDI®) met two of the criteria, four of the instruments met only one of the criteria, and three of the instruments did not meet any of the criteria. Coffield et al., (2004) noted that one of the appealing aspects of the HBDI®, as compared to the other instruments, was that the theoretical basis of the HBDI® theory "incorporates growth and development, especially in creativity," and recognizes that "learning styles are not fixed personality traits, but, to a large extent, learned patterns of behavior" (p. 28).

None of the studies included in this review deal explicitly with the usability of either of the HBDI® formats. However, one of the usability-related aspects of the HBDI® is that the underlying theory uses a simple metaphor that tends to be "much more easily understood by the general public than is either Jung's theory as extended by the Meyer-Briggs Type Indicator (MBTI) or other comparable instruments" (Carey, 1997, p. 10). One of the initial and principal researchers of the HBDI®, C. Victor Bunderson (1994, p. 344), observed that the face validity of the HBDI® appears to be high to most users because they find the theoretical model easy to understand and visualize. Further, users tend to readily agree with their own profiles. Bunderson stated that this is an important advantage of the instrument.

Uses

A number of studies have explored or have suggested specific uses of the HBDI®—some being appropriate uses and others being not so appropriate. Bunderson (1994, p. 341), based on his study of the reliability and validity of the instrument and on his observations of its use in

workshops with working adults, suggested a number of appropriate uses, including the following: (a) better understanding of self and others, (b) enhanced communication, (c) enhanced productivity through teamwork, (d) work climate for creativity, (e) authenticity, (f) enhanced teaching and learning, (g) better management, (h) counseling, and (i) building composite learning groups. A number of studies have dealt with these suggested uses of the HBDI®.

Better understanding of self and others. Coffield et al. (2004) found that the HBDI®, although mostly absent from academic research, "offers considerable promise for use in education and training," being "more inclusive and systemic than others, and taking an optimistic, open and non-labeling stance towards the development of people and organizations" (p. 28). Coffield et al. identified three particular strengths of the HBDI®. First, it incorporates growth and development, especially with respect to creativity. Second, it does not attach permanent labels to people, theorizing that preferences are largely a result of learned behavior rather than being fixed personality traits. As a consequence, use of the HBDI® may stimulate users to examine and refine their ideas about communication and learning. Third, it encourages users to develop stylistic flexibility and, where appropriate, to extend their ranges of competence.

Enhanced communication and productivity through teamwork. Bentley (2000) observed that the HBDI® has been used to develop methods which will help small groups of people with vastly different brain dominance profiles to successfully collaborate. Smith (1993, pp. 93-94) suggested that the HBDI® could help determine how nurses with a mix of brain dominance profiles could be represented on management teams and within various nursing groups. Smith also suggested that organizations and work groups should accommodate the strengths and weaknesses of left- and right-brain thinkers to facilitate better communication. For example, workers should not only give and receive written communications, but should also be

given occasions to communicate in verbal, interpersonal dialogue. Further, holistic problem solving approaches suggested by persons with right-brain preferences should be evaluated, along with technical strategies suggested by persons with left-brain preferences.

Enhanced teaching and learning. The HBDI® has been used and refined in adult learning settings to define valid approaches for helping students with different profiles become successful learners (Bentley, 2000). One example of this use is scientific education. Springer (1983) noted that developing new theories and applications is largely a right-brain activity because it deals with finding new patterns and relationships. Evaluation, on the other hand, is largely a left-brained activity because it involves checking out things in a logical, orderly, sequential, and quantitative manner. Although the scientific method celebrates the left-brain approach, right-brained concept development is also essential. Springer sees the HBDI® as a means of training and developing scientists by combining peoples' different skills and orientations.

Smith (1993) suggested that the usual demand for analytic and conceptual skills required to achieve graduate degrees in typical university programs might function as a barrier to individuals with right-brain and limbic mental preferences. She recommended that nursing schools consider alternatives to the traditional analytic approach in attracting nurses with other mental preferences.

Black (1983) found that matching teaching and learning styles based on brain dominance theories, such as the HBDI®, could produce significant learning outcomes. Likewise, Weaver (1994)—in her dissertation that investigated the impact of computer assisted instruction (CAI) on learner achievement when designed in both left-brain and whole-brain formats—concluded that achievement is significantly increased by using CAI designed in a left-brain format for a

population with strong left-brain preferences. A large government agency, motivated by a Congressional mandate to downsize and streamline operations, conducted research on matching training materials to learners' learning styles, which were measured in part by the HBDI® (Knisbacher, 2000). This research was echoed by similar research performed by Abdullah (2002) with a sample of Chinese college students, who found that predominantly left-brained students preferred instruction designed in a left-brain format.

Better management. Dewald (1989) recommended that managers, and those persons responsible for instructing managers, should be instructed in simple brain dominance theory as being a practical method for achieving the degree of organizational balance that should result from the contributions of personnel with different brain dominance profiles. The United States Forest Service used the HBDI® to determine if its Pacific Northwest division had changed its culture sufficiently to avoid the *groupthink* problems that had previously plagued it (Carey, 1997). Carey (1997) defined groupthink as "a mode of thinking that people engage in when they are involved in cohesive groups, and striving for unanimity overrides motivation for realistic appraisals of alternative courses of action" (p. 2).[2] The HBDI® was the instrument used to make this assessment because it identified cognitive preferences that were relevant in predicting the likelihood of groupthink in that population.

Counseling. Schkade and Potvin (1981) asserted that the application of brain dominance profiles to personnel assessment and placement held significant positive implications.

[2] "Groupthink involves developing a number of shared illusions (invulnerability, inherent morality, and unanimity) that lead to incomplete surveys of alternatives, failure to examine risks, and self-censorship. . . . Groups that emphasize B quadrant thinking are more likely to be dogmatic. Those that emphasize C quadrant thinking are more likely to be striving of unanimity. Emphasis on analysis without integration could lead to consideration of a narrow range of alternatives. Emphasis on integration without careful analysis in the face of facts and logic can lead to poor decisions." (Carey, 1997, p. 10)

Additionally, its application to personnel training and development also help significant positive implications.

Building composite learning groups. McAdam (1989) considered the HBDI® to be positive because it suggested a direction for solving a perennial problem faced in management education, namely, that management training programs tend to select students based on A Quadrant abilities rather than D Quadrant preferences, and thus they tend to "accredit management scientists rather than develop practicing managers" (p. 13). McAdam (1989) observed that current management education appears "devoid of much concern for the development of right brain skills, [and] selection procedures emphasize numeracy and verbal skills" (p. 14). The result is that programs "typically breed left brain dominant, operational reactors," who are concerned with productivity and individual achievement, as opposed to training managers who are tolerant of ambiguity, sensitive to human interactions, and able to strategically plan in turbulent environments (McAdam, 1989, p. 14). She felt that paying more attention to right-brained preferences and skills in both selection and training would result in the development of more effective managers.

Inappropriate Uses of the HBDI®

There are several uses of the HBDI® that would be considered inappropriate. It would be inappropriate to use the HBDI® for high-stakes evaluations and likewise for outcomes such as selection, hiring, or promotion. These uses are inappropriate because the HBDI® is an instrument that measures preferences rather than achievement, and because the HBDI® is a self-report instrument that can, at least with coaching, be faked to present an outcome thought to be desired by decision makers.

Bunderson (1994) notes that "[t]he best insurance against misuse of the [HBDI®] instrument is to avoid the evaluation of different profile categories as being good or bad" (p. 340). Bunderson specifically identified the following uses of the HBDI® as inappropriate due to the fact that validity cannot be assured: (a) clinical or diagnostic testing, (b) medical or psychological classification, (c) admissions testing prior to educational or training programs, (d) placement at different levels within educational or training programs, (e) use in selection or advancement testing for employment, (f) professional and occupational licensure and certification, and (g) any situation where a decision is made about a person that is beyond the control of the person. Validity of these high-stakes uses would be suspect because the validity of the HBDI® depends on honest and volitional responses by individuals—validity is jeopardized to the extent that individuals feel compelled to fake. If the HBDI® were to be used inappropriately, then "favored profiles" for given high-stakes uses would inevitably be exposed, thereby providing incentive for dishonest answers (Bunderson, 1994, pp. 341-42). Bunderson pointed out that Ned Herrmann was always adamant that score interpretation should be free from unfavorable evaluations of one profile against another. The utility of the HBDI® is predicated on its value for personal insight and for appreciating the value of diversity. The instrument is designed to enhance communication and understanding and is not promoted for use in selecting applicants for jobs (Carey, 1997).

A few studies advocated such inappropriate uses, including both the previously cited article by McAdam (1989) and the study by Smith (1993). McAdam advocated using the HBDI® in selecting students for graduate management programs. Smith made the inappropriate recommendation that nurses should be promoted into higher levels of management based, in part, on a consideration of their mental processing preferences as measured by the HBDI®. Smith

(1993, pp. 92-93) further suggested that rewards and incentives should be offered to retain some nurse managers at their current level of management based, again, in part, on their self-reported mental processing preferences.

Criticisms of the HBDI®

The primary criticisms of the HBDI® are that (a) there is not a great deal of research using it in the professional journals—although an increasing number of doctoral dissertations are examining it—and (b) it is a self-report instrument, which is common among many instruments that measure interests, attitudes, and preferences. As such, the validity of the HBDI® depends on honest responses from respondents. This is especially true because results can be faked or coached. However, the HBDI® may be less subject to faking than coaching because the person trying to fake results would have to understand the instrument before he or she could effectively fake it (Bunderson, 1994, p. 340). Coffield et al. (2004) seconded these criticisms, and also noted that the HBDI® has been primarily validated in the field of management and business, and less so in the field of education.

Although none of the articles included in this review have raised this issue, it should be noted that some critics have complained that HBDI® practitioners interpret quadrant scores as representing the areas where certain thinking processes are physically located within the brain. These critics cite brain research and scientific evidence to argue that brain localization has proven to be elusive in medicine and science, and that the evidence for such global thinking processes as found in the quadrants does not necessarily support the notion that these processes are physically located in the brain. HBDI® practitioners must continue to be cautioned that this model is a metaphor and that this literal interpretation is not supported by evidence. The benefit of rapid interpretation and understanding gained through the brain structure metaphor is

valuable, but it can be misleading if users interpret their scores as indicators of something as dominant as their preference for a left hand versus a right hand, or as something that is innate and unchangeable.

Validity in General

Validity is generally recognized as being the most important consideration in evaluating a test. Validity has been defined by Messick (1995) as "an overall evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions on the basis of test scores or other modes of assessment" (p. 741). Messick (1995) goes on to assert that "validity is not a property of the test or assessment as such, but rather of the meaning of the test scores" (p. 741).

Messick's (1998) unified validity model includes some of the matters discussed above, including values, social consequences, utility, and relevance. The heart of validity, however, is construct validity. Construct validity goes beyond simple validity. It is an aid by which we can determine if the inferences made between the instrument's operationalizations and theoretical constructs are legitimate (Messick, 1998, p. 12). Messick proposed six aspects of construct validity to be applied to all psychological and educational measurement: (a) content validity, (b) substantive validity, (c) score structure validity, (d) generalizability, (e) relationships with external scores, and (f) consequences that follow testing. The review herein considers evidence from published studies for each of these aspects. First, I group the evidence into aspects that influence *internal validity*: score structural validity, substantive process validity, and content validity. Second, I group the evidence into aspects that influence *external validity*: generalizability, external relationships, and consequences of testing.

Internal Evidence of Validity

Internal validity evidence concerns the internal structure of the items within the instrument (i.e., their subscores or individual item scores). Factor analysis is often used to examine the structure of the separable dimensions internal to the instrument, by which the intercorrelations among the subscores can be explained. If the dimensions internal to the instrument are as postulated, and are those interpreted in the score reports, this is taken as evidence of structural validity and of substantive validity. External validity evidence, on the other hand, involves studies that include the scores and subscores from an instrument in relation to other external measures whose score meaning and interpretations are already known. The relationships should be as predicted. At the beginning of the investigation of the HBDI® scores and subscores, both kinds of studies were used to understand the constructs being measured by the HBDI® in relation to other instruments whose scores already had established interpretations. In the internal validity section, I cover both studies internal to the HBDI® and studies involving scores external to the HBDI® because during these early studies the internal structure and substantive score meaning was being determined and, through instrument improvements, enhanced.

Score Structural Validity

Score structural validity is the "degree to which the score scales are consistent with the domain being measured" (Messick, 1998, p. 8). For the HBDI®, this deals with whether the "four scores for the four quadrants of the HBDI® scoring report actually form a double bipolar correlated structure with Upper Left as the polar opposite of Lower Right, and Upper Right as the bipolar opposite of Lower Left" (Olsen, Bunderson, & Newby, 2005, p. 2). The

dimensionality and boundaries of this domain can be confirmed through factor analytic studies (Bentley, 2000, p. 10).

Substantive Process Validity

A second aspect of internal construct validity is substantive validity, which "emphasizes the role of substantive theories and process modeling in identifying the domain processes to be revealed in the assessment" (Messick, 1995, p. 745). In this review, the term *substantive processes* is sometimes used to characterize the preferences for different thinking processes assessed by the HBDI®. This aspect of validity "includes fidelity of scoring to the knowledge, skills, ability and other characteristics assessed by the instrument" (Carey, 1997). With respect to the HBDI®, this relates to the theoretical meaning behind the scores, as follows:

> These four clusters of preference (and their corresponding tendencies to avoid their opposite) are: Upper Left, characterized by logical, analytical, mathematical, and technical preferences; Upper Right, characterized by synthesizing, holistic, innovative, more risk-taking preferences; Lower Left, characterized by organized, sequential, carefully controlled and managed thinking, planning, and acting (and the polar opposite of Upper Right mode); and Lower Right, characterized by preference for interpersonal relations, sensitivity to emotions, and musical interests (and the polar opposite of Upper Left mode. (Olsen et al., 2005, p. 3)

Studies that speak to substantive process validity will tend to show that the HBDI® scores actually correspond or fail to correspond to these theoretical constructs. Next, I review studies that have addressed this issue.

Early evidence of structural and substantive validity. Bunderson, Olsen, and colleagues performed six early studies which both evaluated the structural and substantive

validity of the HBDI® and helped to shape it into its present form. These studies are summarized in Bunderson (1994), which formed a technical validation appendix in the book that has served as a user's guide (or user-accessible manual) for the use of the HBDI®: "The Creative Brain" by Ned Herrmann (Herrmann, 1994). This summary offers good evidence that

- four discrete, stable preference clusters exist;
- these four clusters are compatible with the theory underlying the HBDI®;
- the scores derived from the HBDI® are valid indicators of the four clusters;
- the scores permit valid inferences about a person's preferences and avoidances for each of these clusters; and
- the use of the instrument meets high professional standards to the extent that it has been applied in learning, teaching, counseling, and self-assessment settings (Bunderson et al., 1994, pp. 337-338).

The review covers a series of studies.[3] The first study was a literature review, conducted in 1979, which had as its objective the development of a battery of measures against which the HBDI® scores could be compared (Olsen & Bunderson, 1980a).

The second study contained the first factor analysis of the 1979 version of the HBDI® associated with external measures, using 52 General Electric employees (mostly managers) and 91 college students.[4] Because Herrmann had not yet fully articulated the four-fold model of multiple brain dominance, validation was aimed primarily at an overall left- and right-brain score; however, it included tentative "Left Center" and "Right Center" scores that had not fully been quantified and balanced with the Left and Right scores. Factor analytic results from the

[3] Several of these studies also involved the use of instruments other than the HBDI, thereby making them also external validity studies. For the sake of clarity, however, these studies, which provided the original basis for the structural and substantive validity of the HBDI, will all be discussed here.

[4] This study used a battery of instruments that included speeded cognitive tests, learning strategies, and thinking style instruments other than the HBDI.

battery of tests included in this study led to nine strong and interpretable factors. These factors were identified as:

- A – innovative versus safe-keeping practice;
- B – speeded cognitive ability;
- C – use of learning strategies to capture information;
- D – feeling versus thinking preference;
- E – verbal quantitative thinking style;
- F – holistic, non-verbal thinking style;
- G – visual versus verbal learning preference;
- H – learning expansion strategies; and
- I – dominant intellectual preference (tentative).

The Right and Left participant survey scores were strongly involved in factors A, E, and F. The right center participant survey score anchored factor D, and appeared to be closely related to the feeling side of the MBTI's thinking versus feeling scale. The Right Center score was found to be the opposite of the Left Participant Survey score. Factor A showed the Left and Right scores to be polar opposites, with the Right side reflecting MBTI's intuition and perceiving scores, Paivio imagery, and preference for Personal Learning Strategies. Factors E and F were related to different types of cognitive ability: arithmetic, linguistic, and verbal-quantitative cognitive styles. Factor F was related to the visual cognitive tests, confirming the expected cognitive abilities and styles. These consistent correlations with like constructs from other instruments provided convergent evidence of the substantive meanings of the two main HBDI® scores, while the polar opposites of these scores and the unrelated factors provided discriminant validation for the instrument. These results were the beginning of an understanding of the

bipolar structure of the substantive constructs found in the HBDI®. The results suggested that there was promise in the HBDI®, but that the instrument should be analyzed item by item and that a better scoring procedure should be developed (Bunderson & Olsen, 1980b).

The third study, which was unpublished because of details about the proprietary scoring key of the HBDI®, involved an item factor analysis of 439 participants in management education workshops conducted by Ned Herrmann. The purpose of the study was to establish internal construct validity of the existing scores, particularly since the two center scores (i.e., Left Center and Right Center—corresponding to Quadrants B and C) were functioning weakly. A formal and quantitative coding procedure was developed to score each question, evolving from the more holistic scoring procedure the HBDI® had been using. This became the first major study dealing entirely with internal construct validation. Nine factors, three of which were bipolar (items loading on one end of the factor were negatively related to items loading on the other end of the factor), were extracted. The first bipolar factor distinguished the B and D Quadrants. The second bipolar factor distinguished the A and C Quadrants. The A factor had the substantive meaning Herrmann had intended: logical, analytical, mathematical; namely, "left-brain" thinking processes. The D factor had the meaning he intended for Upper Right: synthesizing, holistic, risk-taking processes; namely, "right-brain" thinking processes. The B factor had the meanings he intended for Left Center, with some elaboration of those meanings due to the relationships with other scores, but was now seen as the polar opposite of D. The C factor had the meanings he intended for Lower Right, with some elaboration, but was now seen as the polar opposite of A. Score structure was simple and meaningful. These two factors were slightly correlated so that A and B and C and D were closer together than A and D or B and C. A third bipolar factor emerged from these, distinguishing left and right dominance. This third-order factor also

separated out the two "center" scores in the order Ned Herrmann had presented on his original one-dimensional score sheet: Left, Left Center (now Lower Left), Right Center (now Lower Right), and Right. These factors provided sound support for Ned Herrmann's theoretical model of four separate preference clusters, and provided new information about their bipolar structure (Bunderson, 1994, p. 352).

The fourth study consisted of a factor analysis, using the old instrument and the same dataset of 143 cases, but with the new scoring procedure developed after the third study. The intent of this study was to produce a factor structure based upon personality, learning strategies, learning styles, and cognitive processing, and the four quadrant scores to determine the convergent and discriminant relationships of the four quadrant scores to these other constructs (Bunderson, 1994, p. 364). Strong negative correlations were found between the polar opposites (i.e., A vs. C and B vs. D; Bunderson, Olsen, & Herrmann, 1982). The score structure internal to the HBDI® was now established as two bipolar "quadrant" factors: A versus C and D versus B. There was also a higher-order Left-to-Right factor with A at the negative end, B with a low negative loading, C with a low positive loading, and D at the extreme right end. The higher-order factor reflected Ned Herrmann's original ordering of constructs from Left-to-Right. The two bipolar factors clarified the structure, that the lower left and lower right clusters of preferences were actually the bipolar opposites of the Upper Right and Left respectively.

The fifth study, also unpublished, involved another factor analysis using the new HBDI®.[5] This new instrument increased the content balance and coverage in the different subscore sections. It provided a better balance of questions to assess each of the four quadrants than was found in the earlier instrument. The subscores from this new instrument were included

[5] At approximately this time, the researchers were using a new version of the HBDI with new scoring and new items to balance out and better identify the weakly scored B and C Quadrants. Ned Herrmann accepted these instrument changes and permitted the addition of an entirely new section: Adjective Pairs.

in a battery with cognitive ability tests, several instruments measuring personality dimensions and learning and thinking styles, and a learning strategies instrument. The data were obtained from 205 students at Brigham Young University. The previous three bipolar factors (i.e., B vs. D, A vs. C, and Left vs. Right) were confirmed. Third-order factors were also found, including the following: an Upper Left versus Lower Right dichotomy and, more weakly, an Upper Right versus Lower Left dichotomy (Bunderson, 1994, p. 353). These findings confirmed and strengthened the evidence for structural and substantive validity. These findings also improved the argument for content appropriateness and representativeness by balancing better the items from different key content sections, including Work Elements, Preferred Adjective Descriptors, Hobbies, and 20 Questions.

The sixth study, performed in conjunction with Ho's (1988) doctoral dissertation, involved analysis of items from approximately 8,000 cases obtained from a variety of workshops. Part of Ho's dissertation replicated the third study. He extracted five factors, three of which were strongly bipolar: 1 – safekeeping versus creative; 2 – interpersonal, people-oriented versus technical, analytical; 3 – female, emotional versus rational, logical; 4 – creative, innovative; and 5 – handedness. Factor 2 relates to A versus C, and Factor 1 relates to B versus D. Factor 4 correlated slightly with A, indicating that adjacent quadrants are more likely to be correlated than opposite quadrants. A higher-order factor also appeared to be the familiar general Right versus Left factor. The new items added to the revised HBDI® were found to function well. These results substantiated the previous studies regarding items common to both versions of the instrument (Ho, 1988).

Ho (1988) also examined test-retest reliability, and found the following correlation coefficients between the test and the retest: Left .96, Right .96, A Quadrant .86, B Quadrant .93,

C Quadrant .94, D Quadrant .97, Cerebral .93, Limbic .91, and Introversion/Extroversion .73. The tests were not taken after a fixed interval, so the test-retest reliability may have been different if the retest had taken place after a fixed period of time. Nevertheless, Ho appropriately concluded that the HBDI® results were quite stable with the possible exception of Intro/Extroversion (Ho, 1988, p. 115).

Olsen, Bunderson, and Newby (2005) conducted an analysis of over 311,000 international cases collected by Herrmann International. The purpose of this study was to examine whether previous findings on the structural validity of the HBDI® still applied to the new dataset. This database contained records from 1986 to November 7, 2000. It was unbalanced in that it had a disproportionate number of males. A gender-balanced sample was prepared by randomly selecting percentages of males and females that matched the most recent U.S. census. All other demographic variables were excluded, including linguistic background, despite the fact that many linguistic and national groups were represented in the database. The study was designed to assess the extent to which the previously established structures derived from the HBDI® scores persisted after the internationalization which had occurred up through the year 2000. After performing factor analysis on the sample, the authors found that the two bipolar factors (i.e., Quadrant A vs. Quadrant C and Quadrant B vs. Quadrant D) and the previously found higher-order Left-to-Right factor still existed in this dataset. These data showed greater strength in the Right-to-Left factor than did the earlier U.S.-only samples. This factor appeared at both the first and second orders in the analysis.

Olsen et al. (2005) also examined each of the items. It was found that most of the items not used in the core subscores were still valid according to the key, but there were sufficient items that did not fit as currently constituted, which suggests that consideration should be made

to rekey some items, remove other items from the instrument, and replace items with new items as needed for balance, reliability, and internal validity. The study also suggested improving the key by improving the way the database was structured, and by engaging in an intensive analysis of national and linguistic subgroups to determine how elements of the scoring key should be altered from culture to culture (Olsen et al., 2005).

Other researchers have assessed HBDI® scores and their relationship to other constructs with known interpretations, and they have arrived at similar conclusions. Bentley (2000) investigated the relationships between the HBDI® and the Learning Orientation Questionnaire. Among other questions, Bentley investigated the content of the two instruments; that is, how the judgments of experts on the HBDI® constructs and the judgments of educational psychologists familiar with different psychological domains distributed the HBDI® items across the psychological domains of cognition, conation, affect, values, social, and psychological. This part of her study dealt with the content aspect of internal construct validity in a different way than was discussed above. Earlier studies looked at the content of the HBDI® preference items, drawn from several different perspectives on life, and attempted to balance them and to compare them with other instruments having other types of item content. She hypothesized that the HBDI® would have a broader scope across these different content domains than would the Learning Orientation Questionnaire, and would emphasize more the cognitive and social constructs. Bentley found that five HBDI® experts and two educational psychologists had moderate agreement about how the HBDI® items should be distributed across these domains. Bentley also found that the HBDI® operates in the manner it is predicted to operate.

Deihl (1986), in comparing the HBDI® to the Kolb Learning Styles Inventory, assessed some of the relevant factors of both instruments. She found, on the HBDI®, that Overall Left and

Overall Right measures were correlated at –.84 (*n* = 126), and Overall Cerebral and Overall Limbic measures correlated at –.73 (*n* = 126). Test-retest correlations for the HBDI® ranged from .67 to .81 (*n* = 30) for the subscales (Deihl, 1986).

Payne and Evans (1986) found correlations between right cerebral hemisphere measures and left cerebral hemisphere measures to be –.34. When the limbic scores were added in, the negative correlation reached –.80. The authors concluded that these correlations suggest that the limbic system makes a large contribution to the overall brain pattern. Further, the two limbic scores had a correlation of –.26, and the within-hemisphere score for Cerebral Left and Limbic Left correlated at –.16, while the Limbic Right and Cerebral Right correlated at –.25. The authors, noting that these scores suggested independence, stated that "[t]he fact that independent scores show low correlations suggests relatively unique measurement variance" (Payne & Evans, 1986, p. 25). They cautioned, however, that the data suggest that "conclusions based on split-brain specialization will be instrument dependent," and that "potential users . . . should be cautious about drawing inferences and making generalizations" until methodological advances allow for more sophisticated analyses (Payne & Evans, 1986, p. 25).

Additional studies relating to substantive validity. Breien-Pierson (1988) explored the role of hemisphericity in the area of student composition to test the theory that the composing process and writing of student papers differs relative to the students' hemispheric dominance. In the course of a qualitative study, she followed eight 12th-grade students and four English teacher evaluators through a 4-month composition course after first assessing all participants with the HBDI®. She found that the right-brained students approached the composing process in a different manner than did the left-brained students, and that the right-brained students preferred free and creative writing, while the left-brained students preferred research papers and book

reports. Further, the right-brain dominant students generally disliked teacher-generated topics, while the left-brain dominant students were comfortable with them (Breien-Pierson, 1988). Breien-Pierson also found that the teachers consistently evaluated the student papers relative to the students' hemispheric dominance. Breien-Pierson's study shows that the thinking preferences for different types of writing are those predicted by the substantive meaning of the left and right scores from the HBDI®.

Similarly, Schkade and Potvin (1981) found that electroencephalography (EEG) analysis of accountants and artists showed sharply different hemisphere activity by the two groups, supporting the substantive validity of the Herrmann Learning Profile Survey. The HBDI® theory (and much associated brain research) assigns left-brain thinking processes to accountants and right-brain processes to artists.

Studies relating to other similar instruments. There are a number of studies relating to the substantive process validity of other similar instruments, most of which will not be discussed in this review. An example however, is the study performed by Torrance and Horng (1980). Although they did not use the HBDI®, they supported the HBDI®'s conceptual structure with their investigation of the comparison of the Kirton Adaptation-Innovation Inventory with several measures of creative ability. They found that innovation and the right hemisphere style of learning and thinking were significantly and positively related to Torrance's measure of Creative Personality, Stein's Physiognomic Cue Test, Rorschach's test of originality and movement, and the Torrance Test of Creative Thinking measures of fluency, originality, and creative strengths. They found that adaptation was significantly related to the left hemisphere style of learning and thinking (Torrance & Horng, 1980).

External Evidence of Validity

In previous sections, I focused the review on aspects that influence internal validity. Following Messick's (1998) conceptualization of validity, this section will cover those aspects that influence external validity: (a) generalizability, (b) external relationships, and (c) testing consequences.

Generalizability

Generalizability is a fourth aspect of validity that provides additional corroboration for the construct validity of the HBDI®. Generalizability "is concerned with ensuring that the sample of items are constructed broad enough to be representative [of, or generalizable to] the construct domain intended to be measured" (Messick, 1998, p. 8). Martinez, Bunderson, and Wiley (2000) noted that "reliability and G-Theory studies are commonly used to provide evidence of this aspect of the validation argument" (p. 13). Generalizability cuts across populations, settings, and tasks (Carey, 1997). The recommendation in the Olsen et al. (2005) study that, in the future, linguistic and national samples be studied separately refers to the generalizability issue, but no studies of this sort were found in this literature search. Underwood (1984) tested brain dominance patterns of clothing and textile students with the Herrmann Profile Survey Form, Brainscan, and a researcher-developed task-oriented test. Underwood found no significant difference in brain dominance patterns of males and females. Wallace (1992), while exploring the relationships between brain dominance (measured by the HBDI®), work perceptions, and demographic factors, found that males tended to be left hemispheric and A Quadrant dominant, while females tended to be more right hemispheric and C Quadrant dominant. Coffield et al. (2004) noted that, although the HBDI® is well-established in the business world, it is not extensively validated in education, suggesting that different contexts

could also impact generalizability. In conclusion, one can argue that the issue of generalizability has not been substantially studied and reported. This provides a good avenue for future research.

External Relationships

A fifth aspect of Messick's (1998) conceptualization of validity is external relationship validity. This aspect emphasizes convergent and discriminant validity by looking at predictive studies, including correlational studies, that "provide converging or diverging evidence, depending upon what was predicted" (Martinez, Bunderson, & Wiley, 2000, p. 14). Martinez et al. (2000) asserted that "[m]easures of the same construct should converge to find triangulated evidence for the construct" (p. 14).

Accordingly, this section reviews studies that look at how external, empirical evidence compares with the theory underlying the HBDI®. I first review convergent and discriminant studies that compare the HBDI® to scores on other instruments. In one type of study that can be used to produce evidence of external relationships, researchers have predicted, on the basis of the theory underlying the HBDI®, how certain scores on the HBDI® should correlate with other instruments or outcomes. For there to be convergent validity evidence, one should expect positive correlations between constructs from the HBDI® and from the other instruments that share similar meanings. Further, for there to be discriminant validity evidence, one should expect a lack of correlation between constructs from the HBDI® and from other instruments that are different. This section then looks at correlational studies, in which we should expect related external factors and HBDI® constructs to be correlated.

Convergent and Discriminant Studies

The six core studies discussed above that were performed by Bunderson, Olsen and colleagues give evidence of the nature of the substantive processes measured by the instruments,

and they also provide external validity evidence because they compared the HBDI® to other instruments. Studies 2, 4, and 5 were vital in assuring from the known interpretations of other instruments that the HBDI® was indeed measuring preferences for substantive thinking processes as it purported. Specifically, the second study included a battery of other tests, including self-report instruments measuring other preferences, learning styles, thinking styles, learning strategies, and personality attributes, as well as cognitive ability tests related to left- and right-brain cognitive processes. The results demonstrated predictably similar or predictably different interpretations to the HBDI®.

One of the purposes of the fourth study was to determine the convergent and discriminant relationships of the four quadrants to constructs based on personality, learning strategies, learning styles, and cognitive processing (Bunderson, 1994). The results produced evidence of both internal and external construct validity, demonstrating that the newly strengthened brain quadrant scores cut across a number of domains, the most significant being personality type (MBTI), speeded cognitive tests, and visual imagery scales (Bunderson, Olsen, & Herrmann, 1982).

Subscores from the fifth study were included in a battery with cognitive ability tests, several instruments measuring personality dimensions and learning and thinking styles, and a learning strategies instrument. The findings confirmed the previous three bipolar factors (B vs. D, A vs. C, and Left vs. Right). Third-order factors were also found, including the following: an Upper Left versus Lower Right dichotomy and, more weakly, Upper Right versus Lower Left dichotomy (Bunderson, 1994, p. 353).

Diehl (1986) performed a correlational study comparing the HBDI® with the Kolb Learning Styles Inventory. She obtained Pearson product moment correlations at $p = .01$ ($n =$

125) between the following dimensions: (a) Concrete Experience and right-brain hemisphere dominance (r = .41); (b) Concrete Experience and the Right Limbic (Quadrant C; r = .42); (c) Abstract Conceptualization and left-brain hemisphere dominance (r = .23); (d) Abstract Conceptualization and overall cerebral (r = .49); (e) Concrete Experience and the Right Limbic (Quadrant C; r = .42); and (f) Abstract Conceptualization and the Left Cerebral (Quadrant A; r = .42). These results support the theoretical framework underlying the HBDI®.

Payne and Evans (1986) looked at interrelationships among the HBDI®, the Torrance/Reynolds instrument, and the Kolb Learning Styles Inventory. There were low positive correlations between the HBDI® and the Torrance instrument, with a correlation of .34 for right cerebral hemisphere scores and .46 for left hemisphere scores. The authors expected these findings but did not consider them to be of sufficient strength to consider the measures to be equivalent. They also found the Kolb inventory to be unrelated to any of the dominance scores derived from the HBDI® or the Torrance instrument. This was not surprising, given that the Kolb inventory purported to be measuring different constructs from the HBDI®.

Dewald (1998) conducted a study that explored the relationships between the MBTI and the HBDI®. Dewald's study involved 800 student program managers attending the Defense-Systems Management College in Fort Belvoir, Virginia during 1986-1987. Dewald's results fully substantiated her hypotheses and supported the theoretical foundations for both the MBTI and the HBDI®.

Most of the study participants were sensing, thinking-judgers from the MBTI and were also HBDI® superdominant (HBDI® scores > 100) in Quadrants A and B. Psychological type theory underlying the MBTI describes thinking-judgers as logical decision makers, and sensing thinking-judgers as being practical, orderly, dependable, realistic, and having strong

organizational ability. Underlying HBDI® theory describes double dominance in HBDI® Quadrants A and B as combining the logical, analytical, and rational characteristics of Quadrant A with the controlling, structured, and organizational characteristics of Quadrant B. These theoretical constructs are directly comparable. These results support both underlying theories.

The few feeling (MBTI) individuals in Dewald's (1998) sample were dominant in HBDI® Quadrant C. According to the underlying MBTI theory, feeling individuals tend to make decisions with more conscious consideration of the possible impact that they might have on others. Under the HBDI® theory, individuals who prefer the HBDI® Quadrant C are also characterized by such interpersonal concern. These results also support the underlying theories.

Dewald (1998) found that intuitives and perceptives (MBTI) were also double dominant in HBDI®'s A and D Quadrants. This was a predicted result under the two theories. Under MBTI theory, intuitives and perceptives tend to be independent thinkers who focus on possibilities, theoretical relationships, and future challenges. Similarly, Quadrant D individuals are future oriented, intuitive, and adept at starting new ventures. Double dominance in HBDI®'s A and D Quadrants combines the logical, rational, and problem-solving characteristics of Quadrant A with the future orientation characteristic of Quadrant D. These results, likewise, support the underlying theories.

Dewald (1998) also found that there was a significant relationship between the extraversion-introversion dimension of the MBTI and the C Quadrant of the HBDI®. Thinking-judgers (MBTI), the "tough-minded, executival, analytical, instrumental leaders" (Dewald, 1998, p. 126) showed the highest incidence of avoidance toward Quadrant C. This finding is consistent with MBTI theory that thinking-judgers base their decisions primarily on facts about things in the material world while being generally impervious to the social world of people. Extraverted

thinking-judgers were lower in Quadrant C avoidance than were introverted thinking-judgers. Dewald stated that this finding "suggests a connection between HBDI® preferences and the Jungian theoretical preference that an individual's view of the world and personal self-attitude are depending upon whether the individual is an extravert or an introvert" (p. 126), but HBDI® theory has yet to emphasize the importance of the characteristics of extraversion and introversion. Dewald suggested that this is a new and significant direction for research.

Bentley (2000) conducted a study comparing the Learning Orientation Questionnaire (LOQ) with the HBDI®. One research question dealt with the consistency and accuracy of HBDI® experts in predicting correlations with the LOQ items and scales when there was substantive process reason to expect a correlation. Bentley found small but significant correlations between the HBDI® and the LOQ, and LOQ scores were more likely to correlate with multiple quadrant combinations as they approached HBDI® "whole brainedness" rather than correlating with single quadrant scores. The LOQ transforming learner scores were also more likely to positively correlate with Upper Right scores than with any other single quadrant score, and were more likely to correlate negatively with the Lower Left scores. Bentley concluded that the LOQ and HBDI® measure discriminably different constructs, but share some common constructs as shown by the small but significant correlations.

For example, one LOQ construct incorporates beliefs that learning can help to achieve challenging personal goals, improve the quality of life, help to accomplish professional goals beyond the stated course objective, and provide enjoyment while exploring new topics. Bentley (2000) found this LOQ construct to be comparable to the constructs involving the HBDI® Upper Right Quadrant, which thrive on new ideas and seeing the bigger picture (Bentley, 2000). Bentley further found that the LOQ construct of learner self-assessment of progress to improve

learning ability correlated with the Lower Left Quadrant, which is perceptive of change, and which tends to be efficient, linear, and detail focused.

Surprisingly, Bentley (2000) also found a negative correlation: The LOQ item related to choosing to avoid learning situations correlated positively with the C Quadrant. Bentley did not have a substantive process explanation for this finding. Similarly, she found that LOQ items related to not setting risky or challenging learning goals before beginning a learning task, believing that the instructor can show the best way to evaluate achievement of learning goals, and believing that instructors can plan the best learning approach for accomplishing training objectives, also unexpectedly correlated with the Upper Right, failing to fit the theory underlying either of the instruments. Bentley also had no substantive process explanation for this finding.

In summary, most of the reviewed convergent and discriminant studies supported the theoretical basis for the HBDI®, and supported comparable theoretical bases for other instruments. There were a few unexpected findings, some of which had theoretically consistent substantive process explanations and a few of which did not.

Correlational Studies

There are a number of external factors and phenomena that have been studied in relation to the HBDI®, including business and military management, business management educators and educational administration, instructional presentation preference, occupational groupings, and reading, writing, and verbal stimuli.

Business and military management. Dewald (1989), in a study comparing MBTI and HBDI® scores of military and civilian student program managers, found that there were no significant differences in HBDI® and MBTI scores between those individuals at higher managerial levels and those individuals in middle management or lower levels. Further, there

were no significant differences based on rank for either civilian or military managers in distributions of HBDI® dominance and avoidance patterns. There were no significant differences in Quadrant A and Quadrant C distribution among managerial levels, but there was a significantly lower percentage of B Quadrant dominants among high-ranked civilian managers than there was among middle-ranked civilian managers or high- or middle-ranked military managers. There was also a higher percentage of Quadrant D dominants among high-ranked civilian and industry managers than there was among civilian middle managers or either level of military managers.

Business management educators and educational administration. Wilber (1995) focused on the relationship between brain dominance and characteristics of business faculty in higher education. Wilber randomly selected business faculty in higher education across the United States and surveyed them using the HBDI® and a demographic survey. She found that business faculty tended to exhibit multiple dominance, primarily in the limbic hemisphere, and tended to use primarily lecture and discussion in teaching. As years of teaching experience increased, limbic brain dominance also became more prevalent.

Langford (1995) performed a qualitative study of the leadership characteristics of female educational administrators. Langford attempted to find one highly logical, one highly intuitive, and one holistic female middle manager in school administration. To this end, Langford measured brain dominance characteristics of 17 female middle managers with the MBTI and the HBDI®, intending to select the participants who showed the highest preferences for, respectively, logical, intuitive, and holistic styles. HBDI® findings suggested that no participant reported a preference for a highly logical style or a highly holistic style, with the dominant profile being double dominant in the B and C Quadrants. This indicated a preference for administrative,

structural, and interpersonal feelings among this group of female middle managers (Langford, 1995).

Instructional presentation preference. Knisbacher (1999), in a study of learning and thinking styles of 100 employees of a large governmental agency in Washington D.C., found that relationships existed between learning and thinking styles and instructional presentation preferences, but not with preferred instructional delivery platforms. Participants with dominance in either of the left quadrants tended to prefer a systematic, "bottom-up" approach to instructional presentation, while those with right-brain dominance preferred a "top-down" approach. Further, the triple dominant (a score of 1 in three of the four quadrants) portion of the sample population generally preferred instructor led training, while other left hemispheric combinations tended to favor self-paced instructional delivery. The reverse was true among right hemispheric participants (Knisbacher, 1999).

Occupational groupings. Wallace (1992) used the HBDI® to determine the brain dominance of 121 educational administrators in the Connecticut school systems, and then compared their scores with demographic factors and work perceptions, as measured by an Administrative Dimensions Survey. The participants were generally balanced in brain dominance, with the most prevalent HBDI® profile being double dominance in the A and B Quadrants. Quadrant B was the most preferred and Quadrant C the least preferred. Although there was no significant difference in brain dominance associated with experience, administrators holding doctorates were found to prefer thinking in the holistic, conceptual D Quadrant. Wallace, accordingly, found low-to-moderate predictive relationships between brain dominance and work perceptions.

Smith (1993) examined relationships between brain dominance and management level, educational preparation, and management experience among nurse managers who were members of the Washington Organization of Nurse Executives (n = 160). Smith compared HBDI® scores with scores on her own Management Questionnaire. The majority (97%) of the participants were female. Smith's results showed that the majority of the nurse managers showed a preference for the right-brain approach to processing information, first line managers preferred left-brain and cerebral approaches, and middle and top managers preferred right-brain and limbic approaches. Further, there were statistically significant positive relationships between right-brain scores and level of management, and between cerebral scores and levels of nursing and non-nursing education (Smith, 1993).

Carey (1997) investigated the correlation of HBDI® groupings with occupations in an archival study performed on personnel employed by the U.S. Forest Service. Carey found that the sample showed tendencies toward A Quadrant analytical thinking and D Quadrant integrative thinking. Also, engineers had a significantly higher preference for A Quadrant thinking than other occupations, and had the lowest preference of the groups for D Quadrant thinking. Further, research executives and research biologists had the lowest preferences of all the occupations for B Quadrant thinking, and district rangers had higher preferences for C Quadrant thinking than did the other occupations. Carey found no significant differences among occupational groups for right- and left-mode preferences. All occupational groups reported preferences for the cerebral mode over the limbic mode, but a large minority (48%) of the district rangers showed preferences for the limbic mode. Engineers, in composite, were triple dominant (A, B, and D). Carey's findings supported the hypothesis that scientists and executives would prefer the cerebral mode of thinking, but rejected the hypotheses that management staff and line workers would

prefer the left-brain mode of thinking and that engineers prefer a single style (A Quadrant) of thinking.

Knisbacher's (1999) study investigated the relationships between two independent variables (i.e., learning style and thinking style) and three dependent variables (i.e., instructional presentation preference, preferred instructional delivery platform, and occupational choice). The sample consisted of 100 employees from a large governmental agency in Washington D.C. that was divided equally between two career fields: computer science and linguistics. Data were collected via the Internet using the Kolb Learning Styles Instrument, the HBDI®, and two questionnaires that were used to identify instructional presentation preference and instructional delivery platform preference. Knisbacher found relationships between learning and thinking styles and both instructional presentation preference and occupational choice, but did not find a relationship between learning and thinking styles and instructional delivery platform preference.

Reading, writing, and verbal stimuli. In a qualitative study, Breien-Pierson (1988) tested eight 12th-grade students and four English teachers with the HBDI® to determine their brain dominance, and then observed them writing four papers over a period of 4 months. Breien-Pierson found that right-brained students preferred free writing and creative writing, while the left-brained students preferred writing research papers and book reports. Breien-Pierson concluded that brain hemisphericity influences the composition process.

Testing Consequences and Consequential Validity

Messick's (1998) sixth and final aspect of validity is consequential validity, which "includes evidence and rationales for evaluating the intended and unintended consequence of score interpretation and use in both the short- and long-term" (p. 476). According to Carey (1997), "[c]onsequence includes the value implications of score interpretation as a basis for

action and actual and potential consequences of test use, especially in regard to bias, fairness, and distributive justice" (p. 10). Bunderson's (1994) concept of criterion-related validity evidence is similar; the instrument scores are measured against additional measures that serve as criteria for judging whether people are good at something or are possessed of some valued quality (p. 342).

In this section, accordingly, I review studies that use the HBDI® for prediction of various outcomes. In these studies, the researchers have predicted on the basis of the theory underlying the HBDI® that previously obtained scores on the instrument should be predictive of subsequent performance of some task or of some other outcome. Accordingly, it is useful to look at both studies that show expected consequences and studies that do otherwise.

Studies that show expected consequences. Ho's (1988) dissertation examined whether different criterion groups (occupations) systematically differed in their HBDI® scores. Nineteen out of 25 occupations loaded significantly on at least one of the five factors Ho identified, and tended to load in a manner consistent with Herrmann's model. For example, accountants loaded negatively on Factor A (emotional/interpersonal vs. analytic), suggesting that accountants are analytic, "left-type individuals." The loading of accountants on Factor B (imaginative vs. orderly/organized factor) shows a preference for orderliness and organization. On the other hand, consultant-trainers had a right-brain orientation, with a preference for interpersonal and creative activities. Secretaries had an overall right-brain orientation and a preference for safekeeping types of activities. A Quadrant professions included engineers, finance managers, accountants, engineering project managers, computer programmers, finance officers, manufacturing managers, and computer technicians. D Quadrant professions included science technicians, CEOs, management consultants, marketing, technical trainers, professional students,

employee relations managers, manager trainers, and consultant trainers. C Quadrant professions included trainer coordinators, secretaries, and homemakers. B Quadrant professions included technical sales personnel (Ho, 1988).

Steyn (2003) structured learning facilitation activities to accommodate and develop different modes of thinking and learning for 1st-year engineering students who were studying mathematics at the University of Pretoria, South Africa, and conducted several action research studies on the implementation. Results suggested that the learners had diverse thinking and learning styles and that they had a favorable study orientation toward mathematics. The activities also produced a significant improvement in the students' study orientations toward mathematics (Steyn, 2003).

Studies that show unexpected or negative consequences. Messick (1998) argued that evidence of negative social consequences was a likely indicator of construct-irrelevant variance. "Unanticipated consequences signal that developers may have been incomplete or off-target in test development, and hence, test interpretation and test use is damaged" (Bunderson, 2005, p. 2). To date, I have found no clear examples of such negative consequences in the literature.

Conclusion

It can be stated fairly that the great majority of research studies reviewed support the validity of the HBDI® in all aspects of validity suggested by Messick (1998). Nevertheless, validation work is never complete, because the uses and meanings of words in any instrument can change, and because new people with different backgrounds begin to use it. Furthermore, despite the extensive collection of references reviewed herein, reviewers should perform additional mining. Thus, continuing research should be done to further validate the HBDI® and to keep the validity argument current.

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