Phase I:
Validation Study

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Executive Summary

This research paper reports results from a Phase I validation study for the Herrmann Brain Dominance Instrument® (HBDI®). This is one study from a series of ongoing validation studies conducted with the aim of gathering evidence to support the validity argument for the HBDI®. The purpose of this particular study was to investigate the structural validity of the HBDI® using a large international sample (*N* > 250,000). The authors proposed two hypotheses. First, it was hypothesized that the bipolar structure of Quadrants A versus C and Quadrants B versus D would emerge strongly and clearly from the analysis of the 10 core subscores. Second, it was hypothesized that, given a confirmation of the original bipolar structure, the only higher-order factor to emerge would be the previously established left-to-right factor.

Results support the reliability and validity of the HBDI® and suggest the instrument can be used to measure individual differences in thinking preferences as purported by the underlying theory. Indeed, both study hypotheses were confirmed. First, as predicted by the first hypothesis, there were two negatively correlated clusters of scores at both ends of each of two continua of choices (i.e., Quadrants A vs. C and Quadrants B vs. D). Second, as predicted by the second hypothesis, there was a left-to-right preference cluster factor that emerged as a higher-order factor (i.e., left-brain and right-brain preferences). These results align with the meaning of the Whole Brain® Thinking Model, thereby supporting the structural validity and substantive meaning of the HBDI® quadrant scores.

The HBDI® Four-Quadrant and Left-Right Structure: A Structural Validation Study

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Editor's Note

This paper reports results from a validation study for the Herrmann Brain Dominance Instrument® (HBDI®). The HBDI® is a psychometric instrument that is purported to measure multiple integrated systems of mental preferences. This is one study from a series of ongoing validation studies conducted with the aim of gathering evidence to support the validity argument for the HBDI®. The main focus of this paper is to examine the structural validity of the HBDI® and to determine whether the HBDI® aligns with its underlying theory. Results support the reliability and validity of the HBDI® and suggest the instrument can be used to measure individual differences in thinking preferences as purported. As previously mentioned, this is one study from a series of ongoing validation studies that are conducted as part of Herrmann International's program of research.

Edited by: Daniel S. Stanhope, PhD

Abstract

This document reports results from a structural validation study (Phase 1) of the Herrmann Brain Dominance Instrument® (HBDI®), using a sample from Herrmann International's database of completed surveys from 1986–2000 (*N* = 254,431). Using rigorous factor analytic procedures, the Phase 1 study confirms the structural validity of the HBD® I. In particular, the study confirms that there is a double bipolar structure of preference clusters (Quadrants A vs. C and Quadrants B vs. D) as well as a higher-order left-to-right factor. These results corroborate previous validation studies and are consistent with the HBDI®'s underlying theory. Thus, despite wide internationalization of the HBDI® without major changes, the bipolar and left-to-right structure remains intact, and the meanings of the preference clusters as documented and taught by Herrmann International continue to be valid for interpretation and use.

Introduction

Overview and Purpose

This document reports the first internal validation study in the validation update program initiated by Herrmann International in 2000. This study is called the Phase 1 validation study. The major aspect of validity addressed in the study is the structure of the profile scores derived from responses to items in the Herrmann Brain Dominance Instrument® (HBDI®).

The structural validity of the HBDI® is an integral part of an ongoing, unified validity argument of the HBD® I. *Validity argument* is a concept that has been used by notable measurement scientists such as Messick (1995) and Cronbach (1988), referring to the process of documenting the validity of a measurement instrument. From this view, validity is not a property of an instrument, but of the interpretations and uses assigned to it (Messick, 1995, p. 741). Thus, validation is not a single event, but a continuous process. Similar to a program evaluation, every question cannot be answered all at once. Moreover, the validity argument must respond to changes in the context of instrument use, such as evolving perceptions of participants, changes with implementation details, and societal shifts in meanings of terms in the instrument's items.

The validity argument of the HBDI® centers on a validity-centered design approach, focusing on the instrument's construct validity, as well as its appeal, usability, and values and expectations. Construct validity is arguably the most important and central aspect in the validation of any psychological or educational instrument. It is a concept emphasized by many measurement scientists. Messick (1989, 1992, 1995, 1998a, 1998b) articulated three internal and three external aspects of construct validity. The *structural* aspect of validity is one of the three internal aspects delineated by Messick and is intricately related to the other two aspects, *substantive* and *content*, as will be briefly discussed in the following section.

Structural Aspect of Validity

For the HBDI®, internal validity starts with the structure and meaning of the scores. A continual validation of this structure is an essential process underlying the validity-centered design of the HBDI®. The structural aspect of validity is concerned with evidence that the instrument's internal structure—the specific number and type of measured dimensions—matches the structure of its explanatory theory and construct domain (Messick, 1995, p. 745).

To verify the structural validity of the HBDI®, it must be demonstrated that profile scores cluster in a way that is consistent with the explanatory theory underlying the HBDI®. According to this theory, there are four distinct clusters, or quadrants, of thinking preferences. These preferences are patterned according to two bipolar[1] pairs that contain both a left-brain and right-brain thinking preference (A vs. C and B vs. D; see Figure 1).

According to the HBDI®'s *investment hypothesis*, these bipolar pairs emerge as a result of one's choices under conditions of limited time and resources, including one's genetic dispositions and environment. A person is constantly choosing to "invest" time, talents, and efforts in ways that cater to a particular pattern of thinking preferences, often at the expense of developing other preferences. Over time, an individual's patterns of characteristic preferences cluster in a way that can be explained by the HBDI®'s bipolar, four-quadrant structure, referred to as the Whole Brain® Thinking Model (see Figure 1).

[1] *Bipolar* is a term used here from psychometrics, not psychology. It merely refers to the finding that items cluster on opposite ends of a single factor extracted using linear factor analysis methods. The A versus C and B versus D bipolar factors are not seen as two single constructs, but four. Other factor analytic models could be set up in future studies using homogeneous, rather than mixed international samples to extract four separate factors, corresponding better to the interpretation of the Whole Brain Thinking Model; namely, that the four constructs are separate, but the two pairs are highly negatively related.

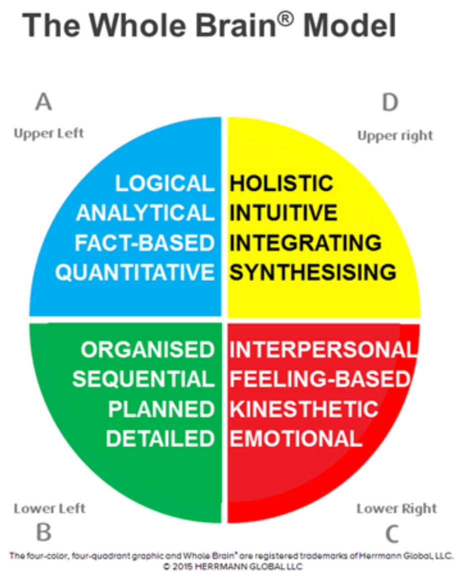

Figure 1. Visual representation of the **Whole Brain**® Thinking Model.

By assessing the types of choices a person has made (or would make) under conditions of limited time and resources, the HBDI® measures an individual's pattern of thinking preferences. There is growing empirical evidence that strong individual differences do exist in specialized brain functions consistent with the two polar-opposite types of preferences assessed by the HBDI®. This evidence is part of the argument for substantive validity of the HBDI® and is documented in the forthcoming HBDI® manual.

The structural validity of an instrument is also intricately related to the content aspect of validity. It is essential for an instrument's content to represent a relevant and comprehensive assessment of the instrument's underlying theory. As discussed more fully in the forthcoming HBDI® manual, the content of the HBDI® matches its theory. The instrument's items are designed to tap into a variety of perspectives, reflecting the most important choices that a person has made (or would make) under conditions of limited time and resources. Items consist of a variety of question types with limited selection options, consistent with the investment hypothesis of preferences under scarcity. The items are grouped into subscores that have been demonstrated to correspond to the Whole Brain® Thinking Model.

What is Important about the Phase 1 Study?

From as early as the creation of the instrument in the early 1980s, researchers have validated the internal structure of the HBDI® (Bunderson, 1988, pp. 359–364; Bunderson & Olsen, 1980; Bunderson, Olsen, & Herrmann, 1982; Ho, 1988). These studies demonstrated the structural validity of the HBDI® confirming the instrument's bipolar A versus C and B versus D structure and left-to-right factor. Much time had passed, however, since these initial studies were conducted, and it was important to investigate whether the HBDI® structure continued to be evident. This investigation was especially necessary considering the growing internationalization of the instrument, including the development of several translated versions.

The purpose of the Phase 1 study was to verify that the structure of the HBDI® was still evident on a large international sample. This sample covers the instrument's development from the mid-1980s through 2000. The two key questions addressed are as follows:

1. Is the double bipolar structure of preference clusters (Quadrants A vs. C and Quadrants B vs. D) still evident?
2. Does the long established left-to-right, higher-order factor still emerge, as specified in the Whole Brain® Thinking Model?

We hypothesized that, despite any changes in the way a large international and multilingual sample may respond to mixed translated versions of the HBDI® , the bipolar structure would emerge strongly and clearly from a factor analysis of the HBDI® 's 10 core subscores (explained below). Conditional on support for this first prediction, we hypothesized further that the only higher-order factor that would emerge is the left-to-right factor.

Method

Sample

This sample for this sample was obtained from Herrmann International's database of scored HBDI® surveys. At the time of this study, the database contained 311,288 surveys, taken from January 1, 1986 to November 7, 2000 (the total number of surveys completed during the specified time period).[2] These surveys included individual item scores and limited demographic information. From this database, male surveys were randomly removed until the sample approximated international population ratios (i.e., 50.7% females and 49.3% males). The resulting sample consisted of 254,431 surveys (128,973 females and 125,458 males).

Although demographic statistics were not compiled for participants' selected countries and languages, the sample consists of a diversity of backgrounds. North America is the largest component, but there are many other linguistic and national groups represented, including European, Middle Eastern, Pacific Ocean, Asian, and South American. By far, the majority of surveys are English, with U.S. English being the largest subset; British Commonwealth and International English are the next largest.

It can be argued that the meanings of terms used in HBDI® items may differ between countries, as well as within countries (e.g., between native and foreign language speakers). Therefore, an important future endeavor is to analyze the HBDI® structure for specific national and linguistic subgroups in order to assess the extent to which elements of the scoring key demonstrate measurement equivalence from culture to culture. The aim of the Phase 1 study, however, was to assess whether the structure is evident for the international population as a whole. We determined that if the structure and meaning are not sufficiently similar to previous work, then it suggests that the HBDI® items and scoring key may not be generalizable to an

[2] A few surveys contain earlier dates than 1986 in the "date entered" field; the accuracy of these dates, however, is unconfirmed. It is known that many surveys were completed before 1986, but the records of these were not converted to a database format compatible with the current set.

international population. If, however, the structure and score meaning of the HBDI® were to remain strong, then the use of the instrument in its present form and with its present scoring key would have evidence of structural validity. Furthermore, the study's results would serve as a baseline for conducting separate analyses for each translated version of the HBDI®

Factor Analytic Procedure

This study used similar factor analytic procedures that have been used for the past 20 years to investigate the structural validity of the HBDI®. Such procedures are well recognized by measurement scientists as being appropriate and technically accurate ways of analyzing scores from cognitive aptitude and ability, personality trait, and preference tests (Carroll, 1993; Cattell, 1978; Gorsuch, 1974, 1983; Tucker & MacCallum, 1997).

These factor analyses are based on oblique models designed for correlated factors, which are generally most appropriate for measuring data about human attributes. For many years, leading factor analysts have understood that factors derived from scoring human attributes, such as those measured by the HBDI® , are generally correlated. Therefore, orthogonal solutions, which are designed for uncorrelated factors, are not generally appropriate for instruments measuring human attributes. Oblique models compensate for the correlated nature of the data by using oblique angles (rather than the right angles used for uncorrelated factors) that better represent the underlying complexity and interrelatedness of human attributes. This correlated factor model is also useful for detecting higher-order factors, such as the higher-order left-to-right factor of the HBDI®.

Although the methods used in this study are well established for oblique rotation and hierarchically organized factors, new methods using structural equation modeling are now available. It is recommended that these methods be examined in future validation studies of the HBDI®, using appropriate samples. The structural aspects of the HBDI® theory are testable by the methods used here and, with more homogeneous samples, by newer methods.

Past analyses of structural aspects of the HBDI® have used both score and item factor analyses. Because item factor analysis is difficult to interpret for bipolar and higher-order items, only score factor analysis was used in this study. With score factors, interpretation is easier and the scoring key is explicitly validated to the extent that its resulting structure has the meaning or interpretation provided in interpretive reports based on the scores. Also, the percentage of explained common variance is much higher when using score factors. The general procedure for the factor analyses described in this report was as follows:

1. Factors were extracted and the number of factors to use was determined. Where possible, Carroll's (1993, pp. 83–90) advice to use the principal axis (first order) factor extraction method was followed.
2. The selected number of factors was rotated to an oblique simple structure, using the Promax analytic rotation program with kappa set to 4. The determination of the number of factors to rotate is based on the so-called "Kaiser test" (eigenvalues greater than 1). In the case of this study, however, where a theoretical model exists, the meaning of the factors is of greater importance; therefore, in some analyses, the number of factors is set to two, consistent with the two bipolar factor theory.
3. A factor intercorrelation matrix was computed to detect second-order factors, if any. This matrix was analyzed to obtain the second-order pattern loadings.
4. The Schmid-Leiman hierarchical factor solution (Schmid & Leiman, 1957; Wolff & Preising, 2005) was computed and examined in order to clarify the relationships among higher-order and first-order factors. Using a matrix algebra procedure, this solution extracts higher-order factors and obtains loadings of individual scores on higher-order and initial rotated factors.

Based on the HBDI® scoring key, continuous score scales were computed as 10 group subscores. These subscores consist of the 10 quadrant scores that are generated from the HBDI®'s four sets of core scores: *Work Elements* (WE), *Key Descriptors* (KD), *Adjective Pairs* (AP), and *Twenty Questions* (TQ). Core scores are obtained from the most central and extensive sections of the HBDI® and best match the central construct measured by the instrument: preference choice under scarcity, as discussed above.[3]

For statistical analysis purposes, the Phase 1 study integrates two core score groups (i.e., WE and KD) by adding them together for each quadrant. The integration of WE (4 items per quadrant) and KD (7 items per quadrant) resulted in a more comparable subscore (made up of 11 items) compared to the AP and TQ subscores, which contain 12 and 18 items, respectively, per quadrant measured. By using comparable numbers of items per subscore, the variables used in this analysis are better balanced and more reliable for factor analyses.

After the integration of WE and KD, there were three sets of scoring categories: *Work Elements and Key Descriptors* (WEKD), AP, and TQ. The first two sets inform subscores for each quadrant: A, B, C, and D. The third set informs subscores for Quadrants B and D only. The 10 subscores are as follows:

1. Work Elements and Key Descriptors – A (WEKD–A)
2. Work Elements and Key Descriptors – B (WEKD–B)
3. Work Elements and Key Descriptors – C (WEKD–C)
4. Work Elements and Key Descriptors – D (WEKD–D)
5. Adjective Pairs – A (AP–A)
6. Adjective Pairs – B (AP–B)
7. Adjective Pairs – C (AP–C)

[3] There are two less central and less extensive groups of HBDI® scores (*Learning and Career Choice Scores* and ancillary scores, including *Hobbies*) that were not used in this study. These scores will be considered in later reports and in the forthcoming HBDI® manual.

8. Adjective Pairs – D (AP–D)
9. Twenty Questions – B (TQ–B)
10. Twenty Questions – D (TQ–D)

These 10 subscores formed the basis for a hierarchical score-level factor analysis, discussed above, that was similar to the validation work accomplished in 1980–1982 by Bunderson, Olsen, and Herrmann (1982). Factor analyses were computed based on the keyed answer values for each of the four quadrant scores from each of the major sections of the HBDI®.

Results and Discussion

Question 1: Bipolar Structure

The first question concerned whether quadrant scores exhibit a strong bipolar structure (A vs. C and B vs. D) as indicated in the Whole Brain® Thinking Model. To answer this question, a factor analysis was conducted for the 10 subscores described above. Using the principle axis factor extraction method, 10 factors were extracted, 3 of which contained eigenvalues greater than 1.0 (Factors 1–3), as shown in Table 1.

Table 1

Extracted Factors: Total Explained Variance

Factor	Initial Eigenvalue			Sum of Squared Loadings			
				Extraction			Rotation
	Total	% of Variance	Cum. %	Total	% of Variance	Cum. %	Total
1	4.17	41.72	41.72	3.86	38.56	38.56	2.66
2	2.36	23.60	65.32	2.10	20.98	59.54	2.84
3	1.01	10.08	75.40	0.79	7.88	67.42	2.01
4	0.82	8.22	83.63				
5	0.41	4.09	87.71				
6	0.40	4.01	91.72				
7	0.38	3.76	95.48				
8	0.31	3.09	98.57				
9	0.14	1.41	99.98				
10	0.00	0.02	100.00				

Note. When factors are correlated, rotated sums of squared loadings cannot be added to obtain a total variance.

As Table 1 shows, Factors 1–3 account for 38.6%, 21.0%, and 7.9% of the variance, respectively, for a total cumulative variance of 67.4%. These three factors were then rotated according to the oblique simple structure, as shown in the rotated pattern matrix in Table 2.

Table 2

Rotated Pattern Matrix Indicating Bipolar Structure

Subscore	**Factor 1 A (-) vs C (+)**	**Factor 2 B (-) vs D (+)**	**Factor 3 L (-) vs R (+)**
WEKD-A	–.70		–.43
WEKD-B		.79	
WEKD-C	.73		
WEKD-D		–.52	.60
AP-A	–.70		–.45
AP-B		.81	
AP-C	.98		–.30
AP-D		–.47	.71
TQ-B		.49	–.25
TQ-D		–.49	.30

Note. Rotation converged in 6 iterations. Loadings below .18 are not shown.

A rotated pattern matrix is useful in factor interpretation when the meaning of the factors is already known, as was the case in this study. The numbers (called loadings) indicate the extent to which the variables can be reproduced by the known factors. As can be seen in Table 2, the loadings of the first two factors indicate the two sets of bipolar scores. For the A versus C Factor, Quadrant A scores loaded strongly negatively and Quadrant C scores loaded strongly positively. Likewise, for the B versus D Factor, Quadrant B scores loaded strongly negatively and Quadrant D scores loaded strongly positively. These two factors are plotted in Figure 2. The third factor is discussed below.

Factors A v C and B v D

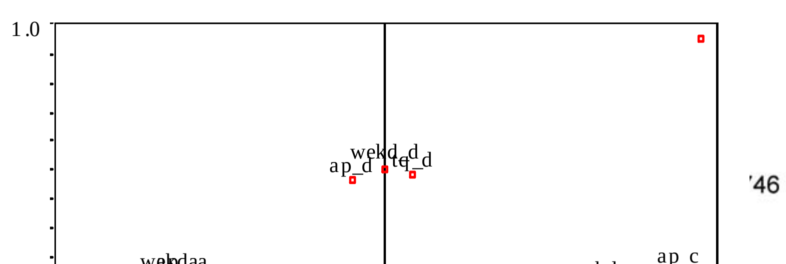

Figure 2. Plot of Schmid-Leiman Factors 1 and 2.

In Figure 2, four clusters of scores are clearly evident, each representing the subscores for a given quadrant. Along the horizontal line (Factor A vs. C), the two Quadrant A subscores (WEKD–A and AP–A) are clustered at the left, and the two Quadrant C subscores are clustered at the right. Along the vertical line (Factor B vs. D), the three Quadrant D subscores are clustered at the top, and the three Quadrant B subscores are clustered at the bottom. When Figure 2 is rotated clockwise 45 degrees, the plot resembles the orientation of the Whole Brain® Thinking Model, with each quadrant's loadings in their proper positions (see Figures 1 and 2). Thus, we conclude that, consistent with our hypothesis, the double bipolar structure of preference clusters is still evident for the HBDI® in this international sample.

However, it is still important to explain Factor 3. This factor appeared to be a left-to-right factor, similar to the higher-order left-to-right factor. Unlike previous validation studies, this factor emerged at the same level as the bipolar factors. Compared to Factors 1 and 2, however, it accounted for substantially less variance—7.8% compared to 59.5%. Thus, it appeared that some aspect of the international sample, or the legacy key as applied to the core scores, brings out the left-to-right factor more strongly.

The factor intercorrelation matrix showed that Factor 3 correlates negatively with Factor 1 ($r = -.14$) and positively with Factor 2 ($r = .21$). Also, Factors 1 and 2 are intercorrelated negatively (–0.14). These correlations indicate the possibility of a meaningful higher-order factor. The meaning is the long-established left-to-right factor found over the years from the HBDI®. A Schmid-Leiman solution can be computed in order to detect any higher-order factors. Such factors, if any, would then be compared with Factor 3. This analysis would help us determine whether Factor 3 is simply an artifact of the higher-order factor. If not, an unknown and unexpected factor had emerged that requires an explanation.[4] The results of the Schmid-Leiman solution are shown in Table 3.

Table 3

Factor Loadings of Schmid-Leiman Solution

Subscore	HOF L (-) to R (+)	Factor 1 A (-) vs C (+)	Factor 2 B (-) vs D (+)	Factor 3 L (-) vs R (+)
WEKD-A	-.48	-.64		-.37
WEKD-B	-.18		-.76	
WEKD-C	.34	.66		
WEKD-D	.45		.50	.52
AP-A	-.48	-.63		-.39
AP-B	-.33		-.77	
AP-C	.32	.89		-.26
AP-D	.44		.45	.61
TQ-B	-.30		-.47	-.22
TQ-D	.33		.47	.26

Note. Loadings below .18 are not shown.

In Table 3, the higher-order factor column of loadings (marked “HOF”) indicates the relationship of the higher-order factor with each of the 10 subscores. As can be seen, this relationship indicates the presence of a left-to-right higher-order factor. All A and B subscores (left-brain) are negative, and all C and D subscores are positive (right brain). Notice that the loadings for Factors 1 and 2 remain very high, but loadings for Factor 3 are reduced substantially (except WEKD-D and AP-D). While generally reduced in absolute value below those found in the HOF, the loadings in Factor 3 show an identical positive–negative pattern as found in the higher-order factor. Further investigations of the plots and statistical relationships between the HOF and Factor 3, both using WEKD and WE and KD separately, corroborated

[4] It is important to remember, however, that with an eigenvalue of 1.01, Factor 3 barely qualified as a meaningful factor (eigenvalue > 1). Except for the value of examining it via this higher-order factor investigation, it could appropriately be ignored.

this similarity. The evidence suggests that the relationship between the two factors approaches a strongly positive linear relationship.

Thus, it is possible that a rotation could be found that would absorb Factor 3 entirely into the higher-order factor. This possibility was not examined in the Phase 1 study. However, if a similar third factor should emerge in future homogeneous samples (single language-translated versions of the HBDI®), it is possible that a confirmatory factor extraction to the hypothesized structure would succeed in fitting the data to a hierarchical model consisting of one higher-order factor and two, rather than three, first-order factors.

Question 2: Left-to-Right Higher-Order Factor

The foregoing results enable us to answer the second question of this study. This question concerned whether a single higher-order left-to-right factor emerges, as expected by HBDI® theory and research. It is apparent that the single higher-order factor calculated in Table 3 is consistent with the left-to-right factor established in previous studies. The largest negative loadings are for Quadrant A, followed by Quadrant B; similarly, the largest positive loadings are for Quadrant D, followed by Quadrant C.

In conclusion, it is clear that the left-to-right structure of the HBDI® is still evident. Only one higher-order factor emerged as a result of this study, and that factor matches the previously established left-to-right factor.

Conclusion

The purpose of the Phase 1 study was to investigate the structural validity of the HBDI®, using a large international sample from 1986–2000. This investigation consisted of two hypotheses. First, we hypothesized that the bipolar structure of Quadrants A versus C and Quadrants B versus D would emerge strongly and clearly from the analysis of the 10 core subscores. Second, we hypothesized that, given a confirmation of the original bipolar structure, the only higher-order factor to emerge would be the previously established left-to-right factor.

Both study hypotheses were confirmed. First, there were in fact two negatively correlated clusters of scores at both ends of each of two continua of choices. Second, there was a left-to-right preference cluster factor that emerged as a higher-order factor. Both of these structures are closely connected in meaning to the Whole Brain® Thinking Model, thereby supporting the structural validity and substantive meaning of the HBDI® quadrant scores.

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Phase II: Validation Study

Better Thinking. Better Performance. Better Results.

Executive Summary

This research paper reports results from a Phase 2 validation study for the Herrmann Brain Dominance Instrument® (HBDI®). This is one study from a series of ongoing validation studies conducted with the aim of gathering evidence to support the validity argument for the HBDI®. This Phase 2 study focused on investigating the structural validity of the HBDI® using an updated sample from 2000–2005 (*N* = 181,139) and using an experimental scoring key that seeks to advance the reliability, validity, and balance of the HBDI® through continuous improvement. The authors set out to replicate structural validity results from previous studies (e.g., Phase 1 validation study) using a more diverse international sample as well as to provide additional evidence by including items that were omitted from the Phase 1 study. The paper contains two hypotheses and one research question. First, it was hypothesized that the bipolar structure of Quadrants A versus C and Quadrants B versus D would continue to emerge strongly and clearly from analysis of the most valid subset of core scores. Second, it was hypothesized that the established left-to-right, higher-order factor would continue to emerge. Finally, the research question asked whether including the additional items would produce an effect on the factors that is consistent with the hypothesized dimensional structure of the HBDI®.

Results provided the strongest and cleanest evidence to date for the structural validity of the HBDI® and suggest the instrument can be used to measure individual differences in thinking preferences as purported by the underlying theory. Both study hypotheses were confirmed. First, there were two negatively correlated clusters of

scores at both ends of each of two continua of choices (i.e., Quadrants A vs. C and Quadrants B vs. D). Second, the left-to-right factor emerged as a higher-order factor (i.e., left-brain and right-brain preferences). Lastly, it was demonstrated that including the additional items produced results that further support the structural validity of the HBDI® and align with the Whole Brain® Thinking Model. As anticipated, the experimental scoring key, which was developed as the next iteration of the legacy scoring key in an attempt to continuously improve the HBDI®, correlated very strongly with the current scoring key but provided added reliability, validity, and balance. Ultimately, the experimental scoring key demonstrated that it can inform next steps in the endeavor to continuously improve and advance the theoretical and empirical rationale for the HBDI®. In sum, the results of the Phase 2 validation study are in harmony with the theory behind the Whole Brain® Thinking Model and support the structural validity and substantive meaning of the HBDI® quadrant scores. Furthermore, the study produced the strongest evidence to date, and it did so on a sample that is more generalizable based on the greater degree of international representation.

Validity of the HBDI® Four-Quadrant and Left-Right Structure: A Structural Validation Study Using New Millennium Database

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Editor's Note

This paper reports results from a validation study for the Herrmann Brain Dominance Instrument® (HBDI®), which is a psychometric instrument that measures multiple integrated systems of mental preferences. This is one study (Phase 2) from a series of ongoing validation studies that aim to collect and document evidence contributing to HBDI®'s validity argument. The main focus of this paper is to examine a recent sample from Herrmann International's global database to provide updated evidence for the structural validity of the HBDI®. This paper also examines the impact of an experimental scoring key and HBDI® items that were not analyzed in the previous validation study (Phase 1). This study corroborates the Phase 1 validation study and provides the strongest evidence to date in support of the structural validity of the HBDI®. Further, the additional HBDI® items produced scores that were consistent empirically and theoretically with the core scores. These results suggest the instrument aligns with its theoretical underpinnings and can be used to measure individual differences in thinking preferences as purported.

Edited by: Daniel S. Stanhope, PhD

Abstract

This document reports results from a structural validation study (Phase 2) of the Herrmann Brain Dominance Instrument® (HBDI®), using a sample from Herrmann International's database of completed surveys from 2000–2005 (*N* = 181,139). The Phase 2 study implements an experimental scoring key, Version 6x (V6x), consisting of the subsets of questions that best match the underlying theory of the HBDI®. Using the experimental key, this study provides the strongest and cleanest confirmation of the HBDI®'s structural validity to date, in terms of the double bipolar structure of preference clusters (Quadrants A vs. C and Quadrants B vs. D) and a higher-order left-to-right factor. These results are consistent with, yet stronger than, previous validation studies, and are also strongly consistent with the HBDI® theory. In addition, the Phase 2 study explores the inclusion of 2 *Other Choice* scores involving life choices in education and occupation. These choices generate subscores for Quadrants A and C. The addition of these 2 scores allows for the same number (3) of scoring categories for all 4 quadrants. A factor analysis was conducted that demonstrates the 2 scores are consistent empirically and theoretically with the 10 core subscores.

Introduction

Overview and Purpose

This document reports the second internal validation study in the validation update program initiated by Herrmann International in 2000. This study is called the New Millennium (Phase 2) validation study because its sample was drawn from surveys taken from years 2000–2005. This document was prepared based on an initial study that was completed in 2006, and on re-analyses to confirm the accuracy of the results reported here. The major aspect of internal validity addressed in the study is the structure of the profile scores derived from responses to questions in the Herrmann Brain Dominance Instrument® (HBDI®).

The structural validity of the HBDI® is an integral part of an ongoing, unified validity argument of the HBDI®. This argument is explained in more detail in the report of the first internal validation study (Phase 1 Validation Study; Olsen, Bunderson, Newby, & Wendt, 2013). The structural aspect of validity is concerned with evidence that the instrument's scoring structure matches the internal structure of the construct domain—the specific number, type, and theoretical meaning of the dimensions (Messick, 1995, pp. 745–746).

To verify the structural validity of the HBDI®, it must be demonstrated that profile scores cluster in a way consistent with the HBDI®'s underlying theory. According to this theory, there are four distinct clusters of thinking preferences, organized into a conceptual model using four quadrants of a circle, and designated by the letters A, B, C, and D and the colors blue, green, red, and yellow. These preferences are patterned according to two bipolar pairs that each contain left-brain and right-brain thinking preferences (A vs. C and B vs. D). These pairs also contrast upper and lower halves, while the left half (A and B) constitutes a *left mode* and the right half (D and C) constitutes a *right mode*. Left mode and right mode, respectively, contain types of thinking that early brain researchers identified with the left and right brain (see Figure 1).

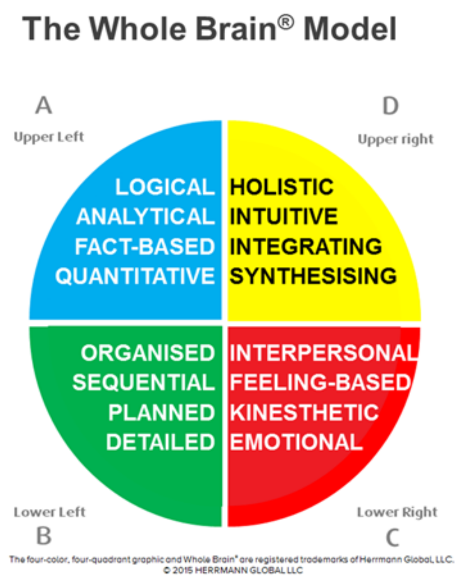

Figure 1. Visual representation of Whole Brain® Thinking Model.

According to the HBDI®'s investment hypothesis, these bipolar pairs emerge as a result of one's choices, across his or her lifespan, under conditions of limited time and resources. Choices are influenced by one's genetic dispositions, early nurture, and later experiences. Each person is constantly choosing to "invest" time, talents, and efforts in ways that cater to and strengthen a particular profile of thinking preferences, often at the expense of developing other preferences. Over time, an individual's pattern of characteristic preferences across many life choices cluster in a way that can be explained by the HBDI®'s bipolar, four-quadrant structure, referred to as the Whole Brain® Thinking Model.

The HBDI® simulates these life choices by using question types that require preference choices under scarcity (the number of choices are restricted in a variety of ways in different content sections of the instrument). The HBDI® quadrant scores thus reflect one's past investment choices and predict future choices, providing measures of an individual's characteristic pattern of thinking preferences.

There is growing empirical evidence that the thinking processes articulated by HBDI® theory are similar to individual differences in specialized types of thinking found through other brain-related research. Moreover, some pairs of thinking processes seem to contrast almost as opposites, as in HBDI® theory. That is, strong individual differences exist in brain organization or specialization that are consistent with the two polar opposite types of thinking preferences. This evidence is part of the argument for substantive validity of the HBDI® and is documented in a forthcoming HBDI® technical manual. The evidence for structural validity of the HBDI® involves the contrasting pairs A versus C, D versus B, and Left versus Right. Structure is thus intertwined with substance. It is also intertwined with the content aspect of validity, because the different sections of the HBDI® sample from different content areas—different domains of life choices.

What is Important about the New Millennium (Phase 2) Study?

Early on, during the creation of the instrument, Ned Herrmann used brain studies and statistical studies to guide the creation of the early HBDI® toward types of thinking found in early brain research (Herrmann (1988). In the early 1980s, researchers used statistical methods, including factor analysis, to validate and guide the improvement of the internal structure of the HBDI® (Bunderson, 1988, pp. 359-364; Bunderson & Olsen, 1980; Bunderson, Olsen, & Herrmann, 1982; Ho, 1988). The most recent study in this series was the first in Herrmann International's current validation update program. In this study, commonly referred to as the Phase 1 Validation Study, Olsen and colleagues (2013) examined the structure of the HBDI® profile scores using a large international sample of surveys taken from 1986–2000. Through a factor analysis of the instrument's 10 core subscores, the Phase 1 study confirmed that the bipolar A versus C and B versus D structure is strongly present in the structure of the instrument's 10 core subscores as then scored. The study also confirmed the presence of a higher-order, left-to-right factor, a necessary factor for HBDI® theory. This factor has been confirmed in previous validation studies. This left-to-right factor also ties back to the historical development of the instrument. The HBDI® began by examining the possibility of a continuum ranging from left-brain thinking to left-center and right-center thinking to right-brain thinking. The results of the Phase 1 study confirmed that the HBDI® has retained its structural validity in spite of the growing internationalization of the instrument.

The purpose of the Phase 2 study was to update the validity argument for the HBDI® on a more recent sample of HBDI® profiles, and to do so using an experimental scoring key. The three key questions that were addressed with this sample and data are as follows:

1. Do quadrant scores (using the most valid subset of core scores) exhibit a strong bipolar structure (Quadrants A vs. C and Quadrants B vs. D)?
2. Does the long established left-to-right, higher-order factor still emerge, as specified in the Whole Brain® Thinking Model?
3. Does the inclusion of two *Other Choice* score categories (for Quadrants A and C) produce an effect on the factors that is consistent with the

hypothesized dimensional structure of the HBDI®?

We hypothesized that, by using a new experimental key, the bipolar structure of the HBDI® would emerge more strongly and with a cleaner simple structure when compared to previous analyses. Conditional upon support for this first prediction, we hypothesized further that the only higher-order factor that would emerge is the left-to-right factor. The third question is a research question in which we hoped to find that certain important *Other* scores as well as the core scores are consistent with the dimensional structure of the HBDI®.

Unlike the Phase 1 study, the Phase 2 study was restricted to surveys taken after January 1, 2000. Thus, by comparing the data of the Phase 2 and Phase 1 studies, it can be observed whether or not the factor structure has changed during the 5-year period examined, in comparison with the Phase 1 sample. This previous sample used surveys taken primarily during the 1990s. If the factor structure changes over the time periods, it will be an indication that the meanings of questions have changed. Such an evaluation is important, considering that meanings of terms can evolve in different ways over time. Another important reason for comparison is the increasing internationalization of the HBDI®, including the larger percentage of surveys translated to languages other than English in the Phase 2 sample.

Another difference with the Phase 2 study is its use of the previously mentioned experimental scoring key. This key is referred to as the Version 6x (V6x) key. The V6x key was developed as recommended following a variety of additional analyses conducted as a larger part of the Phase 1 validation study. Following up on the recommendation to seek improvements in the key for the existing V6 key, a simulation of the forthcoming Version 7 of the HBDI® was developed using the Phase 2 international sample. This V6x key was created by identifying the best subset of questions that should remain in the HBDI®. The V6x key does not score a small number of questions that are not performing as well as the ones retained. The experimental key also standardizes the quadrant scores, then it provides a common mean and standard deviation for each quadrant score. This standardization differs from the previous key (the *legacy key* used in versions up through V6.1) in which differential weights were used for different content sections of the HBDI®. Applying a common mean and standard deviation is necessary for V7 of the HBDI® and future versions, since the number of questions cannot be expected to remain constant under continuous data-driven improvements.

The experimental V6x key is expected to help Herrmann International update the HBDI® to a new Version 7.0, which will consist of new and additional questions in various time-tested sections, and some substantially reworked sections. The current version of the instrument is Version 6; for this study's sample, surveys from Versions 4, 5, and 6 are included. The V6x key may be applied to all the data in this sample because the questions used in the new key from V4, V5, and V6 are identical for all three versions.

The investigations using the Phase 1 sample examined all items in the instrument and determined that only the *core scores* would be factor analyzed at that time. These findings have influenced the development of the V6x key based on this Phase 2 sample. Core scores were found to best match the central construct measured by the HBDI®: preference choice under scarcity, as discussed above. There are four sets of core scores: *Work Elements* (WE), *Key Descriptors* (KD), *Adjective Pairs* (AP), and *Twenty Questions* (TQ). For statistical analysis purposes, however, the WE and KD sets were combined into one category: *Work Elements and Key Descriptors* (WEKD). This combination was implemented in the Phase 1 study.[1] After the integration of WE and KD, there were three types of core subscores: four WEKD scores, four AP scores, and two TQ scores, which generates 10 subscores. The WEKD and AP categories inform scores for each quadrant: A, B, C, and D. The TQ category informs scores for the B and D quadrants only.

Beyond the core scores, the *Other Choice* score category items (Learning and Career Choices and Hobbies) were not included because the question format and detailed questions in the Version 7 instrument will differ importantly from Version 6 in all these sections. However, this study's analysis does include two *Other Choice* scores, as discussed below in connection with the third research question of this study.

Several other items were not scored by the V6x key because they are not concerned with preference choice under limitations; rather, they are concerned with matters for which there is little if any choice (e.g., hand dominance, energy level, motion sickness). Although these items have been useful in the past, and some will continue to be used in Version 7, their separation from the quadrant scores will be clearly specified in Version 7. The ones retained will, however, continue to serve as helpful teaching metaphors to HBDI® practitioners, and indicators for assisting in the formation of working groups during workshops.

[1] In this and the Phase 1 study, the integration of WE (4 items per quadrant) and KD (7 items per quadrant) resulted in a WEKD score more comparable (11 items) to the AP and TQ groups, which contain 12 and 18 items, respectively, per quadrant measured. By using comparable core score groups, subscores were better balanced and more reliable for factor analyses.

How well does the V6x key, consisting of only a subset of the core score questions, which in turn form only a subset of the entire HBDI®, compare with the existing quadrant scores being used in the field by Herrmann International and their partners? The V6X key has a high correlation with the legacy key (see Table 1). The first row displays correlation coefficients between the keys' core scores for each quadrant score. The second row shows the correlations when the two Learning and Career Choice (LC) scores are added to the sum of the core scores (these scores are explained in detail in connection with the third research question below). As can be seen, the correlations are very high, ranging from .87 to .93 for the correlation of the core scores (.95 when LC_A and .93 when LC_C is added). Thus, it is clear that although the V6x key was designed to up-step the validity of the HBDI®, the V6x quadrant scores share a substantial amount of variance with the corresponding quadrant scores derived from the legacy key in use prior to the introduction of V7.0.

Table 1

Core Score Correlations between V6x Key and Legacy Key

	Quadrant A	**Quadrant B**	**Quadrant C**	**Quadrant D**
Core Score Sum	.93	.87	.90	.92
CoreSum+LC	.95		.93	

Note. *N* = 181,139. LC = Learning and Career Choice.

It is expected that the V6x key will be used as a baseline for comparing Version 7's indices of reliability and validity. Furthermore, the extensive database of V6 and previous surveys can be searched and each item can be analyzed to evaluate the performance of translated versions of the items in different languages. The design goal is to have sets of translated questions that perform the same measurement function in each translated version of the HBDI®. To achieve this, items must be replaced if they do not measure the same construct as in the American English anchor version. The assumption of wide generality of the constructs measured by the HBDI® is based on considerable user experience with translated versions of the HBDI®, now including 20 different languages. Users report that the preference profiles cross cultural boundaries. This assumption will be challenged by plans to examine the different language versions to assure that each item taps its targeted construct. The generalizability aspect of a great validity argument will require more data before the assumption of generalizability has strong support.

Method

Sample

Similar to the Phase 1 study, the Phase 2 sample was obtained from Herrmann International's database of scored HBDI® surveys. The sample was restricted to

181,139 HBDI® surveys taken between January 1, 2000 and March 6, 2005. The original sample size was 210,636 (the total number of surveys completed during the specified time period); however, surveys from male respondents were randomly removed until the sample approximated international population ratios (i.e., 51% females, 49% males). The resulting sample consisted of 181,139 surveys (92,368 females and 88,771 males).

Although it was not feasible to compute demographic statistics for participants' selected countries and languages, this study's sample is known to consist of a diversity of backgrounds. Considering that the pace of internationalization for the HBDI® has increased in the past 5 years, the Phase 2 sample is more diverse than the Phase 1 sample. North America is still the largest component, but there are many other linguistic and national groups represented, including European, Middle Eastern, Pacific Ocean, Asian, and South American countries. The majority of surveys use the English language, with U.S. English being the largest subset. After British and International English samples, French and German are the next largest language groups, respectively.

It can be argued that the meanings of adjectives, occupational names, hobbies, and other HBDI® items may differ between countries, as well as within countries (e.g., between native and foreign language speakers). Therefore, an important future endeavor is to analyze the HBDI® structure within specific national and linguistic subgroups in order to assess the extent to which translated questions and section formats perform the same measurement functions across translations. The aim of the Phase 2 study, however, was to use the new V6x key to investigate the structure of the

HBDI® on an international population as a whole. If successful, this study's results would serve as a baseline for conducting separate analyses for each translated version of the HBDI®.

Factor Analytic Procedure

This study used similar factor analytic procedures that have been used before (e.g., Phase 1) to investigate the structural validity of the HBDI®. Such procedures are well recognized by measurement scientists as being appropriate and technically accurate ways of analyzing the structural validity of a set of scores from cognitive aptitude and ability, personality trait, and preference tests (e.g., Carroll, 1993; Cattell, 1978; Gorsuch, 1974, 1983; Tucker & MacCallum, 1997).

The factor analyses discussed in this report use quadrant subscores consisting of many items. The general procedure for the factor analyses was as follows:

1. Factors were extracted and the number of factors to use was determined. Where possible, we followed Carroll's (1993, pp. 83–90) advice to use the principal axis (first order) factor extraction method.
2. The selected number of factors was rotated to an oblique simple structure using the promax analytic rotation program with kappa set to 4. The determination of the number of factors to rotate is based on the so-called "Kaiser test" (eigenvalues greater than 1). In the case of this study, however, where a theoretical model exists, the meaning of the factors is of greater importance. Where appropriate (including a very low eigenvalue greater than 1), the number of factors extracted will be limited to the two hypothesized factors.

3. A factor intercorrelation matrix was computed in order to detect second-order factors, if any. The matrix was then analyzed to obtain the second-order pattern loadings.
4. The Schmid-Leiman hierarchical factor solution (Schmid & Leiman, 1957; Wolff & Preising, 2005) was computed and examined in order to clarify the relationships among higher-order and first-order factors. Using a matrix algebra procedure, this solution extracts higher-order factors and obtains loadings of individual scores on higher-order and initial rotated factors.

Comments on Factor Analytic Methods Used in this Study

The use of principal axis factor extraction and promax rotation is often applied with datasets where no pre-existing theory exists. This application is labelled “exploratory factor analysis” and the methods used in this study are often thought of as being exploratory. However, the intent of this study is to confirm a hypothesized factor structure, not to explore a set of variables. There is a prediction for every score in the battery in terms of exactly which factor it should load on strongly and at which end of the bipoar factor; also, on which factor each variable should show very small or zero loadings. Thus, the use of these factor analytic methods is confirmatory, but without a statistical test of goodness of fit. When the fit between data and theory is good enough qualitatively, it provides a link with past studies, and offers an opportunity for applications of more advanced methods later.

It is recommended that confirmatory factor analytic methods should be used starting with homogeneous samples consisting of only one language version. In the Phase 1 study and in this one, the broader question of factor structure was addressed in an international sample, first with the existing key, and then with an experimental key that bridges the HBDI® toward the new Version 7.

Similar to the Phase 1 study, the subscore variables for analysis were computed as continuous score scales for 10 group subscores. These subscores consist of the 10 quadrant scores that are generated from the HBDI®'s core score categories (discussed above). The analyses reported below used the standardized version of each score. The 10 subscores are as follows:

1. Work Elements and Key Descriptors – A (WEKD–A)
2. Work Elements and Key Descriptors – B (WEKD–B)
3. Work Elements and Key Descriptors – C (WEKD–C)
4. Work Elements and Key Descriptors – D (WEKD–D)
5. Adjective Pairs – A (AP–A)
6. Adjective Pairs – B (AP–B)
7. Adjective Pairs – C (AP–C)
8. Adjective Pairs – D (AP–D)
9. Twenty Questions – B (TQ–B)
10. Twenty Questions – D (TQ–D)

Results and Discussion

Question 1: Bipolar Structure

The first question concerned whether quadrant scores exhibit a strong bipolar structure (A vs. C and B vs. D) as indicated in the Whole Brain® Thinking Model. To answer this question, a factor analysis was conducted for the 10 subscores described above. From this analysis, 2 first-order factors emerged, accounting for 67.7% of the variance. The third eigenvalue was .928; thus, a third factor was not extracted because it was less than 1.0. As can be seen in Table 2, the loadings of these factors confirm the two hypothesized bipolar scores. For Factor 1, Quadrant B scores loaded strongly negatively and Quadrant D scores loaded strongly positively. Likewise, for Factor 2, Quadrant A scores loaded strongly negatively and Quadrant C scores loaded strongly positively.

Table 2

Rotated Pattern Matrix Indicating Bipolar Structure (Key V6x)

Subscore	**Factor 1: B (-) vs. D (+)**	**Factor 2: A (-) vs. C (+)**
WEKD–A		–.77
WEKD–B	–.71	
WEKD–C		.72
WEKD–D	.74	
AP–A		–.89
AP–B	–.80	
AP–C		.83
AP–D	.80	
TQ–B	–.70	
TQ–D	.74	

Note. Loadings below .11 are not shown.

These two factors provide the strongest confirmation to date for the two bipolar dimensions, having high loadings where they should appear and low loadings elsewhere. In addition to the loadings being generally higher than they were in previous studies, the structure of the analysis is clean and simple. The outcome of a simple structure means that the factor loadings of most or all variables are high on the factors on which they are expected to load (i.e., the variable is an indicator of the factor), and they approach zero (no correlation) on the factors on which they are not expected to load. In this analysis, no unmatched loadings are greater than or equal to .11—in fact, 6 of the 10 unmatched loadings are below or equal to .05. Conversely, all theorymatched loadings exceed .70, which is high for group subscores on an instrument such as the HBDI®. This clean and simple structure of the 2 first-order factors is plotted in Figure 2.

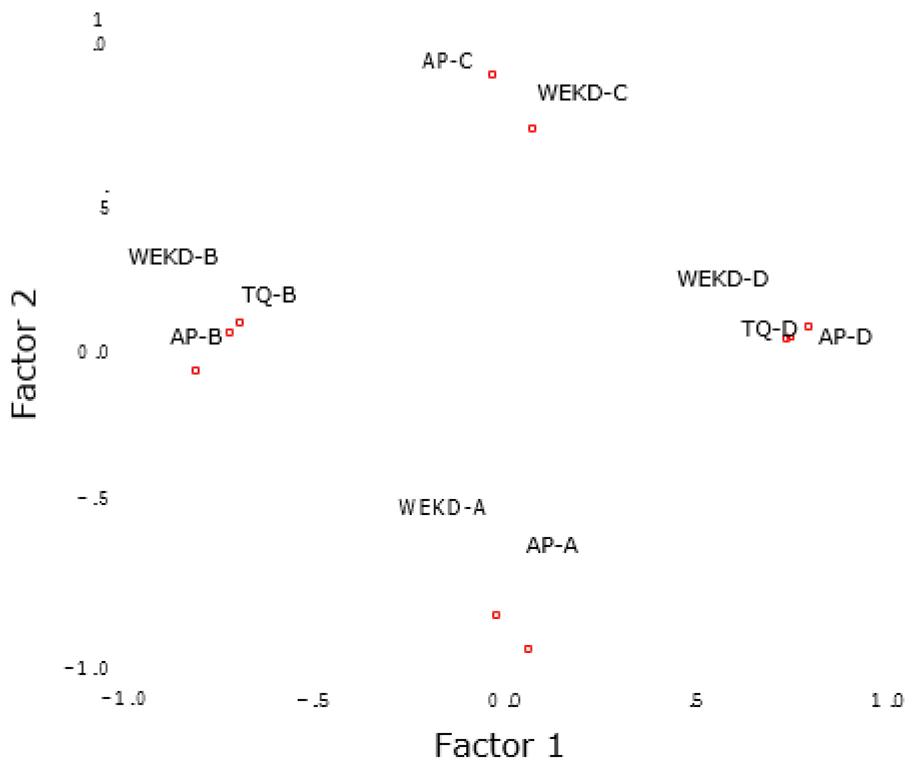

Figure 2. Simple structure of four-quadrant model (Key V6x).

In Figure 2, Factor 1 is Quadrant B on the left (negative) end of the horizontal axis, opposite Quadrant D on the right (positive) end. Factor 2 is Quadrant A on the top (positive) end of the vertical axis, opposite Quadrant C at the bottom (negative) end. This graphic gives meaning to the description of the HBDI® quadrants as located on opposite ends of two bipolar factors. All of the core scores are clustered closely to their respective factors, showing the desired simple structure. Flipping the A and C clusters so that A is at the top (reflecting any variable in this manner is standard practice in factor analysis) and rotating the resulting graphic 45 degrees counterclockwise gives the standard HBDI® quadrant structure shown in Figure 1.

Considering the clear structure of the four-quadrant model of the HBDI®, it would be expected that each of the four quadrant scores is internally consistent. This expectation was verified using the coefficient alpha method of internal consistency reliability. As can be seen in Table 3, the quadrant scores have respectable reliability coefficients for the components of a four-part profile. Each of these profile components (quadrant scores) is interpreted and used repeatedly in applications promoted by Herrmann International—these quadrant scores must meet standards of reliability. According to international standards,[2] internal consistency reliabilities above .70 are regarded as good, and those above .80 are regarded as excellent (EFPA, 2005).

Table 3

Internal Consistency Reliability Coefficients of Quadrant Scores (Key V6x)

N	**Quadrant A**	**Quadrant B**	**Quadrant C**	**Quadrant D**
181,139	.84	.77	.80	.81

In summary, the factor analytic results for Question 1 indicate that the bipolar four-quadrant structure of the HBDI® is still evident. In fact, this study marks the strongest hypothesized loadings and cleanest simple structure yet reported in the series of validation

studies of the four-quadrant structure of the HBDI®.

Question 2: Left-to-Right Higher-Order Factor

The second question concerned whether a single higher-order left-to-right factor emerges, as expected by HBDI® theory and research. To answer this question, a

[2] According to the reliability standards of the European Federation of Psychologists' Associations (EFPA) reliability standards (2.11.1, 2.11.2; p. 23), internal consistency reliabilities above .70 are generally considered to be "good" while those above .80 are in the "excellent" range. The sample size reported here is more than adequate.

Schmid-Leiman solution was conducted. The factor intercorrelation of .31 between Factors 1 and 2 was used, as calculated in the analysis of the 10 scores reported above (see Table 4).

Table 4

Factor Loadings of Schmid-Leiman Solution (Key V6x)

Subscore	**HOF: L (-) vs. R (+)**	**Factor 1: B (-) vs. D (+)**	**Factor 2: A (-) vs. C (+)**
WEKD–A	–.44		–.65
WEKD–B	–.35	–.61	
WEKD–C	.42		.59
WEKD–D	.44	.61	
AP–A	–.46		–.75
AP–B	–.47	–.69	
AP–C	.42		.68
AP–D	.44	.66	
TQ–B	–.36	–.59	
TQ–D	.39	.62	

Note. Loadings below .07 are not shown. HOF = Higher-Order Factor.

In Table 4, the higher-order factor column of loadings indicates the relationship of the higher-order factor with each of the 10 subscores. It is important to note that, consistent with the standardized nature of the V6x key, the subscores have been standardized as *z*-scores (*M* = 0, *SD* = 1). It is clear from the table that the higher-order factor column of loadings is indicative of the left-to-right factor established in previous studies. The largest negative loadings are for Quadrant A, followed by Quadrant B; similarly, the largest positive loadings are for Quadrant D, followed by Quadrant C.

In addition, two of the three Quadrant B loadings are smaller (in absolute value) than both of the Quadrant A loadings (excepting AP–B). Likewise, two of the three Quadrant D loadings are larger than both of the Quadrant C loadings (excepting TQ–D). These relationships are shown in Figure 3.

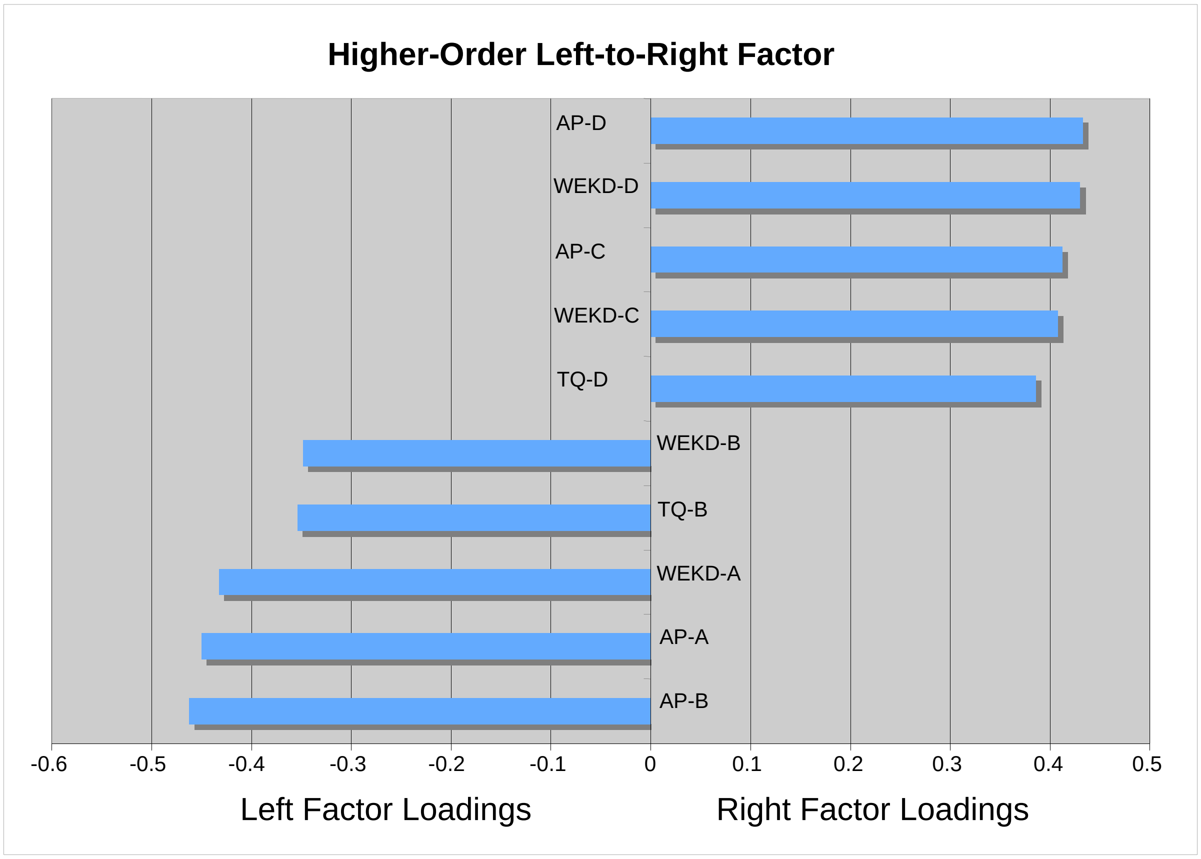

Figure 3. Plot of core subscores arranged along Left-to-Right Factor.

In comparison with results from the first-order analysis shown in Table 2, the simple structure for Factors 1 and 2 is just as clean. Although the highest loadings are generally no longer in the high .70s and .80s (due to the higher-order factor absorbing some variance from the factors), the unmatched scores are closer to zero, each being below .07.

In summary, it is clear that a single higher-order left-to-right factor is evident in factor analyses of the 10 subscores of the HBDI®, using the experimental V6x key.

Question 3: Effects of Two *Other Choice* Scores on the Factor Structure

The third question of the Phase 2 study concerned whether the effect of adding the two *Other Choice* scores is still predictable by HBDI® theory. Are the two *Other Choice* scores for A and C aligned with the A-to-C bipolar factor established using the core scores as predicted? Are they unrelated to the B-to-D bipolar factor as predicted? By including these two scores, the number of scores for each bipolar dimension will be equalized because *Twenty Questions* generates only B and D quadrant scores.

Consistent with the investment hypothesis, *Other Choice* score items pertain to life choices under scarcity. The questions in the HBDI® relate to choices respondents have made in avocational, educational, and occupational areas. In the current version of the HBDI® (Version 6), these items are grouped into four categories: *Hobbies* (HO), *Best-Worst Subjects in School* (BW), *Educational Focus* (EF), and *Occupation* (OCC). Excluding Hobbies, the remaining questions are called *Learning and Career Choices* (LC). The two subscores created for this study, LC–A and LC–C, combine information from three of the four categories: BW, EF, and OCC. The legacy key was used for the EF and OCC categories; for BW, a slightly improved key was used. Currently, these categories do not have an equal number of scoring opportunities as do the three core score categories. This factor analysis can determine whether the three LC item types demonstrate structural validity when included with the core scores. If successful, this analysis will confirm the value of the revised LC scores in V7.0. It will also provide a baseline against which to compare the factor structure of V7.0 and subsequent versions.

It is important to note that the two LC scores will still need improvements regarding the type and number of items in order to be balanced in reliability and number of scoring opportunities with the core score categories. Nevertheless, the two scores have a modest degree of internal validity, as evidenced by their correlations with the core scores for Quadrants A (r = .49) and C (r = .38). Thus, it appeared likely, prior to this analysis, that the two scores would meaningfully contribute to Quadrants A and C. In the future version of the HBDI® (V7.0), we expect that additional questions and clarification of the EF and OCC scores will further improve the correlations with A and C and also contribute to Quadrants B and D.

This factor analysis is similar to the first-order analysis (above) except 12 subscores (10 core scores and 2 LC scores) will be included. As a result of an eigenvalue slightly greater than one, three factors were extracted, as shown in the rotated pattern matrix in Table 5.

Table 5

Rotated Pattern Matrix Indicating Three Factors

Subscore	**Factor 1: B (-) vs. D (+)**	**Factor 2: A (-) vs. C (+)**	**Factor 3: A–C Doublet**
WEKD–A		–.59	–.28
WEKD–B	–.70		.16
WEKD–C		.75	
WEKD–D	.76		.13

AP–A		–.75	–.14
AP–B	–.80	–.18	.10
AP–C		.98	–.15
AP–D	.83		.12
TQ–B	–.69		
TQ–D	.74		
LC–A			–.90
LC–C			.90

As Table 5 shows, the contribution of the two LC scores (LC–A and LC–C) to the A-versus-C factor is not revealed with this extraction and rotation. The two scores do not load onto either of the two bipolar factors (Factors 1 and 2), but rather form a third factor (Factor 3) with high positive and negative loadings for the two LC scores. This factor is called a *doublet factor* because the two LC loadings are so highly correlated (negatively) with each other as almost exclusively to define the weak Factor 3. The remaining loadings shown, greater than .10, are all relatively low.

Interestingly, the A and C loadings in Factor 3 are positively correlated to those in Factor

2 (A vs. C). A factor intercorrelation matrix indicated a substantial positive correlation of .50.

This strong relationship between Factors 2 and 3 indicated that if only two factors were extracted, the result might be that the two LC scores would load on the A-to-C factor as predicted.

The extraction of three factors, based empirically on the weak eigenvalue of 1.19—and based on the theory behind the HBDI®—is thus seen to be a poor choice (this is referred to as overfactoring and is not uncommon when using the eigenvalue-greater-than-one criterion). Thus, the analysis was repeated and respecified so that only two factors were extracted and rotated. This resulted in a reduction of explained variance from 72.5% to 67.5%. This percentage of explained variance is somewhat less than the variance in the previous 10-subscore analysis. The result of extracting and rotating the two hypothesized factors is shown in Table 6.

Table 6

Rotated Two Factor Pattern Matrix

Subscore	Factor 1: B (-) vs. D (+)	Factor 2: A (-) vs. C (+)
WEKD–A		–.80
WEKD–B	–.73	
WEKD–C		.66
WEKD–D	.73	
AP–A		–.81
AP–B	–.83	
AP–C		.70
AP–D	.79	
TQ–B	–.70	
TQ–D	.74	
LC–A		–.69
LC–C		.70

Note. Loadings below .13 are not shown.

As can be seen, simple structure in Table 6[3] is comparable to the structure generated by the analysis from 10 subscores. It is evident that the inclusion of LC score along with the core scores measures substantially the same quadrant preference

[3] In order to display consistent loadings, the values in Factor 2 were multiplied by -1. This was also done in Table 6 to reflect the weak doublet factor, Factor 3. Reflecting and rotating otherwise arbitrary mathematical vectors to align them with a theory that has guided the construction of the measures is standard practice.

clusters as do the core scores, even though the high negative correlation between LC–A and LC–C can produce a weak doublet factor if the eigenvalue-greater-than-one criterion is used instead of the meaningfulness criterion.

The clean and simple structure of this analysis is shown from the plot in Figure 4. This plot is comparable to the plot of 10 subscores (Figure 2). To better portray the familiar four- quadrant structure of the HBDI®, the graph has been edited to reflect A as negative and C as positive. When the graph is rotated 45 degrees counterclockwise, the quadrant structure is evident.

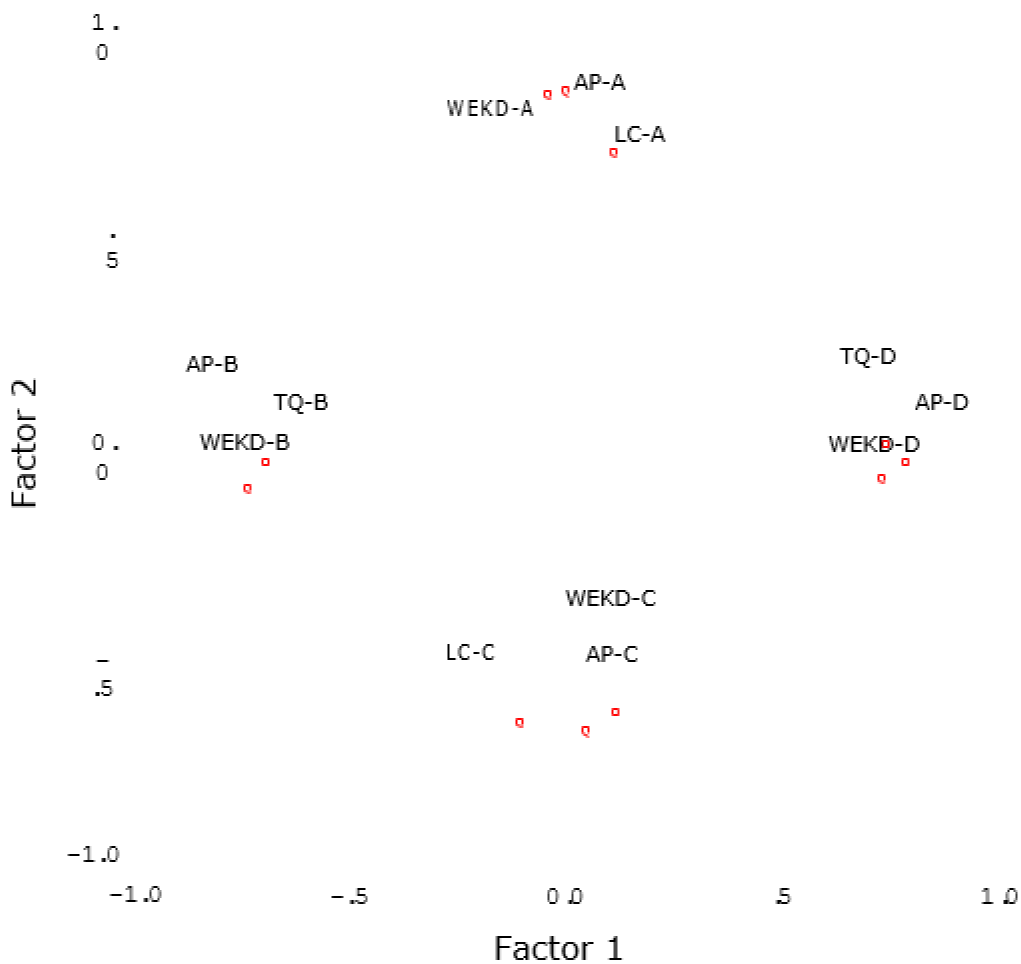

Figure 4. Simple structure of the four-quadrant model, using 12 subscores (Key V6x).

Implications for HBDI® Users

The version 6X scores are highly correlated with the existing quadrant scores, which currently use V6.1 of the HBDI®. This means that the experimental scores will reflect the same meanings as the existing quadrant scores of the HBDI®. The 6X scores connect backward to the existing instrument and forward to the new V7.0 instrument. The LC scores for A and C are about the same as the scores in the current V6.1 instrument. The net of this study, in connection with the previous Phase 1 validation study, is that the meanings taught by HBDI® practitioners, and explained to users in their profile package, are supported by validity evidence. The scores do reflect the four-quadrant structure. By carrying the V6x subset of scores forward into V7.0, the statistics that support the internal validity and reliability of the new version should be no lower than the statistics reported herein, and have excellent prospects of improving in a future program of continuing instrument improvement.

Conclusion

The Phase 2 validation study demonstrates that the theoretical structure of the HBDI® is still evident empirically, including the two pairs of bipolar preferences and the higher-order left- to-right factor. In addition to generally replicating the findings of the Phase 1 study, questions 1 and 2 indicate that neither the passage of time nor increased internationalization of the instrument has diminished the structural integrity of the HBDI®. Moreover, the results using the experimental V6x key are stronger and reveal a cleaner simple structure than any validation of the HBDI®'s four-quadrant structure to date. Regarding the third question of this study, it was demonstrated empirically that the inclusion of two *Learning and Career Choices* subscores (LC–A and

LC–C) had the predicted effects. Both the theory of structure, and the meanings inherent in the construction and use of these scores, is fully consistent with the HBDI®'s Whole Brain® Thinking Model as has been understood for years by HBDI® users.

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