THE VALIDITY OF THE HERRMANN BRAIN DOMINANCE INSTRUMENT

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Abstract: The Herrmann Brain Dominance Instrument (HBDI) provides a valid, reliable measure of human mental preferences when applied in a professional way, interpreted in conformity with the four-quadrant model, and scored with the approved scoring method.

This appendix was prepared to answer questions that both lay users and professionals in measurement might ask about the Herrmann Brain Dominance Instrument (HBDI). Does the HBDI actually measure what it purports to measure? Is there defensible evidence based on accepted measurement standards that the scores produced by this instrument provide a reliable and valid guide to a person's profile? Are preferences for different types of thinking, feeling, and doing (expressed through responses to the instrument) an outward manifestation of an underlying reality in the brain as this book suggests? Under what circumstances does the HBDI maintain its validity? These types of questions boil down to three basic ones:

1. Is the four-fold or quadrant model of brain dominance supported by research data?

2. Is the instrument a good way to quantify and thus make evident the underlying preferences for different ways of using the brain?

3. Is a particular application of the scores appropriate and valid?

The short answer to these questions is that on the basis of the investigations reported in this appendix and elsewhere, there is good evidence that:

1. Four stable, discrete clusters of preference exist.

2. These four clusters are compatible with the model explained in this book.

3. The scores derived from the instrument are valid indicators of the four clusters.

4. The scores permit valid inferences about a person's preferences and avoidances for each of these clusters of mental activity.

5. Furthermore, the use of the instrument meets high professional standards as it has so far been applied in learning, teaching, counseling, and self-assessment settings.

More detailed answers are considered under the following, headings:

Professional Standards for Using the HBD Instrument: Relationship to Validity (This section discusses the circumstances under which validity can be maintained.)

Understanding Validity: The Kinds of Evidence to Support Validity. (Construct-related evidence is the most important. Constructs are the set of ideas or concepts in the quadrant model about how people prefer to use different brain processes, or avoid them. This section discusses internal and external construct validity.)

The Constructs Measured by the HBD Instrument (This section defines the constructs and the assumptions underlying their measurement. It reports some descriptive statistics from a study of 8000 cases.)

Review of Six Studies Dealing with Internal and External Construct Validity. (This is the longest, most technical and detailed section of the appendix. The studies all used the statistical method of factor analysis to validate inferences about how the items

internal to the HBDI group together and how the scores from the HBDI relate to *external* scores of both similar and different constructs.)

Future Research (Three areas of future research are discussed: (1) refining the scoring and improving the scaling of the HBDI, (it) validating inferences about how people with different profiles activate their brains differently, and (3) validating inferences about how people with different profiles behave differently, that is how do they do such things as learn, teach, communicate with one another, work together in teams, and select occupations.)

PROFESSIONAL STANDARDS FOR USING HBD INSTRUMENT: RELATIONSHIP TO VALIDITY

Major test publishers of quality measurement instruments all subscribe to a set of professional standards for the construction, evaluation, and use of tests. Standards are published in *Joint Standards for Educational and Psychological Testing,* promulgated by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education (loins Standards, 198~). Some organizations publish their own standards, which expand on but generally refer to the Joint Standards (e.g., ETS, 1986). The Joint Standards list validity as the first item of concern, but also deal with reliability, sound methods of test development and revision, scaling, norming, score comparability, and the quality of manuals and user's guides.

For a small organization that is not a major test publisher, Applied Creative Services, Ltd., has done an exceptional job of establishing high professional standards for test development, validation, and appropriate use. This book, with its appendix, is the most detailed presentation to date of the concepts and methods on which brain dominance measurement and its uses are based. Documentation has been provided and research has been supported throughout the entire history of the development of the HBDI, and research continues today. High standards of instrument interpretation and use are maintained by requiring certification of those who would score and use the HBDI. Regularly scheduled certification workshops have been given at least 4 times each year since 1981 to maintain these high standards.

Certified users know that the HBDI is not a "test." The Joint Standards also recommend against using the word "test" to describe questionnaires dealing with personality, interest, attitude, and the like. It is a preference profile derived from evidence about the varieties of mental processes evident in the human brain, and refined on the basis of practical application and continuing empirical research over a period of about 11 years.

Standards for use of a measurement instrument really depend upon the uses for which the instrument was intended. In selecting from the various professional standards and codes for quality, fairness, and professional use of measurements, the following stand out as being most applicable to the HBDI:

1. *To Communicate Clearly With all Intended Audiences*. The materials and instructions associated with the use of the HBDI should avoid technical jargon and explain the relevant brain preference constructs and the profile scores clearly. This book augments and replaces earlier materials but does not replace the certification experiences.

2. *To Supply Evidence of the Quality and Usefulness of the Measurement Instrument*. The materials associated with the HBDI should represent accurately the quality and usefulness of the instrument and base such statements on empirical evidence (e.g., the data cited in this appendix). Another kind of evidence is provided to users during certification workshops and management education workshops where the instrument is used.

3. *To Help Users Interpret Their Scores*. Users must be informed of how to interpret their scores. At a certification workshop considerable effort is expended in providing full explanations of the scales used for reporting the scores and how these are related to the brain preference constructs. Information can be provided about different subpopulations and their profiles. Questions are given to help instrument users avoid over-interpreting and misinterpreting scores. Users are told about other sources of information in addition to the profile scores to help them make the kinds of inferences appropriate to the four-fold brain dominance model.

The communication of proper instrument interpretations of the HBDI goes beyond what can be written in a book like this or in a test manual. Much of the attitudinal, emotional, and interpersonal information that assures the proper use of the HBDI can best be communicated nonverbally. This is done through the establishment of "learning communities" in a properly conducted workshop or learning situation involving the HBDI.

The best insurance against misuse of the instrument is to avoid the evaluation of different profile categories as being good or bad. The modeling demonstration by good teachers through both verbal and nonverbal means occurs in certification and other workshops where proper instrument use is taught. These teachers develop a positive and creative climate in which all participants' profiles are seen as good and where authenticity is valued. If a teacher or group leader with a Lower Left preference made disparaging remarks and created a climate where being "right-brained" was seen as being somewhat "flaky" or undesirable, or if a right-brained person in authority designated the lower left as boring, or stereotyped left-brained people as "Nerds", the climate for the appropriate use of the profile scores would be damaged. The means to promote growth rather than a bland acceptance of everyone as different and wonderful is provided through the "whole-brain concept." Groups can aspire to function together in a more "whole-brained" way, valuing the contributions of the disciplined managers and analytical left-brained people within the group, as well as the interpersonal

facilitation of those people who prefer the activities in the Lower Right quadrant and the intuitions of those people who favor the activities of the Upper Right quadrant. In addition to fostering acceptance of the contribution of different people within a group, the whole-brained concept leads individuals to aspire to greater situational access to less preferred quadrants.

Because of the need for a subtle and frequently nonverbal climate that honors all profile differences, yet strives for greater completeness, certification workshops are desirable. Such workshops epitomize proper use of the HBDI. This is why it has been seen as so important by Ned Herrmann and his associates to offer certification and other workshops to provide the level of understanding required for professional application of the HBDI.

Coachability and Fakeability

As with other questionnaires dealing with interests, attitudes, and preferences, the validity of the HBDI depends upon honest responses from each respondent. While studies have not been conducted, it is probable that a coached person (a reader of this book, for example), could greatly influence the scores if he or she knew that selection to an important job, promotion, or reduction in force were at stake, and had information about what profile was desired.

The instrument is probably less subject to faking than to coaching because without some coaching about the nature of the brain dominance constructs, providing information about the descriptive adjectives, work situations, and so on for each quadrant, a person trying to fake answers may not know how to do it. The resulting profile might still reveal the primary patterns of dominance and avoidance.

Appropriate Uses of the HBDI

Appropriate uses for the HBDI include, but are not limited to the following areas:

1. *Better Understanding of Self and of Others*. To learn about one's own brain dominance profile and to understand how that profile compares to that of other people and other occupational groups.

2. *Enhanced Communication*. To be able to understand and predict the way different profiles might affect communication which leads to problems or to enhancement of interpersonal relationships on the job and at home.

3. *Enhanced Productivity Through Teamwork*. To learn how to increase the productivity and enjoyment of interpersonal associations in work, at home, and elsewhere. This can be accomplished through honoring and building upon the great advantages of differences in enhancing the effectiveness of teamwork in problem-solving, teaching and learning, etc.

4. *Work Climate for Creativity*. To identify inhibitors to creativity, productivity, and a positive work climate, and to establish the conditions for a positive work climate that will foster creativity.

5. *Authenticity*. To foster a climate of authenticity among groups of people who must work together.

6. *Enhanced Teaching and Learning*. To improve the effectiveness of learning and teaching and to achieve greater enjoyment in learning and teaching.

7. *Better Management*. *To* improve management of human activity in a variety of jobs ranging from supervision of work groups at lower levels to executive functioning at the highest level.

8. *Counseling*. *To* relate a person's profile to the profiles of others in college major fields, occupational groups, work groups, or families as a guide to clarifying and improving current relationships or making wise decisions.

9. *Building Composite Learning Groups*. To organize, in advance of a group learning activity, heterogenous or homogenous pairs, triples, sextets, etc. in order to promote understanding of interpersonal communications and of "whole-brained" teamwork in creative problem-solving and design.

Experience exists in the professional use of the HBDI in all of these applications. The conditions for validity and proper use can be maintained in each of these applications.

Uses of the HBDI Where Validity Cannot be Assured

The HBDI was not validated for use in clinical or diagnostic testing, nor in medical or psychological classification. It was not validated for use in admissions testing prior to educational or training programs nor for placement at different levels within these programs. (Using a test score as a condition for admission is an application distinctly different from the use of the HBDI to assemble optimal seminar groups.) It was not validated for use in selection testing for employment, for professional and occupational licensure and certification, nor for making a decision about a person that is beyond the control of that person.

While validity studies have not been performed for these uses, such studies could be done. Because of the strong

cross-situational applicability of the instrument, demonstrated later in this appendix, it is likely that some such studies would show high predictive validity. For example, a study which used the HBDI to select people for jobs would likely show that people selected using the HBDI would be more satisfied and successful in that job. Nevertheless, the continued validity of such an application would be suspect for two reasons:

1. In common with other questionnaires of its type, the validity of the HBD instrument depends on honestly and freely given responses by the individuals who take it. This in turn depends on the climate of trust created by the persons in authority who require the instrument. It would be difficult to maintain conditions under which respondents would continue to believe that "honesty was the best policy."

2. Preference questionnaires like the HBDI are inherently coachable. In the employment selection example, word would inevitably get out about what type of profile the employment office favored. Respondents could then learn to produce that profile without authenticity.

More validity studies are indeed needed to guide the users of the HBDI in the many applications in which the conditions for authentic responses and proper follow-up can be maintained. The areas of using profile scores in teaching and learning, in academic, vocational and interpersonal counseling, in work redesign, and in managing work groups are especially promising for future research.

Having considered the conditions of proper use under which validity can be maintained, we will now consider the topic of validity itself and the evidence for the validity of inferences drawn from the profile scores produced by the HBDI.

UNDERSTANDING VALIDITY: THE KINDS OF EVIDENCE THAT SUPPORT VALIDITY

Validity is generally recognized to be the most important consideration in evaluating a test or questionnaire instrument. The concept refers to the appropriateness, meaningfulness, and usefulness of specific inferences made from test scores. It is not the scores themselves that are valid or not valid, but rather the specific inferences we might make from those scores and from the scales underlying the scores. The test validation process is designed to accumulate evidence to support a given type of inference. Different studies are needed for different types of inferences. The studies cited herein focus on inferences about four clusters of mental preference and how different profiles may be interpreted. Other studies would be needed to validate predictions about occupational satisfaction, management effectiveness, the different effects of teaching treatments for different profiles, etc.

There are several types of evidence used to support the validity of different inferences. These include content-related evidence, criterion-related evidence and construct-related evidence. Constructs are concepts or ideas about what an instrument measures. Construct validity is what this appendix is all about and is discussed in detail later.

Content-related Evidence of Validity

Content validity or content representativeness refers to the closeness of the match between the content categories involved in some description of a content domain and the content of the items in the instrument. For example, the terms and tasks sampled by test items in an insurance agent certification exam should match and sample well from the terms and tasks used by knowledgeable and competent insurance agents. Since the Herrmann Brain Dominance Instrument is designed to measure preferences, and is not a test of knowledge, content validity is not an important issue here.

Criterion-related Evidence of Validity

Criterion-related evidence requires additional measures besides the HBDI scores. These additional measures serve as criteria for judging that certain people are good at something or are possessed of some valued quality. High grades are a criterion of academic success. Publications and patents are criteria of professional productivity. Scored responses to a questionnaire may serve as a criterion of marital or job satisfaction. The HBDI scores may be correlated with such criteria to validate inferences about which profiles are related to academic success, professional productivity, marital or occupational satisfaction, etc. The HBDI scores themselves may be used as a criterion to select groups of people of distinctly different profiles in order to validate inferences about how these people will react or perform on some other measure of interest.

Criterion-related evidence of validity is important to this appendix. It is a part of most of the studies cited herein. This kind of evidence, however, is really most appropriately viewed as evidence to support the construct validity of an instrument. A recent scholarly and complete treatment of the entire topic of validity by Samuel Messick of Educational Testing Service (Messick, 1989) argues that construct related evidence of validity is the only fundamental and necessary type of evidence. All other kinds of evidence for validity are supportive in confirming or disconfirming inferences about the construct validity of an instrument. Before turning to this topic, let us consider first the older idea of face validity.

Face Validity

The topic of face validity is of particular relevance to a preference questionnaire. Face Validity means that an instrument, the

scores, and their explained meaning "look or feel right" to the persons who will use them.

While the terms "Face Validity" and "Self-Validation" are not found in the section on validity of the latest Standards for Educational and Psychological Testing (Joint Standards, 1985), these concepts are highly pertinent to instruments such as the HBDI, which is dependent on honestly given preference judgments and forthright biographical reports.

Word of mouth recommendation is one major way that information about the HBDI has been spread. The recommendation of trusted others influences the attitude with which a person first fills out the instrument. Thus, "self-validation" is of the utmost importance. Self-validation may occur when a new user has an experience in a workshop, at home, or on-the-job that may be interpreted using information about his own or other people's profiles.

Experiential validation means that such users interpret the inferences drawn from their scores as valid and relevant to their own, and other people's communication, thought processes, work, and personal creativity. Situations where self-validation can occur are sought by Ned Herrmann and his colleagues in all applications of the HBDI. Self validation is not an attempt to gather selected testimonials, but to offer each user the opportunity to develop his/her own testimonial from personal experience with the instrument.

Face Validity to Users

The face validity of the HBDI to most individual users appears to be very high. They find the four-fold model easy to understand and to visualize, perhaps because it is not complex, perhaps because they are familiar with the bilateral symmetry of their body parts and with known personal preferences for hand, foot, eye, side of face, ear, and presumably, with parts of their brain. This concept of dominance is also exemplified by handedness. This conceptual familiarity is an aid to face validity. So is the ready agreement of users with their own profile: "That's me alright." The user's personal profile is defined using the very adjectives the user picked to describe himself or herself. This ready understanding and acceptance is claimed by HBDI advocates to be one of the strongest advantages of the instrument.

Evidence for this form of user acceptance of their profiles could be validated empirically. Such evidence was collected by questionnaire in 1979 and 1980, but these data have not been published. After that face validity was monitored for a time in groups by show of hands. Since so few exceptions to the face validity of the quadrant model and of an individual's own profile were found using these methods, use of the HBDI continued without further efforts to collect empirical evidence of user acceptance. Instead, considerable effort is made to provide users with experiences which are self-validating. Exercises such as describing the "work I do best," followed by contrasting the responses of people representing dominance in the different quadrants offer users the opportunity to validate their own profile in contrast with others in a group. These activities both demonstrate and enhance the understanding and acceptance of a person's own profile. This understanding and acceptance is what we have chosen to call "face validity". These activities also meet high standards for instrument use related to clear communication, and assistance to users in interpreting their scores.

Face Validity to Professionals

It is also useful to consider the face validity of the concept of brain dominance measurement to experts in scientific fields associated with the brain. Here it is safe to say that the very idea of left brain-right brain dominance remains somewhat controversial. For reasons mentioned (i.e., bilateral symmetry and selective dominance of body parts), the idea of dominance and avoidance within different recognizable "areas" of the brain is easy to grasp by the public. Such ideas can have considerable face validity. This has led to a surge of popularizations in advertisements, cartoons, articles, and demonstrations and claims by consultants, lecturers, and writers that may oversimplify and erroneously interpret research on brain lateralization, specialization, and dominance.

This background of popularization of brain concepts has occurred before our rapidly changing scientific understanding of the brain has even begun to stabilize. In reaction to the oversimplification, it is easy to overlook those applications which have been tried and tested over many years, and for which serious attempts have been made to provide evidence of validity. The HBDI stands out in this respect, for it has been studied and improved over a period of 11 years before the publication of this book. Some claims have been validated. Others claims are replicable and can be demonstrated reliably in group settings, but have not yet been systematically quantified, confirmed or disconfirmed, and published.

Most professionals within a discipline ignore or quickly dismiss the work of those not certified in their own discipline. Some professionals, however, have taken the time to investigate the HBDI, and their articles, letters, and comments regarding the HBDI indicate that there are many more who support than detract. The increasing use of the HBDI in published articles, theses, and dissertations is evidence of acceptance by professionals.

As a colleague who has investigated the validity of his work. I have been asked by Ned Herrmann to evaluate the relevancy of the occasional attacks he has received. He has sent two, a letter and an article. These two detractors based their criticism on their impression that the model is making a statement about the geographical location of functions in specific areas of the brain. Despite impressions these writers may have formed, the four quadrant model explained in this book depends fundamentally on preference clusters and the idea of dominance or avoidance of these clusters for individuals, not on ideas about the localization of brain function.

Since preference and avoidance are the fundamental constructs of the HBDI, we will turn now to the topic of construct validity.

Construct Validity

Of the several types of validity, evidence of construct validity is the most general and the most relevant to the HBDI. The

word *construct is* a term frequently used by behavioral scientists to refer to a theoretical concept about some kind of human trait, capability, kind of process, etc., that is not directly observable. The ideas of left and right brain dominance are theoretical constructs, as are the four quadrants of the brain dominance model.

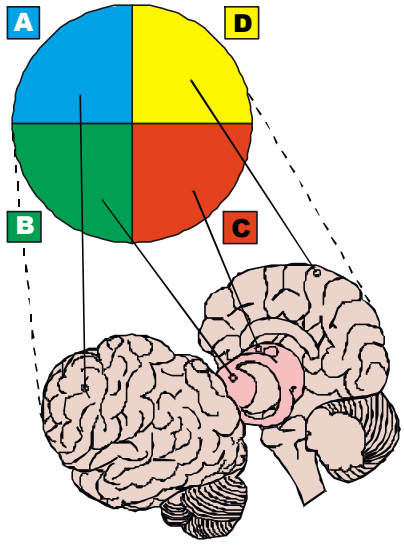
Internal Construct Validity. Internal construct validity refers to the number of distinct constructs measured by an instrument, often referred to as the "dimensionality" of the instrument. It also refers to the match of the scores to the dimensions; thus, it is concerned with the validity of the scoring key. There are four distinct constructs, but two pairs of them seem to fall along the opposite ends of two underlying dimensions of preference or avoidance.

Internal construct validation studies tell us which kinds of mental processes cluster together (e.g., logical and mathematical), and those which are negatively related or unrelated. Internal construct validity does not tell us anything about other important constructs not measured by the HBDI, or how important the four brain dominance constructs are as compared to others.

External Construct Validity. External construct validation enables us to assess the validity the entire four construct theory of brain processing by comparing the measures of the constructs internal to the HBDI to measures of constructs external to the HBDI. These external constructs can be either similar to or different from the constructs underlying the HBDI. We are able to predict whether external constructs should be positively or negatively related, or unrelated, to the HBDI scores. These predictions can be validated.

The constructs underlying the four-quadrant theory are very general. They were formed on the basis of observations of men and women in many important life situations; at work, at home, and at play. Thus, the constructs should relate to many important actions and decisions that can be observed (and sometimes measured) in situations other than that of responding to biographical and preference items on the HBDI.

Evidence of external validity can validate inferences drawn from the quadrant model of multiple brain dominance. It can help show how general and how useful the four constructs of brain dominance are in a variety of life situations. Construct validation is an unending process in this case because there are so many predictions or inferences that can be made from a model of preferences in brain processing. The existence of the HBDI scores makes it possible to confirm or disconfirm many of these predictions—doing so in the quantitative and replicable manner demanded by scientists.



THE CONSTRUCTS MEASURED BY THE HBD INSTRUMENT

The constructs measured by the HBDI are summarized metaphorically in reference to Ned Herrmann's insightful image of the rotated triune brain, seen from the back of the head, with emphasis on the dual cerebral and limbic hemispheres. Figure A-1 is a redrawing of Figure 3-12. Chapter 3 to emphasize the four keys constructs. The picture in Fig. A-1 helps us to see four major parts of the brain and reminds us that there exist four major clusters of preference or avoidance. Tracing along the intercommunication lines in Fig. A-1 can also suggest the great distance between the processes of A vs. C and B vs. D. These pairs are least often found preferred by the same individual, and dissonance is produced when the two opposites are widely divergent. The illustration also embodies the idea that the two left quadrants (upper left and lower left) and the two right quadrants (upper right and lower right) are "closer" than their opposites in the opposing hemisphere. Thus, the AB and CD pairs are found together and are more compatible. Figure A- 1 suggests geographic location of function. Thus it is perhaps the source of some criticism. The strong communication lines between the parts of the brain offset this criticism because they suggest that functions are typically distributed, not localized.

Definitions and Assumptions

There are several assumptions and definitions upon which brain dominance measurement is based:

1. Common words can be used to describe the many different information processes available for use in the normal human brain. These nontechnical words can be found in the brain specialization/ lateralization literature. These terms and descriptions are relevant to the application areas described in this book. The terms are understandable to persons of average education when used on the instrument and in communicating about its interpretation.

2. Individuals prefer a subset of the many brain processes potentially available to them. This preference is analogous to their preferences for the right versus the left hand, right versus left eye, etc. A strong preference for a particular subset of processes is called dominance of that subset. A tendency not to use a set of processes is called an avoidance.

3. Information-processing functions in the brain need not be considered one at a time because there are several major clusters of information processes. People tend to prefer one or two clusters more than the others. They may avoid one or two.

4. A person's characteristic preference pattern of dominance and avoidance can be determined from honestly given responses to questions about educational focus, career choice, work elements, inner self perception through free and forced adjective choices, values, and use of discretionary time. The questions involve the terminology discussed in 1 above. These preference responses, when combined according to a fairly complex scoring protocol, are strongly related to the person's characteristic dominance pattern, which manifests itself in perception, thinking, learning, communicating, and interpersonal relationships.

5. A person's Brain Dominance Profile is a model using numbers and a graphic which refers to that characteristic pattern of preference and avoidance.

The Constructs and Their Scores

Although the main independent constructs are the four quadrants plus Introversion/Extroversion, there are nine main scores derived from the HBD Instrument; Left and Right Dominance, the four quadrant scores, Cerebral and Limbic preferences, and Introversion/Extroversion. There are also several minor scores useful in making certain inferences, and a construct of balance referred to as being "whole-brained." Ranges and means are derived from the scores of 7989 individuals analyzed as a part of the doctoral dissertation work of Kevin Ho. About one third of these were women. These score means do not include any weight from college major or occupational choice, which would add up to 14 points to the sum of the two left vs. right score means and to the sum of the four quadrant score means.

1. **Left versus right brain dominance.** It is useful to measure an overall left versus an overall right brain dominance without making the cerebral/ limbic distinction. Two overall scores are given by the instrument, one for left and one for right. The left and right score means are summarized in table A-1.
2. 2. **The four quadrant constructs.** These constructs are the fundamental constructs in the four-fold model of brain dominance.

TABLE A- I

Breakdown and Summary of Left and Right Scores.

	LEFT SCORES			RIGHT SCORES		
	Low	High	Mean	Lo«-	High	Mean
Men	18	151	95.2	17	165	86.0
Women	27	141	81.0	32	173	102.3
Combined	18	151	91.0	17	173	91.11

A. *Upper left*—This construct implies a cluster of processes related to the preference for mathematical, technical, analytical, and logical thinking. These preferences express themselves in school, in work, in interpersonal relationships and in hobbies. See Table A-2.

TABLE A-2

Summary and Breakdown of Upper Left Scores

	LOW	HIGH	MEAN
Men	14	138	75.1
Women	11	128	53.3
Combined	11	138	68.6

B. *Lower left*—The construct of lower left refers to preferences for those processes which deal with an organized, planned, orderly, and step-by-step approach and avoidance of risk and novelty. See Table A-3

TABLE A-3
Summary and Breakdown of Lower Left Scores.

	LOW	HIGH	MEAN
Men	9	140	68.1
Women	18	129	68.8
Combined	9	140	68.3

C. Lower Right—This construct refers to a class of processes described as a concern for emotions, interpersonal warmth, and feelings, and as an interest in music and communication through speaking, writing, and reading. See Table A-4.

TABLE A-4
Summary and Breakdown of Lower Right Scores.

	LOW	HIGH	MEAN
Men	8	128	55.5
Women	23	126	74.9
Combined	8	128	61.2

D. Upper Right—This construct refers to the synthesizing and intuitive modes of thought: holistic, visual, imaginative thinking. See Table A-5.

TABLE A-5
Summary and Breakdown of the Upper Right Score.

	LOW	HIGH	MEAN
Men	15	179	73.9
Women	17	164	79.1
Combined	15	179	75.5

In addition to the four quadrant scores described above, adjective pairs scores are often singled out as reflections of preferences for the four quadrants. These are generally highly correlated with the overall scoring and indeed form a part of it. However, they show which quadrants are preferred when one is forced to make a choice.

3. **Cerebral versus Limbic scores.** Even though there is more evidence for an overall left versus overall right dominance mode, it is sometimes useful to look at the balance in a particular individual or group between cerebral (upper) and limbic (lower) processing. Two scores are provided which statistically combine the left and the right cerebral for an overall cerebral score, and the left and the right limbic for an overall limbic score. See Table A-6.

TABLE A-6
Summary and Breakdown of the Cerebral and Limbic Scores.

	CEREBRAL (UPPER)			LIMBIC (LOWER)		
	LOW	HIGH	MEAN	LOW	HIGH	MEAN
Men	40	156	99.04	33	153	82.1
Women	37	136	87.91	36	148	95.4
Combined	37	156	95.74	33	153	86.0

4. **Introversion/Extroversion.** This bipolar dimension is an old standby in personality theory. It refers to the extent to which an individual prefers to look within (introvert) for information about the world versus looking outside, especially to other people (extrovert). This dimension is measured in the Myers-Briggs Type Indicator, an instrument for classifying types of personalities based in the theories of the psychologist Carl Jung. The HBDI I/E score has been correlated with the Myers-Briggs Type score and is highly related. Introversion/Extroversion is rated on one 9-point scale in the HBD instrument, and other items also reflect this distinction. The

introversion/extroversion scores for the men and women combined range from 1 to 9 with a mean of 5.5. The introversion/extroversion scores for men ranged from 1 to 9 with a mean of 5.4. The introversion/extroversion scores for women ranged from 1 to 9 with a mean of 5.7.

5. **Minor scores.** The consolidated score sheet, generated when the HBDI is scored, breaks out several of the different components that go into the overall quadrant scores. This breakout sometimes provides additional diagnostic information. For example, Ned Herrmann has observed that a higher score in motion sickness, especially for a left-brained individual, is an indication that the individual may be more receptive to experiences which will broaden his or her acceptance of a less preferred quadrant, and thus move him/her toward being more "whole brained."

6. **The "whole-brained" construct.** This construct is a key one for personal growth. A person's preferences for different types of thought are not seen as inexorably fixed. While each dominance pattern is good and valuable in its own right, being characteristic in many cases of whole occupational groups with demonstrable social value, it is of adaptive value for an individual to utilize brain processes situationally. The circular profile grid displays a graphic metaphor of "being whole brained." While only a small fraction of the population is quadruple dominant, an individual can benefit from recognizing areas of avoidance and can practice less predictable and less stereotyped modes of thought, depending on the situation.

Reliability of the Scores

The "whole-brained" construct acknowledges that a person's brain dominance scores can change over time (e.g., an avoided quadrant may become more used through conscious effort). Despite this, the overall pattern appears to be fairly stable. Empirical data on test-retest stability has not yet been collected systematically. However, Kevin Ho found 78 repeated measures of the same persons in a large data set, and calculated the test-retest reliabilities (see Table A-7).

TABLE A-7
Test-Retest Reliabilities for 78 Repeated Measures.

Left	.96
Right	.96
A Quadrant	.86
B Quadrant	.98
C Quadrant	.94
D Quadrant	.97
Cerebral	.98
Limbic	.91
Intro/Extroversion	.73

Classes of Construct Validity Studies

A good program of construct validity for the HBDI would include the following types of studies:

1. *Internal construct validity studies* to determine the dimensionality of the instrument and the relationship of those dimensions to the four brain dominance constructs and to the scoring key. Two such studies are included in this appendix.

2. *External construct validity studies* to determine how general and pervasive the brain dominance constructs are across other domains of human traits that have been measured, such as personality, cognitive abilities, and learning and thinking styles and strategies. Those studies also validate specific predictions made from constructs of brain dominance. Three such studies are reported here, and an increasing number of new ones are beginning to appear in the thesis and dissertation literature and in journals.

3. *Generalizability studies*. Generalizability refers to the validity of the HBDI scores across different situations or contexts. The scores should be construct valid for either sex and for different cultures. Generalizability studies answer the question: Is the HBDI scoring valid for different languages, genders, and age groups, or do different keys need to be developed? There is evidence, not reported here, that it is generalizable.

4. *Experimental manipulation* is required to validate some inferences, such as what portions of the brains of people with different profiles are activated when they perform different tasks. A few studies are referenced herein, but this appendix is not the place for a thorough review of either these studies or the numerous studies of the HBDI that bear on other aspects of external validity.

Construct validation must be an ongoing process. When it stops, a set of constructs like the four-fold model of brain

dominance has stopped being useful, and an instrument like the HBDI has grown static. This appendix is thus only one response among many in an ongoing program of construct validation being conducted by numerous collaborators and users of the HBDI.

SIX STUDIES DEALING WITH INTERNAL AND EXTERNAL CONSTRUCT VALIDITY

While Ned Herrmann was still head of manager education at General Electric, his organization contracted with the WICAT Education Institution and later with WICAT Systems for a series of studies to determine the construct validity of his instruments and methods. Together with my colleague, Dr. James B. Olsen and a series of research assistants, we conducted several studies. These will be listed and discussed briefly in this section. A more detailed examination of each of the studies follows in a later section.

Study 1. A literature review. A literature review was conducted in 1979 spanning multiple measurement domains, including cognitive aptitudes, personality, thinking styles, learning styles, and learning strategies. The objective was to develop a battery of measures against which the HBDI scores could be compared and contrasted. This work is reported in a WICAT Technical Report (Olsen and Bunderson, 1980a).

Study 2. External Construct Validation. The first factor analysis of the 1979 version of the instrument used a battery of measures selected as a result of the first study, applied against a set of scores derived from the current Participant Survey and Twenty Questions Instruments. At this time the four-fold model of multiple brain dominance as described in this book had not been fully articulated, so the construct validation at that time was aimed primarily at two scores: an overall left and an overall right score. The results of the first factor analysis indicated that there was promise in the brain dominance scores, but that the instrument should be analyzed item by item and a better scoring procedure developed. This study is reported in a WICAT technical report (Bunderson and Olsen, 1980b).

Study 3. Internal Construct Validation. An item factor analyses of 439 cases, which included both GE and non-GE participants in management education workshops, was performed to establish internal construct validity of the existing scores. Ned Herrmann's holistic scores were found to be valid. New scoring procedures were developed as a result of this analysis. Bunderson and Olsen factored all of the items in both the Participant Survey and the Twenty Questions Instruments, developed a set of subscores, factor analyzed these, and obtained a remarkable construct validation of the four clusters of preference. The study was not published at the time, but is summarized below. The revisions resulting from this study were: (a) combining Participant Survey and Twenty Questions into one instrument; (b) adding a more balanced set of adjectives and work elements; (c) adding adjective pairs; and (d) introducing the circular quadrant graph. This new instrument and scoring procedure are now taught in the Certification Workshops conducted by Ned Herrmann.

Study 4. External Construct Validation. A second factor analyses used the old instrument but the new scoring procedure and applied to the same data set described in Study 2 above. It produced evidence of external construct validity and was documented in a WICAT Technical Report (Bunderson, Olsen, and Herrmann, 1982).

Study 5. External Construct Validation. The third factor analysis was performed by Olsen and Bunderson in 1982 using the new instrument, a battery of cognitive ability tests, several instruments measuring personality dimensions and learning and thinking styles and strategies. Subjects were 205 students at Brigham Young University. This study was not published at that time, but is summarized below.

Study 6. Internal Construct Validation. This study was conducted in connection with Kevin Ho's doctoral work in Instructional Science at Brigham Young University (Ho, 1987). Ho analyzed the items from about 8,000 HBD Instruments obtained through a variety of workshops conducted by Ned Herrmann and his colleagues during 1984, 1985, and 1986. One part of Ho's dissertation (which dealt with the use of the quadrant scores for occupational profiling) was to replicate the earlier internal construct validation study (Study 3 above). Some of Ho's results are summarized below.

A variety of theses and dissertations (several dozen) at a number of universities have used the HBDI, and senior investigators have employed it in studies, providing evidence for external validity related to other behaviorally measured constructs. In addition, some studies have been conducted to validate inferences about actual brain processing of persons with different HBDI profiles. It is beyond the scope of this appendix to summarize these.

Validity Study Summaries

Studies 2 through 6 will now be examined in detail.

Study 2. *The First Factor Analytic Study of the 1979 Versions of the Participant Survey and the Twenty Questions (143 Cases)*

Factor analysis is a multivariate statistical method commonly used in both internal and external construct validation studies. A factor analytic study starts with multiple variables (scores) on a large number of persons. It results in a reduced number of dimensions,

called "factors." The idea is that although there may be many separate scores dealing with a large number of processes that go on in the brain, there are only a few major constructs that deal with related clusters of processing activity. The idea is also that these constructs will, if all goes well, be apparent in the factors that result from the analysis. The first Factor Analytic Study involved 31 scores derived from 15 instruments. Six of these scores were derived from *Participant Survey* and *Twenty Questions*. These consisted of:

?? An overall right and an overall left score.
?? A "left center" and a "right center" score.
?? A right Twenty Questions and a left Twenty Questions score.

Herrmann had been using the Twenty Questions scores prior to this study and had developed two numerical scores, one for right and one for left. The *Participant Survey* was originally scored holistically to obtain overall "primary and secondary dominance" in four categories: left, left center, right center, and right. It was necessary to develop numerical scores for each of these four constructs, specifically for this study. The other tests in the battery were selected from several broad categories of human trait measurement: personality, cognitive abilities, learning styles, and learning strategies. These are discussed below in some detail since they were used not only in this study but also in two others.

Tests of Personality. Four scales were used from the Myers-Briggs Type Indicator, highly regarded as a measure of personality type. These included:

?? **Intuition/sensing.** *Sensing* individuals are said to obtain information from the five senses (according to the Jungian theory on which the Myers Briggs is based). These individuals look for "hard" facts and tangible information. The *intuitive* individuals obtain information from inferences, insights, and the search for relationships. They experience "gut" level perceptions about the meaning of information.

?? **Thinking/feeling.** The *thinking* individual thinks through problems and decisions analytically, objectively, and logically. The *feeling* individual weighs the implications of problems and decisions in terms of the feelings and values of the persons involved. This information is usually processed subjectively.

?? **Judging/perceiving.** The *judging* person wants to make decisions and judgments in an orderly, planned way. Once decisions are made, this individual will follow through with the decisions. He has deep beliefs about how the world is organized and would like to modify or change the world to better meet his needs. The *perceiving* individual wants to see, experience, and understand the world as it is. This individual wants to view every side of a question or issue and may avoid making decisions.

?? **Introversion/extroversion.** *Extroverts* gain information from the environment, from people, activities and objects. The extrovert prefers to work with others. The introvert gains information from self-referent thoughts, concepts, and ideas. The introvert prefers to work alone.

Tests of Cognitive Ability. Seven tests of cognitive ability were selected. Five were chosen from the ETS Kit of Factor Reference Tests (Ekstrom, French, Harman, and Derman, 1976). These five were Necessary Arithmetic Operations, Gestalt Completion, Street Gestalt Completion, Paper Folding, and Hidden Figures. Two tests, Necessary Arithmetic Operations Test and the "Similarities" subtest from the Wechsler Adult Intelligent Scale (1958) were chosen after telephone communication with neuropsychologists indicated those as good markers for cerebral left processing. The Gestalt Completion Test from the ETS Kit and the Street Completion Test (Street, 1931) were chosen to be related to holistic synthesizing abilities, supposedly of the right cerebral hemisphere. The Paper Folding Test from the ETS kit was also selected as being related to right hemispheric abilities. The Hidden Figures test from the ETS kit and a score derived from the Ravens Progressive Matrices, were selected as markers for integrated hemispheric abilities. Because of time limitations, only the eighteen even-numbered items were used from the Ravens Progressive Matrices, Advanced Set II (Ravens, 1962). These require both reasoning and visual abilities.

Tests of Cognitive Styles. Correlates for cognitive and learning styles came from four sources:

?? The *Hill Individual Difference Questionnaire* (Hill, 1976), supplied four subscales: (1) the verbal linguistic preference (VL); (a) verbal quantitative preference (VQ); (3) qualitative auditory (QA); and (4) qualitative visual (QV).

?? The *Paivio Individual Differences Questionnaire* (Hitchcock, 1978), an indicator of learning style, supplied two subtest scores—a verbal score (Verb) and an imagery score (Imag).

?? The *Word/Shape Sorting Test* (Galin and Johnstone, n.d.) consists of 60 items, each of which contains three shapes. Given these shapes, each with a word in it, subjects are asked to cross out one, leaving two related shapes or two related words.

?? Not a commonly recognized cognitive style test, *Face Recognition* (Benson, Van Allen, Hamsher, and Levin, 1975) was included because of its presumed relevance to the supposed right hemisphere ability to recognize faces.

Tests of Learning Strategies. Based on some early work by Claire Weinstein, James B. Olsen developed an instrument called

Learning Methods and Activities. This consisted of 35 scale items measuring how frequently a student used various learning strategies. Olsen performed a factor analysis from which he developed five subscores mentioned below.

1. Verbal learning strategies
2. Visual learning strategies
3. Selection of parts (keywords and main ideas)
4. Purpose oriented learning strategies
5. Personal experience oriented learning strategies.

Individuals Tested. The 143 participants all completed the 15 instruments using a self-administration procedure involving a cassette tape of instructions. The group included fifty-two General Electric employees, mainly managers, who had participated in workshops conducted by Ned Herrmann and 91 college students and graduates from Brigham Young University. The college sample was distributed between the following majors and graduates:

social science (15)
organizational behavior (12)
mathematics (11)
electronics technology (10)
accounting (9)
art and design (7)
honors (6)
life sciences (5)
business management (4)
engineering (2)
education (2)
foreign language (1)
physics (1)
computer science (1)
various college graduates (5)

The test battery took approximately 3 1/2 hours to complete and yielded 31 different profile scores.

Method. A largely exploratory, partly confirmatory factor analysis was conducted. It was partly confirmatory because several hypothesis which had been developed as a result of the literature review (Study 1) were examined in this study. It was determined by the appropriate tests that 10 factors should be extracted.

In factor analysis, the factors first extracted rarely correspond to constructs of interest to investigators. The first factors are mathematical abstractions that pick up the most variance in the correlations among the variables, 31 in this case. Such factors need to be rotated into a different configuration that will reveal constructs of greater interest. For example, if we correlated a variety of measures such as height, weight, shoe size, waist measurement, etc., we might extract two factors. The first one might look like generalized bigness, but we could rotate the two to define the two more meaningful dimensions or constructs of height and weight.

Using the principal factors method, 10 factors were extracted from the correlations among the 31 scores. These were rotated using a promax rotation program prepared by Gorsuch (1976). Some factor analysts recommend using orthogonal (uncorrelated) factors. We selected the promax rotation because we expected the factors to be correlated with one another to some degree. It is our assumption that the brain constructs are related, due to the many interconnections discussed in this book. There is no reason to expect that clusters of preference for different kinds of information processing will be totally uncorrelated; indeed, the correlations between factors are also of interest in the construct validation process.

Results. The salient factor loadings from the factor structure for nine of the ten factors are presented in Table A-8. (The tenth factor was not interpreted.) These factor loadings are correlation coefficients between the original score and the underlying dimension or construct. If a correlation is close to 1.0, the relationship is very strong and positive. If close to -1.0, the relationship is strong and negative. If close to 0, the variable or score has no relationship to the construct defined by the factor. The first factor accounts for the greatest portion of common variance, the second next most, and so on.

The factors in Table A-8 list only the scores with loadings greater than .29 or .30. You may assume that scores not listed were so close to 0 as to have no important relationship to that factor. In interpreting factor A, Intuition, Right 20 Questions and Right Participant Survey scores all have high loadings of .64 to .69. These are considered to represent a strong relationship to the factor in question, which we named "Innovative vs. Safe-Keeping Preference." This factor is bipolar, that is, it has two opposite poles. At the negative end we find Left Participant Survey and Left 20 Questions, also with high correlations of -.60 and -.62 with the underlying factor. We can infer that there is a construct of preference for certain ways of thinking, and that the intuitive, holistic, modes of the Right scores are at one end and the logical, linear modes of the Left scores are at the other. The existence of a bipolar factor dimension does not mean that the Left and Right modes are opposite ends of the same thing, but that if you prefer the one, you are likely to neglect or even avoid the other.

The reader can examine the other factors in Table A-8 to see what scores cluster together in the same factors, which factors are the strongest (listed in order), and which variables cluster together. One example of clustering that was not expected is Necessary Arithmetic Operations (a "Left" process) as factor B. which included the "Right" processing scores of Paper Folding, Gestalt Completion, etc. This shows that the kind of test (speeded ability test) is more important than the kind of process in this factor. In

general, considerable variance from the type of test is evident; speeded ability test, preference inventory, and self-reported use of learning strategies. This produced a larger number of factors than would be expected in a more homogeneous battery. Factors A, D, and I are composed of preference measures, B of cognitive tests, and C and H of learning strategies. The exceptions are E and F. which mingle preference with cognitive ability. Factor G mingles a behavioral measure, word-shape sorting, with visual learning strategies.

TABLE A-8
Salient Factor Loadings for Learner Profile Measures

Variables	Loading
Factor A- Innovative vs. *Safe-Keeping Preference*	
Intuition vs. Sensing (Myers-Briggs. Intuition High)	.69
Right Twenty Questions -	.68
Right Participator Survey	.64
Perceiving-judging (Myers-Briggs, Perceiving High)	.61
Imagery on Paivio Test	.40
Personal Experience L.S	.34
Visual L.S.	.29
Verbal on *Non.* Test	.29
Verbal Quantitative	-.37
Left Participant Survey	-.60
Left Twenty Questions	-.62
Factor B -*Speeded Cognitive* Ability	
Paper Folding Test	.74
Raven Matrices	.63
Necessary Arithmetic Operations	.64
Hidden Figures	.57
Card Rotation	.55
Verbal Quantitative Style (Hill)	.36
Gestalt Completion	.32
Street Gestalt Completion	.31
Factor C-Use of Learning *Strategies to* Capture Information	
Verbal on Paivio Test	.65
Verbal L.S.	.58
Imagery on Paivio Test	.63
Selecting Par, L.S.	.60
Personal Experience LS.	.52
Visual L.S.	.44
Purpose-Oriented L.S.	.37
Introversion-Extroversion (Introversion High)	.46
Factor D- Feeling vs Thinking *Preference*	
Right Center Participant Survey	.56
Thinking/Feeling (Myers-Briggs, Feeling High)	.42
Intuition/Sensing (Intuition High)	.34
Qualitative Auditory (Hill)	.33
Left Participant Survey	-.40
Factor E-Verbal Quantitative Thinking Style	
Verbal Linguistic (Hill)	.62
Verbal Quantitative (Hill)	.41
Left Participant Survey	.40
Necessary Arithmetic Operations	.39
Thinking Feeling (Feeling High)	-.39
Right Participant Survey	-.42
Factor F-Holistic Non-Verbal Thinking Style	
Right Participant Survey	.65
Gestalt Completion Test	.54
Qualitative Auditory (Hill)	.38
Card Rotations	.27
Word-Shape Preference Test (Word High)	-.35
Left Participant Survey	-.57
Factor G-Visual vs. Verbal Learning *Preference*	
Visual Learning Strategies	.66
Qualitative Visual	.60
Imagery on Paivio Test	.48
Verbal on P.M. Test	-.34
Word Shape Preference (Words High)	-.36
Factor H-Learning Expansion *Strategies*	
Purpose Oriented L.S.	.69
Personal Experience L.S.	.49
Similarities Test	.27

Factor I -Dominant Intellectual Preference (Tentative)

Left-Center Participant Surrey	.54
Left Participant Survey	-.41
Verbal Quantitative Preference	-.34

The intercorrelations among these nine factors were:

	A	B	C	D	E	F	G	H	I	J
A	1.00									
B	-0.21	1.00								
C	0.20	0.10	1.00							
D	0.14	-0.05	0.06	1.00						
E	-0.28	0.32	-0.05	-0.06	1.00					
F	0.26	0.05	0.08	0.04	-0.31	1.00				
G	0.05	0.19	0.11	-0.18	-0.12	0.12	1.00			
H	0.06	-0.08	0.12	0.30	0.00	0.07	-0.05	1.00		
1	0.11	-0.38	0.01	0.09	-0.21	0.16	-0.20	-0.01	1.00	
J	0.19	0.27	0.30	0.23	0.03	0.20	-0.02	0.05	-0.07	1.00

Lessons Learned From the First Factor Analysis Study

The evolving brain-dominance constructs and their new quantitative scores took a big step forward as a result of the first factor analysis. The Right and Left Participant Survey scores were strongly involved in factors A, E and F. The new Right Center participant survey score anchored factor D and could be interpreted as being closely related to the *feeling* side of the Myers-Briggs Thinking vs. Feeling score. The opposite of the Right Center Score was found to be the Left *Participant Survey*.

The Left and Right *Participant Survey* scores had the highest communalities in the entire battery. Communality is a measure of common variance accounted for by a given score. Variables with a high communality are related to many other variables. Right and Left Participant Survey had communalities of .78 and .77 respectively and were followed by the Paivio scores with .72 and .70. Communality is also a lower bound estimate of reliability, indicating that these Participant Survey scores were quite reliable. The Right and Left Twenty Questions scores had about average communality, but the left center and right center scores were very low, indicating that they shared less reliable variance with other measures, or were themselves less reliable.

From a construct point of view, Factor A showed the right and left scores to be polar opposites, with the right side reflecting Intuition and Perceiving from Myers Briggs, Imagery from the Paivio, and preference for Personal Learning Strategies. On the left side, the verbal quantitative learning style combined the left *Participant Survey* and left Twenty Questions.

Of considerable interest are Factors E and F. which show that the left and right scores are related to different kinds of cognitive ability. The left Participant Survey went with the Necessary Arithmetic cognitive test as well as the linguistic and verbal-quantitative cognitive styles. Factor F showed that the right participant survey combined with the visual cognitive tests; Gestalt Completion, Street Gestalt, and Card Rotation. The Right score was also related to the Hill Qualitative Auditory Cognitive style. Thus an aspect of the right and left constructs relate to cognitive abilities and cognitive styles in the expected directions.

External construct validation helps us infer the meaning of an otherwise obscure construct from its relationships to other constructs we know something about. The *Right construct* (factors A and F) is seen as related to Intuition as a personality orientation, visual abilities like Gestalt Completion and Card Rotation, and preference for personal experience learning strategies. The *Left construct* (the negative side of A, and factor E) is shown as converging with verbal quantitative and verbal linguistic thinking styles, the Necessary Arithmetic cognitive test, and preference for words over shapes. The *Right center construct* (factor D) is shown in this study to converge with feeling as a personality orientation, somewhat less with intuition, and with the qualitative auditory cognitive style.

Discriminant validation is seen in the polar opposites of these scores and in the unrelated factors. The important Factor B. Speeded Cognitive tests, contains all of the cognitive tests (except for the Similarities Test which did not function as expected). Factors C, G and H were all learning strategies factors of one type or another and are clearly discriminated from the brain construct scores, except for secondary relationships.

Note that the extroverted personality type as measured by the Myers-Briggs is discriminated from the brain dominance scores, but is strongly related to the learning strategies factor C. This active learning is in accord with the interpretation of extroversion as a tendency to look to the external world for information versus the introverted way of looking inward. Based on our understanding of the constructs before this study, Olsen and I had hypothesized a correlation of introversion with the right brain and extroversion with the left brain. We had to correct our thinking on this, because the correlation was in the opposite direction. In a series of studies, we have found Introversion to be somewhat correlated with the A quadrant and Extroversion with C, but it will separate as its own factor if other introversion or extroversion measures are in the battery.

Study 3. *Item Factor Study (439 cases, old instrument)*

Despite indications of construct validity and reliability of the right and left scores, the two center scores were functioning poorly. Thus it was decided to obtain another larger data set and conduct an item factor analysis to see if the four scores left, left center, right center and right could be further discriminated. This became the first major study dealing with internal construct validation.

Methods. In late 1980, Ned Herrmann provided 439 Participant Survey and Twenty Question forms which had been administered to workshop participants at General Electric Workshops. Many of these were GE managers and engineers but many were from interested professional groups from a variety of other companies who had participated in GE's open education offerings. The following list shows how many people we had in each of several occupations. This list does not include many other occupations with fewer cases.

Accounting (10)
Finance (9)
Sales (13)
Marketing (8)
General business (19)
Personnel (10)
Public relations (16)
Computer programming (12)
Engineering (39)
Chemistry (12)
Physics (14)
Art (23)
Industrial design (15)
Management training (27)
Teaching (19)
Educational administration (30)
Management (30)
Students (13)
Manufacturing (19)

A broad range of college majors was also represented in the sample.

Item scores were obtained by using dichotomous scores (either 1 or 0) for every adjective, hobby, and work element in the instrument. Five point scale scores were assigned to each of the twenty questions, and scores were assigned to different aspects of handedness, rankings of preferred college subjects, motion sickness, and introversion vs. extroversion.

The first step was to perform a principle factor analysis and promax rotation of the item intercorrelations (Pearson). The item intercorrelation matrix consisted of the intercorrelations between ninety-one items, twenty from Twenty Questions and seventy-one from the Participant Survey. This step was used to obtain information to produce subscores for a second factor analysis.

Results. Nine factors were extracted, three of them were bipolar; that is, items loading on one end of the factor were negatively related to items loading on the other end of the factor. Those types of items that had the more significant loadings on the nine item factors are summarized in Table A-9.

TABLE A-9

Item Factors from Participant Survey and Twenty Questions *Listed in* Order *of* Greatest Common Variance

Factor 1. *Safekeeping Preferences versus Creative Synthesis*

Positive loading items involved preferences for specific instructions, step by-step methods, detailed planning, administration, organization, and avoidance of uncertainty.

Negatively related items involved conceptual thinking, dealing with creative aspects, and desire to synthesize and express ideas.

Factor 2. *Analytical Problem Solving versus Interpersonal/Empathetic*

Positive loadings involved analytical, logical, technical and mathematical problem solving.

Negative loadings were for items involving interpersonal aspects, dealing with emotion, intuition, and liking to make decisions based on first impressions and hunches.

Factor 3. *Creative Making of Things*

These items involved self-descriptions as creative, artistic, getting ideas from daydreaming, and enjoyment of arts and crafts.

Factor 4. Active Outdoor Pastimes versus *Reflective Introversion*

These items involved preference for outdoor activities like boating, fishing, swimming, diving, tennis, camping, and woodworking and being more competitive with others than with self.

The negative loadings were for being an introvert, reading, and spending a day alone with one's thoughts.

Factor 5. *Intuitive Preferences vs. Orderliness*

Items showing a preference for English as a best subject, also for creative writing, expressing ideas, being a writer and reading. Disliked were math, home improvements, and being logical and technical.

These preference items were chosen by persons who like to rely on hunches, enjoy breaking rules, and get ideas from daydreaming and first impressions.

At the negative pole were items for being reliable rather than imaginative, taking a step-by-step method, and controlling things by thorough planning and organization.

Factor 6. *Hobbies Preferred by the Non-Mathematical*

These items dealt primarily with hobbies, including cooking, reading, music listening, sewing, and gardening. Math was not liked as the best subject.

Factor 7. *Dominant Management*

Preference items for managing, leading, organization, ability to anticipate solutions, and being dominant were positively related. Avoided were preference items for emotions, music, or introversion.

Factor 8. *Preference for English Over Math*

This was a weak factor dealing with English and Foreign Language as "best subject" over math, and by preferring more detail and less creative aspects.

Factor 9. *Creative Writing*

Items showing a preference for English as a best subject, also for creative writing, expressing ideas, being a writer and reading. Disliked were math, home improvements, and being logical and technical.

Because these items were based primarily on dichotomous item scores of unknown stability, no serious attempt was made to interpret these nine factors as stable constructs Rather they were used to develop "item parcels" consisting of subsets of 5 to 15 items. Each item in a parcel was given one point, so a score of 0 to 15 or so was possible in each parcel. Both positive and negative ends of Factor 1 (safekeeping vs. creative), Factor 2 (analytical problem solver vs. interpersonal/ empathetic), and Factor 4 (active outdoor pastimes vs. reflective introversion) were scored separately. The two ends were seen as separate preference constructs. This transformed the nine scores into twelve scores.

When these twelve subscores, now much more stable than the original individual item scores, were factor analyzed, they produced a clean two-factor solution. The first factor was what we have come to know today as upper right versus lower left (D vs. B). People preferring the "D" end of this factor describe themselves as holistic, creative, synthesizers, intuitive, artistic, and spatial. People with opposite preferences choose controlled, detailed, and dominant. This factor was well measured by the Twenty Questions Items with the right brain preferences dealing with day-dreaming, hunches, getting a kick out of breaking rules, and getting best ideas when doing nothing. The "B" quadrant preferences, on the other hand, dealt with liking step-by-step processes, being reliable versus imaginative, disliking uncertainty, having a place for everything, planning and organizing, and preferring specific instructions.

The second factor was also bipolar, but did not involve many Twenty Question items. It was produced largely by the adjectives, work elements, and best/worst subjects. The two Opposite ends of this factor were the two dominant types that today we call Upper Left (A) and Lower Right (C). "A" people prefer the adjectives "logical," "analytical," "mathematical"; and the work elements "technical", "analytic" and "problem solver". They generally like math as their best subject. Lower Right items were "like to rely on first impressions," emotional, intuitive, interpersonal, expressing ideas, teaching and training.

These two bipolar 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 correlation between two second order factors can produce a third order factor. It did in this case; a third order factor emerged which was a strong bipolar left-right dominance factor. (Since the two bipolar factors were obtained from item parcels developed from a first-order factorization of the items, they could be thought of as second-order factors.)

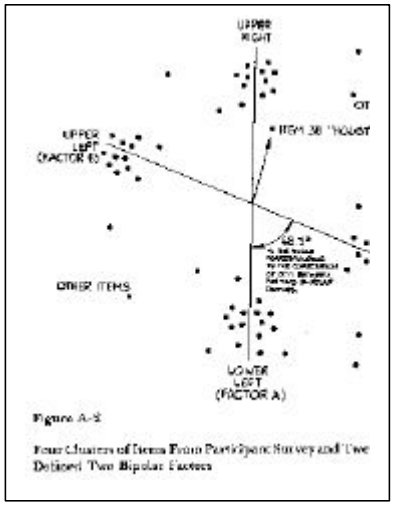


Figure A-2

Four Clusters of Items From Participant Surveys and Two Defined Two Bipolar Factors

The two bipolar factors and the overall right/left higher-order factor provided a better definition of the four constructs than we had hoped. At that time Olsen and I were most interested in deeming *left-center* and *right center* as constructs. We sought to learn how to score those clusters of preferences that Ned Herrmann had observed in people and called "left-center" and "right center."

The two bipolar factors validated the existence of these clusters in a convincing manner. They showed *right center* to be the preferred or avoided opposite of tough-minded upper left thinking: *the feeling* side of the thinking-feeling dichotomy we had first seen in Study 2 in relationship to the Myers Briggs Thinking vs. Feeling scale. The second bipolar item factor showed the elusive *left center* to be the preferred or avoided opposite of holistic, intuitive upper right thinking—risk-avoiding through control and organization vs. the risk-taking appeal of new ideas, intuitions, and alternate visions.

Moreover, the strong third-order factor validated the existence of the overall right-left distinction as a pervasive dichotomy in human thought, observed by many thinkers and scientists from Hippocrates to Sperry.

The study also validated Herrmann's holistic "primary" Scores as the loadings in Table A-10 show. Assigning scores to each holistic primary score produced the correlations from

which the extension loadings in Table A-10 were derived. (Factor extension makes it possible to obtain loadings on scores not included in the main factor analysis).

Table A-10 shows that Ned Herrmann's intuitive idea of one Left-Right dimension with two "center" scores, is supported by the preference clusters which exist in the item data from Participant Survey and Twenty Questions. This construct is validated by Factor L vs. R. the higher order bipolar factor. Right is the positive end, Left is the negative end, and the two "center scores" fall midway on the positive and negative sides. The two second-order factors A vs. C, and D vs. B. provide a better description of the item data and lead to a two-dimensional instead of a one-dimensional model. The holistic left and right "primary" scores, scored personally by Ned Herrmann, show considerable convergent and discriminant validity against the internal dimensions. The two "center" scores should have had loadings of about -.50 on B and about .50 on C, respectively, to have been as strong. Table A-10 shows that the loadings were in the right direction on B and C but were weak, indicating lower reliability or validity of the original holistic "center" scores. The new quantitative B and C scores helped clarify the constructs of B and C and improved their reliability and validity.

TABLE A-10

Validation of Holistic "Primary Scores" Against the Left vs. Right

Factor and Two Bipolar Preference Factors

Herrmann's Original "Primary" Scores	3rd-Order L vs R (Left Negative)	2nd-Order B vs D (B Negative)	2nd-Order A vs C (A Negative)
Primary Left	-.51	-.22	-.47
Primary Left-Center	-.12	-.24	.08
Primary Right-Center	.14	.02	.18
Primary Right	.54	.52	.20

The data tables from this study were reported with some excitement to Ned Herrmann, who served as the technical coordinator of the study as well being a mentor in brain dominance constructs. We were all pleased that we could now develop stable scores for right and left center, and differentiate the items representing the four preferences from the overall left-right score. These numbers, plus the metaphor of factor analysis which used the concept of vectors, provided "left-brained" input to Ned Herrmann's creative thought processes that soon resulted in the theoretical constructs of "Lower Left and Lower Right" and the quadrant plot of the four-fold profile.

Factor analysis uses a mathematical model based on vector algebra. A vector can be depicted geometrically as an arrow drawn in relation to coordinate axes. For two dimensions, such as we found, the vectors can easily be plotted on a piece of paper. In the item factor study, factors are axes, items are vectors. Generally the first, most important factor is drawn as the vertical axes (see Figure A-2). The second factor is correlated with the first one, so it is not drawn at right angles. A correlation coefficient has the geometrical interpretation of being the cosine of the angle between two vectors (or two axes). Thus a correlation of 0 corresponds to 90 degrees, and a correlation of 1.00 corresponds to 0 degrees (e.g., item vectors are colinear). The single correlation between the two major factors gives rise to a second order factor, over-all right-left brain dominance. This factor, which requires a third dimension, is not depicted. The groups of small circles in Figure A-2 represent the clusters of some items from Participant Survey and Twenty Questions. Each circle represents the endpoint of a vector corresponding to the position of each item in relation to the two factors. One item (38, Holistic) is drawn as an arrow to provide an example.

Factor analytic results communicate quite well to technically trained individuals, but less well to others. Nevertheless, Figure A-2, taken in relation to Figure A-1, is an attempt to communicate with readers of all the profiles that Ned Herrmann developed in the four-fold model and describes in this book. Figure A-2 shows that there is indeed a simple, powerful clustering of preferences and avoidances that shows itself in the empirical data. The quadrant model does deal with important clusters of preference for statements that people regard as being more or less descriptive of themselves. The HBDI does have internal construct validity.

The item factor analysis and some other analyses Olsen and I conducted led to recommendations which Herrmann incorporated into a revised HBD Instrument. It included both Participant Survey and Twenty Questions and some new adjectives, work elements, and adjective pairs. New scoring protocols and a new consolidated score sheet were developed.

Study 4. *Refactorization of the 143 Cases*

Methods. The old (1979) Twenty Questions and Participant Survey Instruments for the 52 General Electric employees and 91 college students were rescored using the new scoring procedure developed from the understanding of the four item clusters. This resulted in the first set of quadrant scores. The Introversion/Extroversion score from the HBDI was also included in this analysis. However, to avoid the strong clustering of speeded cognitive tests, only three were left in the battery; Street Gestalt Completion and Gestalt Completion as markers for holistic synthesizing cognitive processes, and Necessary Arithmetic Operations as a marker for analytical, mathematical, cognitive processes. Similarly, to reduce and simplify the learning styles and learning strategies instruments, only two of the Hill scales, verbal linguistic and qualitative visual, were left in. The two Paivio scales for verbal and imagery were left in, along with the two learning strategies, verbal learning and visual learning. The intent was to produce a factor structure based on personality, learning strategies, learning styles, and cognitive processing, and the four quadrant scores in order to determine the

convergent and discriminant relationships of the four quadrant scores to these other constructs.

Results. Table A-11 presents the names associated with the variable labels. Only variable labels are given in Table A-12, which contains the promax factor structure (correlations of variables with factors) for the reduced battery with the new fourfold dominance scores. Factor loadings greater than .33 are statistically different from zero at the .05 level.

TABLE A-11

List of Variables and Their Labels

Label	Description
INTRO	HBD
GC	Gestalt Completion
NA	Necessary Arithmetic Operations
SGC	Street Gestalt Completion
WS	Word-Shape Preference (Words)
SI	Weschler Adult Intel. Similarities
I	MBTI Introversion vs. Extroversion
N	MBTI Intuition vs. Sensing
F	MBTI Feeling vs. Thinking
P	MBTI Perceiving vs. Judging
VL	Verbal Linguistic (Hill)
QV	Qualitative Visual (Hill)
VERB	Verbal Paivio
IMAG	Imagery Paivio
VLS	Verbal Learning Strategies
VILS	Visual Learning Strategies
L	HBD A
LL	HBD B
LIZ	HBD C
R	HBD D

TABLE A-12

Promax Factor Structure for Learning Profile Variables and Hemispheric Dominance Scores

Factor Structure Matrix

A	B	C	D	E	F	G	
INTRO	0.01	0.82	-0.19	-0.12	0.05	-0.31	0.08
GC	0.08	0.14	0.13	0.09	0.57	0.07	0.10
NA	0.11	0.04	-0.19	-0.16	0.20	0.10	0.37
SGC	0.17	0.04	0.01	0.03	0.64	0.09	0.11
WS	-0.06	-0.30	-0.12	0.27	-0.26	0.24	-0.01
S	0.26	-0.05	0.04	0.01	0.17	0.05	0.11
1	0.05	0.82	-0-21	-0-24	0.17	-0.37	0.13
N	0.70	-0.14	0.12	0.23	0.15	0.28	-0.23
F	.20	-0.11	0.52	0.17	0.00	-0.02	-0.22
P	0.63	-0.03	0.15	0.20	0.09	-0.06	-0.23
VL	0.13	0.00	-0.44	-0.12	0.13	0.14	0.06
QV	0.28	0.08	0.15	0.46	0.34	-0.23	-0.07
VERB	0.31	-0.31	0.09	0.09	0.19	0.84	-0.02
IMAGE	0.31	-0.24	0.32	0.75	0.21	0.28	-0.02
VLS	0.12	-0.19	0.24	0.28	0.04	0.38	-0.01
VILS	0.18	-0.15	0.18	0.80	0.06	0.02	-0.10
L	-0.14	0.12	-0.34	0.10	0.04	-0.05	0.68
LL	-0.33	-0.03	0.07	-0.15	-0.03	0.03	0.45
LR	0.29	-0.25	0.61	0.13	0.22	0.32	-0.27
R	0.59	0.11	0.27	0.22	0.37	0.10	0.08
V*	17	10	10	8	7	6	6
CV's	17	27	37	45	52	58	64

V = Percent Variance
CV = Cumulative percent variance

The intercorrelations among the seven factors were:

A	B	C	D	E	F	G
A	1.00					
B	0.00	1.00				
C	0.12	-0.17	1.00			
D	0.24	-0.11	0.35	1.00		
E	0.35	0.19	0.17	0.23	1.00	

F	0.04	-0.44	0.15	0.05	0.07	1.00	
G	-0.14	0.13	-0.15	-0.08	0.23	-0.01	1.00

Factor Interpretations

- Factor *A: Lower Left vs. Upper Right*

  Factor A cross-validates the organized vs. creative synthesizer factor (B vs. D) found in the large sample of 439 persons. Positive loadings were found for the creative synthesizer preference (D) and the Intuition and Perceiving scales of the Myer's-Briggs Type Indicator (MBTI). Negative loadings were found for the organized, controlled preference (B) and for the Sensing and judging scales of the MBTI.

- Factor B : Introversion *vs. Extroversion*

  Factor B has high loadings on the Herrmann and Myers/Briggs Introversion-Extroversion scales (the simple correlation between the two was .73). Negative though non-significant correlations were found for the Lower Right construct indicating that it may be associated with extroversion. Negative correlations were also found on the word score of the Word Shape Sorting test and the Verbal and Imagery scales of the Hill IDQ,. The correlation of verbal preference with extroversion is not surprising since extroverts like to communicate verbally with other people.

- Factor *C : Upper Left (A) vs. Lower Right (C)*

  Factor C cross-validates the HBD A vs. C factor found in the larger sample of 439 persons. Positive loadings were found for the HBD G, and the Feeling scale on the MBTI, (thus the MBTI "thinking" scale is highly related to the Cerebral Left Construct). Negative loadings were found for the HBD A score and the Hill Verbal Linguistic Preference scale.

- Factor D : Visual *Learning Preference*

  Factor D includes significant positive loadings on all three visual learning style and strategy scales. A negative loading was found for the Word score of the Word Shape Sorting Test, indicating a preference for shapes over words. It is interesting that visual vs. verbal preference discriminated from one another in Factor D and F, rather than the three different instruments producing three instrument factors.

- Factor E: *Visual Closure and Upper Right*

  Factor E has positive loadings on the two gestalt completion tests, the qualitative visual preference, and the upper right construct(D). The Word Shape Sorting Test also signaled a shape preference. The new upper right score was thereby shown to be related both to cognitive spatial ability and to behaviorally measured preference for shapes over words.

- Factor F: *Verbal Learning Preferences*

  Factor F has positive loadings on the Verbal scale of the Hill Individual Differences Questionnaire, the Verbal Learning Strategy score, **HBDI** C score, and the Word Shape Preference Test. Negative correlations were found for the two Introversion scales.

- Factor *G: Analytical, Mathematical Processing*

  Factor G has positive loadings on **HBDI A, HBDI B,** and the Necessary Arithmetic Operations Test.

In summary, the new brain dominance scores were still found to be pervasive in cutting across a number of domains. Personality type was the strongest domain, seen in relation to the Myers-Briggs intuition and perceiving scales (HBDI D) and feeling vs. thinking scales (HBDI D vs. HBDI A). But HBDI A also relates to a speeded cognitive test of logical mathematical processing, while HBDI D relates to cognitive tests of visual closure, so these constructs are more than personality. Also, HBDI D is related to visual learning styles and strategies. The correlations could almost be predicted from knowledge of the constructs alone.

The intercorrelations among the four Myers-Briggs Scales were consistent with results found in the construct validation literature on this well-researched instrument. Thus, we judge that the Myers-Briggs Scales were functioning properly in this study. One difference in the two theoretical models (Myers-Briggs and Herrmann) is that the Myers-Briggs assumes a person must be characterized by one or the other end of each of their four scales, while the Herrmann constructs allow a person to express preferences for activities at both of the poles in a single profile.

The data from the HBDI shows strong negative correlations in the population between the polar opposites, A vs. C and B vs. D. The Myers-Briggs Scales are also polar opposites. The Brain Dominance constructs permit a person to have an individual brain profile in which a person might prefer to be both a "thinker" and a "feeler" or both a "risk avoider" and a "risk taker" at the same time. According to personal comments made to the author by users or reported by Ned Herrmann, these personal dichotomies are felt strongly by the people with these less common profiles. They know they have these personal inconsistencies to live with. The subgroup of people with strongly bipolar profiles constitutes an interesting group for future research.

Study 5. *The First Factor Analysis with the New Instrument*

Even though the refactorization of the 143 cases was quite interesting, it was based on the old Participant Survey and Twenty Questions. The item factor analysis (Study 3), led to a new scoring protocol and a revised instrument with 120 instead of 91 items.

An analysis was designed and data collected in 1982 to determine whether the new Brain Dominance scores as measured by the new instrument would continue to have the cross-situational applicability and convergent and discriminant validity found with the old rescored Participant Survey and Twenty Questions. These data are currently being reorganized for publication.

The completed Promax Analysis is of interest to the quest for evidence of convergent and discriminant validity, so it is reported here for the first time. As in the second factor analysis, the study design involved a battery consisting of the four HBDI scores, personality measures, learning strategies, learning styles, and tests of cognitive style and processing. The sample consisted of 182 BYU students drawn from a wider cross section of college major fields than in the earlier analysis.

The Test Battery. The test battery consisted of the following types of tests:

1. Brain Dominance Profile Scores, A, B. C, and D
The revised HBD Instrument was scored with the new key to produce the four quadrant scores.

2. Cognitive Tests
The battery included a wider variety of cognitive tests. It included all of the tests in the first factor analysis except WAIS Similarities and Ravens Matrices, plus two new tests:

a. The Remote Associates Test—claimed to be a test of creative thinking based on difficult and remote verbal associations.
b. The Metaphor Triads Test—is a group-administered test with color slides showing three objects. Two of them can be related in a concrete fashion and a different pair in a deeper metaphorical fashion. The deeper metaphorical response was the one scored.

3. Personality Type Tests

a. The Myers-Briggs Type Indicator was included.
b. A personal style instrument developed by Kolb was included. It has frequently been used in management education activities. It had four scales: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation as personal styles.

4. Thinking Style Tests

a. All of the Hill thinking style scales were included. In addition to the Verbal Linguistic, Verbal Quantitative, and Qualitative Visual scales employed in the previous analysis, the Qualitative Empathetic, Rule Orientation, and Purpose Orientation scales were added.
b. The Word-Shape Sorting Test was included.

5. Learning Strategies

a. All five of the learning strategy scales developed by Olsen were included: verbal, visual, purpose oriented, personal experience, and structured learning strategies.

The Relation of the Brain Dominance Constructs to High-Order Factors. Before presenting selected results from this study, it is useful to observe that the bipolar A vs. C and B vs. D factors often appear in higher-order factors. The constructs of brain dominance have become much clearer since 1982, when this factor analysis was conducted. Moreover, the ways that measures of these constructs should behave in external validation studies have become much clearer. The two bipolar factors that give rise to the four quadrant scores have now been shown in several studies to be pervasive and general. This is as it should be,because these constructs purport to describe generalized preferences for complex, interrelated, and intercommunicating processes of thought and action mediated in the human brain. Thus, the expectation should be that these bipolar factors will emerge in higher order factors because these are the most general. In the internal validity analysis of the *439* cases, the item parcels were derived from first order item factors, and thus the two bipolar factors were second order. The overall left vs. right dominance was a third order factor. Correspondingly, we should look for manifestations of these two bipolar factors among the higher order factors in batteries of preference and biographical information that cut across many types of instruments. Cognitive tests can be included too, so long as they do not constitute a very large percentage of the battery, or else the prediction does not hold. In these cases we may get familiar "G" factors of cognitive ability among the higher-order factors.

Results of The Higher-Order Promax Analysis. The Gorsuch program used in studies 2, 3, and 4 was again used with the scores from the battery of tests.

The Gorsuch program executes a Schmid-Leiman Solution. This statistical procedure shows the status of the original variables on first-order and all higher-order factors. The analysis produced four second order and two third order factors. The two third order factors are listed in Table A- 13, defined by the most significant scores loading on these factors. The first and most important third order factor is most strongly marked by the upper Left/ Lower Right dichotomy with extroversion also manifesting itself, perhaps due to its correlation with lower right. The measures that load on this bipolar factor are in accord with the constructs behind the upper left/lower right distinction. Necessary Arithmetic Operations is related to Cerebral Left as it was in the earlier study.

The second third-order factor is weakly consistent with the upper right vs. lower left dichotomy. The Myers Briggs Perceiving and Intuition dimensions mark the positive end of this factor along with the Remote Associates test of creative thinking. The upper right loading is not strong on this weak factor but is in the relationship predicted by the quadrant model. The lower left score marks the negative end along with rule oriented, structure oriented, and purpose (main idea) oriented learning strategies and the verbal learning strategy.

Study 6*. Selected Results of the Kevin Ho Study (7989 cases)*

TABLE A-I3

Salient Loadings on Third Order Factors Derived from a Cross-Instrument Analysis of Personality, Thinking Style, Learning Style, and Cognitive Tests With Four HBD Scores

	Factor I (Third 0rder)	Factor II (Third Order)
Herrmann Brain Dominance		
EDD A	-41	
HBD B		-22
HBD C	44	
HBD D	22	18
Extroversion	32	
Myers-Briggs Type Indicator		
Extroversion/Introversion	35	
Perceiving/Judging		27
Intuition/Sensing		20
Kolb: Concrete Experience	31	
Panic: Imagery	31	
Olsen: Learning Strategies		
Group	33	
Personal Experience	30	
Visual	23	
Verbal	24	-20
Purpose (Main Idea)		-22
Structured		-22
Hill Individual Differences Questionnaire		
Kinesthetic	25	
Qualitative Empathetic	23	
Rule-Oriented		-20
Cognitive Tests		
Necessary Arithmetic	-21	
Remote Associates Test		20

Methods. As one step in his dissertation study of occupational preferences and their relationship to brain dominance as measured by the HBDI, Kevin Ho analyzed the HBDI scores from 7989 subjects. The scores were derived from responses to the revised HBD instruments taken by participants in many workshops, individual consultations, and public presentations by Ned Herrmann in 1984, 1985 and 1986. Instead of the 91 items Bunderson and Olsen had analyzed in the earlier study of 439 cases, Ho analyzed 120 items from the instrument current through 1986. Until this time no internal construct validation had been undertaken using this revised instrument.

Some of the 120 items were transformed into dummy types of variables to make interpretation of the factors easier. This resulted in having 127 variables for the factor analysis. In the interest of being consistent with the original validation studies by Bunderson and Olsen, a principal factors method of factor extraction was used in the factor analysis.

The appropriate tests indicated that either five or seven factors could be extracted. Both of these solutions had many similarities to the earlier study with the 439 cases. After examining both sets of results (five and seven factors), it was decided that in the interest of interpretability and simplicity, the five factor solution would be used.

Of the five factors extracted, three were strongly bipolar; that is, these three factors had a number of both strongly negative as well as positive loadings. This is similar to the results of the previous validation studies. The following is a listing of the five factors in order of the greatest common variance accounted for, along with those types of items that loaded strongly on each of the factors (see Table A-14).

TABLE A-14

Five Factors and Those Types of Items That Loaded on Them

Factor 1. *Safekeeping vs. creative*

Positive loadings included preferences for order, planning, administration, organization, reliability, detail, and a dislike for uncertainty.

Negative loadings include preferences for holistic thinking, conceptualizing, synthesis, creating, and innovating.

Factor 2. *Interpersonal, people-oriented vs. technical, analytical*

Positive loadings include preferences for interpersonal, verbal, people oriented, emotional and musical types of activities and style.

Negative loadings include preferences for analytical, technical, logical, and mathematical types of activities and style.

Factor 3. *Female, emotional vs. rational, logical*

Positive loadings include preferences for emotional, spiritual, musical, artistic, reading, arts and crafts, introvert and feeling types of activities and style. The gender item(female) also loaded positively on this factor.

Negative loadings include preferences for logical, rational, mathematical types of activities and style.

Note: Although similar to factor 2, this factor is subtly different. The gender item (female vs. male) is very strong. Notice the emotional, spiritual, introverted aspects of factor 3 as opposed to the interpersonal aspects of factor 2. Both factors 2 and 3 appear to share the same negative pole; that is, those items that are negatively correlated with factors 2 and 3 are those which are logical, analytical, mathematical and technical in nature.

Factor 4. *Creative, innovative*

The loadings for this factor include preferences for innovating, conceptualizing, creating, imaginative, original and artistic types of activities and style. A small number of negative loadings occurred: controlled and conservative.

Factor 5. *Handedness factor*

This appears to be loaded positively by left hand items and negatively by right hand items. This factor is at least partially an artifact of the small number of items measuring handedness in the HBDI and the way they were scored

Because this initial factor analysis dealt with items, and the results from item factor analysis tend to be unstable, factor scores were generated for each subject on each factor. These factor scores can be thought of as being construct or scale scores. They are similar to the item parcel scores in the first internal construct validation study with 439 cases. These five factor scores for each of the subjects were factor analyzed again using a principal factors method of extraction.

Results. The Promax solution produced two bipolar factors. The two factors and the loadings of each of the five factor scores on the two factors appears opposite in Table A-15.

Factor A vs. C appears to be the now familiar interpersonal and emotional vs. analytical, and logical factor. It is interesting to note that factor 4 (the creative factor) also loads slightly on factor A, thus indicating that adjacent quadrants are more likely to be correlated than opposite quadrants. Creativity is seen by Herrmann to be a function of more than one quadrant, especially of D combined with A or with C.

Factor B vs. D appears to be the familiar creative (upper right) vs. safekeeping (lower left) factor. The bipolar nature of these factors is more clearly seen in the positive and negative loadings of individual items in these two factors. not shown here.

As was expected, the handedness factor (factor 5) did not load significantly on either factor A or B.

A higher order factor was also produced. It appears to be the familiar overall left vs. right factor. The Schmid-Leiman solution showing the correlations between the five factor scores and the higher order factor (I) as well as the two primary bipolar (a and b) factors can be found in table A-16.

TABLE A-15

Pram= Factor Structure Matrix

	Factor A vs.C (A negative)	Factor B vs.D (B Negative)
Factor 1 Safekeeping vs. creative	-.14	-.59
Factor 2 Interpersonal vs. analytical	.59	.22
Factor 3 Emotional vs. rational	.61	.25
Factor 4 Creative	.39	.65
Factor 5 Left handedness	.O6	.05
eigen values	1.77	1.12
cumulative variance	35.42%	57.79%

The correlation between these two factors was .37.

TABLE A-16

Correlations of Variables With Higher Order and Primary Factors

Primary Factor	Higher order factors		
	I	a	b
Factor 1 Safekeeping vs. creative	-.33	.07	-.49
Factor 2 Interpersonal vs. analytical	.36	.47	.00
Factor 3 Emotional vs. rational	.38	.47	.02
Factor 4 Creative	.46	.13	.47
Factor 5 Left handedness	.05	.04	.03

The higher order factor (I or the overall right vs. left factor) accounted for 39% of the common variance, while the primary factors ("a" or the emotional, interpersonal vs. rational factor and analytical factor and "b" the creative vs. safekeeping factor) accounted for the other 61 ~c of the common variance.

The Schmid-Leiman solution above, shows that the higher order factor does indeed appear to be a general right vs. left factor. The extension loadings of the items into this 3-factor space confirmed the placement of items in clusters that were found in the previous internal validation study.

The new items added after the previous internal construct validation functioned well according to the predictions of the quadrant model. Thus, the scoring key for the HBDI, taught in the certification workshops, was validated by this study. The results suggested, however, that a refined scoring key with differential item weights would offer a further refinement. A weighted key would, however, be impractical except through computer scoring.

Discussion. The results of this factor analysis substantiate the internal validation results of the earlier Bunderson and Olsen studies in relation to the items common to both the old and new instrument. The results also showed that all new items functioned properly. The two bipolar factors were found again and the higher order "right/left" factor was again extracted. This strengthens the evidence for construct validity of the four clusters of brain dominance in the HBDI.

FUTURE RESEARCH

Refining the Scoring and Improving the Scaling of the HBDI

This book recounts how the HBDI Instrument has been improved over a period of years based on a combination of research and feedback from practical applications. That process is continuing today. Ned Herrmann and his colleagues are supporting a research program, which has several aspects. One activity is to develop a database of HBDI scores balanced in terms of occupations and gender. Given such a database, internal construct validation studies such as that of Kevin Ho could lead to several improvements in the instrument:

?? A weighted scoring scheme could be developed to better reflect the A-C and B-D factors and the third-order Left-Right factor.

?? Scaling of the four quadrant scores to a common standardized metric could be accomplished so that comparisons between quadrant scores would be more accurate.

?? A set of standard occupational profiles could be developed.

?? Generalizability studies could be conducted to determine whether gender-specific keys would be desirable.

Such a balanced database with weighted and resealed scores would also support a variety of cross-tabulation studies to show the joint occurrence of different preferences or avoidances in a balanced sample reflective of the larger population. Generalizability studies to different cultures would require a database appropriate to each culture.

Intercorrelations Among the Four Construct Scores

As the meaning of the four quadrant constructs evolve, the definitions of each quadrant cluster in relation to the others should explain the inter-correlation among the HBDI scores.

The intercorrelations among quadrant scores found in Kevin Ho's sample of 7989 cases (Study 6) can be seen in Table A-17. These correlations are generally in line with the factor structure, but show some departures that could be corrected by a more refined weighted scoring scheme.

Note that the two left quadrants, A and B. and the two right quadrants, C and D, are positively correlated. This fact, along with the negative correlations between A and D (-.53) and B and C (-.20), lead to the higher-order Left/Right factor. Note also that scores for processes which fall on the opposite ends of bipolar

factors are strongly negative. A vs. C is -.77, B vs. D is -.68, and Left vs. Right is -.91. Recall that the constructs are seen as representing separate clusters of brain functions, not different ends of a single process. The negative polarity between the opposites must be explained as part of the construct. A possible explanation lies in the concepts of preference and avoidance. These concepts require item types that involve some selecting of one descriptor and rejecting of another, which contributes to but does not fully account for the polarity.

TABLE A-17

Correlations Between the 4 Quadrant Scores, Left *and Right Scores, oral Cerebral and Limbic Scares.*

	A	B	C	D	Left vs. Right
A	1				-.91
B	.08	1			Cerebral vs Limbic
C	-.77	-.20	1		-.78
D	-.53	-.68	.88	1	

The research now going on can lead to a refined set of intercorrelations. Both weighted scoring and a balanced sample could affect the correlations. The six intercorrelations between the four scores should ultimately be explainable by the quadrant model. Thus, it is desirable to learn what these correlations would be in a balanced sample with weighted scores. We would expect the A-B correlation to be positive and of the same magnitude as the C-D correlation (.08 seems too low). We would expect the A-D correlation to be negative and of the same magnitude as the B-C correlation (-.53 seems too large in absolute value).

With scores scaled to a common standard, the summary scores (1 = dominant preference, 2 = available for situational use, 3 = avoidance) could be made more precise in order to support more precise inferences about the nature of avoidance and its occurrence in the population and in different subgroups. A summary score of 3 is probably sufficient as a rule of thumb for its current applications, but the concept of avoidance, and its measurement, needs further definition. The research now underway may lead to further advances.

Validating Inferences About How People with Different Profiles Activate Their Brains Differently

While inferences about the location within the brain of different sorts of mental activity are not important to the uses of the HBDI discussed in this book, such inferences could be validated or confirmed experimentally.

A variety of hypotheses could be tested. For example, the well-known neuroscientist, Karl Pribram, stated in a public lecture that creativity, or as he describes it, the "guts" to take a risk and follow an intuition, is mediated in the frontal limbic and hippocampal systems. He contrasts this with risk avoidance, which he says is mediated in the posterior convexity. Experiments could be conducted using subjects dominant in B quadrant, subjects dominant in the D quadrant, and subjects dominant in both the B and D quadrants to find out whether people of the opposite dominance would use these parts of their brains differently when confronted with tasks offering the use of safe-keeping or intuitive/risk-taking processes.

When attempting to validate inferences about the identification of any of the four quadrant constructs with a particular brain system, it is better to use the neutral descriptors A, B. C, D, rather than the cerebral or limbic designators, which prejudge location.

A variety of measurement techniques, including EEG recordings and Positron Emission Tomography (PET) Scans could be used to determine which parts of the brain are active while performing different tasks. One could also compare these measures for people with different profiles. The emphasis on the brain as the source of the four preference clusters is an interesting and motivating aspect of Herrmann's theory of brain dominance. It is easier to visualize having a preference for certain clusters of mental processes we control within our own brains than to imagine what it is about us that is our "super-ego," or our tendency towards "psychasthenia," or some other purely psychologically defined construct.

Research to validate inferences about brain functioning in relation to different profiles would broaden external construct validation in an interesting way. It would provide us with explanations of how different brain systems mediate processes identifiable within each preference cluster.

Some such studies have been conducted. It is beyond the scope of this appendix to review all of these, but the following studies are representative of the kinds of questions that have been asked.

The Schkade Study of EEG Differences in Accountants and Artists

Lawrence Schkade, Professor and Chairman of the Systems Analysis Department at the University of Texas at Arlington used the HBD Instrument to select 12 clearly left-brained senior accounting students and 12 clearly right-brained seniors in studio art. He took brain waves (Electro-encephalogram readings) from these students and computed the Fourier transforms of the brain waves. He looked at the alpha frequency (8-13 cycles per second). He computed the ratio of the power of the EEG waveforms of the left hemisphere to that of the right for each subject and computed the mean ratio for each occupational group. The results indicated that accountants and artists differ not only in their HBDI scores, but in their brain waves as well. A ratio of the power of the left hemisphere to the right would be 1.0 if both were used equally. The mean power ratio for accounting students was .77 (more alpha from the right, from which we may infer more active processing in the left.) The mean power ratio for art students was 1.2 (more

alpha from the left than the right hemisphere). The results were statistically significant with a probability less than .001 that they could have resulted by chance (Schkade and Potvin, 1981). Doktor and Bloom (1977) have also observed that different occupational groups show different amounts of alpha in the two hemispheres.

Studies of Lateralization of Cognitive Style

The account that finally emerges from the research relating cognitive styles measured behaviorally to activity measured directly from the brain is not likely to be simple. For example, consider the cognitive style Field Independence vs. Field Dependence, developed over three decades of research by the renowned psychological scientist Herman A. Witkin (Witkin, Dyk, Faterson, Goodenough and Karp, 1962; Witkin, 1977). The field independent person (also called analytical field mode) is able to analyze the feelings of the vertical sensed from the body and separate these from the appearance of the vertical in a visual field. Thus the field independent person will move a rod more accurately to the vertical when distracted by a tilted frame when in a darkened room where both rod and frame are lighted. The field dependent person (also called global field mode) will move the bar closer to the apparently vertical axis of the tilted frame. The Hidden Figures test is another measure of Field Independence (high scores) and Field Dependence (low scores).

This cognitive style, like the HBDI scores, is very pervasive, cutting across performance in perceptual tasks, cognitive problem-solving tasks, and ways of relating to people in the world. Witkin's description of the two cognitive styles is sufficiently similar to the A-C dichotomy that it is tempting to hypothesize them as related.

Field Independent	Field Dependent
Analytic	Global
Autonomous of others	Highly sensitive to others and influenced by them
Keeps other at "arms length"	Seek physical and emotional closeness
Sometimes demanding, inconsiderate	Warm, friendly, tactful
Better at restructuring to solve complex problems	Slow at restructuring to solve problems
Good at breaking set	Lore functionally fixed
Better at special tests of perception and reasoning	Better at verbal fluency tests
Technical, mathematical occupations	Social, Intrapersonal occupations

Field Independence-dependance is a Bipolar Dimension. The hidden figures test is negatively correlated with C, positively correlated with A and D. Witkin's hypothesis was that field independence was a more differentiated and less global state and that this would be reflected in the lateralization, or separation, of functions within the two brain hemispheres. Research with right handed males confirmed this. Oltman, Semple, and Goldstein (1979) used LEG recordings to show that males who were field independent were more likely to use one or the other hemisphere, but not both together, in performing different tasks that have been associated with either the right or the left brain. The LEG recordings for field dependent men were more correlated between the two hemispheres. They were less correlated, indicating greater lateralization, in field independent man.

In another study, Zoccolotti and Oltman (1978) used a tachistoscope to present letters and faces to either the right visual field (linked to the left brain) or the left visual field (linked to the right brain). This study showed that right handed males who were field independent did significantly better in recognizing letters when presented to their right visual field (left brain) and better with faces when presented to their left visual field (right brain). Field dependent men did equally well with either hemisphere, showing less differentiation of function.

Summary of Needed Brain Research

These studies show that inferences about the relationship of pervasive cognitive styles to the activation of the brain in different ways can, with some effort, be validated. There are substantial individual differences in characteristic patterns by which the brain is activated. It is likely that different patterns of activation will someday be shown to be correlated with high level cognitive styles, of which the two bipolar HBDI factors are prime candidates because of their internal and external construct validity. It is also likely that the patterns of activation will prove to be complex and hard to isolate, measure, and interpret.

Validating Inferences About How People with Different Profiles Behave Differently

A wide range of workshop activities conducted by Ned Herrmann and associates have repeatedly provided experiences that are self-validating for the participants. These "experiments" could be quantified and tested statistically. Some examples follow. Assume that people are arranged in the room in a continuum from left to right as they would be arranged by rank on the 3rd order Left-Right factor.

?? **Answering questions.** People on the left raise their hands to questions like "I like order and organization." People on the right to ones like "I depend on hunches in solving problems."

?? **Style of presentations.** Teams from the left come back with a leader, a flip-chart with 3 organized points to present, and are

right on time. People from the right struggle in late with no leader, no organization, and a lot of hand-waving and global statements.

?? **What work turns me on.** The list from the left is distinctly different from the list from the right. In addition, each side considers the opposite work either as "flaky" or "boring."

?? **Occupational choice.** The profiles of different occupations, based on the average profiles of people who are successful in that occupation, are quite different from one another. Such profiles could be used for counseling persons contemplating entering each occupation. Profiles could also be used to help students choose their college majors.

?? **Interpersonal communication.** Through interactive drawing, people learn that nonverbal communication with a person who has a different profile can be difficult; with someone who has a similar profile, a matched person, wordless communication can be easy.

?? **Preferred mode of learning.** The ACTAL workshops present ways to match presentations and practice activities to different profiles. For example, C quadrant people seem to do well in group discussions. Each such guideline is an hypothesis subject to confirmation or not.

?? **Improving group functioning.** Ways are presented to enhance authenticity and teamwork in families or work groups. Principles are given to value diversity and improve productive functioning. Each principle could be confirmed or not.

The demonstration of these phenomena in the workshops, like the physics or chemistry demonstrations given in excellent science classrooms, are compelling to the participants. These demonstrations could be replicated under standardized situations and validated or disconfirmed as general principles for dealing with differences.

SUMMARY

Evidence for the internal and external construct validity of the HBDI has been presented in this appendix. The following statements can be made with confidence that they are supportable by replicable validation studies.

Internal Construct Validation

1. There are four distinct clusters of preference ant avoidance measured by the HBDI.
2. The four clusters are consistent with the description given in this book of the quadrant model of brain processing.
3. The scores derived from the instrument are reliable.
4. The internal factor structure consists of two bipolar 2nd order factors (A vs. C and D vs. B) and a single bipolar third order factor (Left vs. Right Dominance).
5. Avoidance is most often found in the end opposite to a preferred end of one of the bipolar factors.

External Construct Validation

1. The Left vs. Right Score and the four quadrant scores are involved in a pervasive and a predictable way with the mental processes involved in measures of other constructs:
   ?? personality type
   ?? cognitive style/cognitive abilities
   ?? learning style

2. The bipolar factors internal to the HBDI are also found in first, second, and third-order factors in batteries of instruments that cut across these different instrument types. The quadrant constructs thus have explanatory and predictive power well beyond the HBDI item types.

3. While the HBDI scores share variance in predictable ways with speeded cognitive ability factors, introversion/extroversion and the tendency to use different learning strategies, these are all different factors which separate as distinct factors in properly constructed test batteries.

4. By contrast, the Myers-Briggs Type Indicator and other high-order measures of pervasive personal styles load on the same bipolar factors with the HBDI scores. They appear to be different rotations of item clusters which, while developed based on different theoretical models, may ultimately be explainable by a common set of constructs.

Future Construct Validation Research

1. There is a small amount of tantalizing evidence that the brain dominance constructs are related to the selective activation of certain functional subsystems in the brain. While no simplistic geographical model is expected to be valid to explain the four pervasive HBDI construct and the Left vs. Right factors, research with LEG recordings, PET scans, and other methods for measuring brain functioning may reveal stable correlations between different brain activation patterns and different HBDI profiles.

2. A variety of self-validating experiences in learning, teaching, communicating, counseling, and occupational choice are commonplace for users of the HBDI. Criterion-related evidence of the reliability and validity of these predictable relationships with different profiles could be readily obtained, extending the research base for new valid applications of the HBDI.

Conditions for Validity Depend on Professional Standards and Use

A number of standards for proper use, and conditions under which validity has been established were presented. A brief summary is that the HBDI scores can be used with the assumption of validity in those situations where the respondent has confidence in the professional use of the resulting scores and has not been coached to affect some outcome.

Through observing standards, holding certification workshops, and supporting research to continually validate and improve the HBDI and refine its uses, Ned Herrmann and his associates have met high standards for professional use of the HBDI.

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