

# Research Proposal

## The Highlands Ability Battery

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December 1, 1994

### I. Research Proposal

The Highlands Ability Battery is a set of 20 tests which measure strengths and weaknesses of certain abilities as well as other characteristics important for career and life decision-making. The tests composing the battery are:

1. **Classification:** a problem-solving ability in which the person must solve a presented problem using a holistic, right-brained, non-logical approach.
2. **Concept Organization:** a problem-solving ability in which the person must solve a presented problem using a logical, linear, left-brained approach.
3. **Idea Productivity:** a measure of the rate of production of ideas. Not a measure of creativity, only a measure of the rate of flow of ideas.
4. **Spatial Relations/Theory:** a measure of the person's ability to visualize and manipulate three-dimensional space and three-dimensional objects in his or her mind. Particularly loads on ability to visualize space.
5. **Spatial Relations/Visualization:** a measure of the person's ability to visualize and manipulate three-dimensional space and three-dimensional objects in his or her mind. Particularly loads on ability to visualize and manipulate objects.
6. **Design Memory:** a measure of the person's ability to visualize and remember a two dimensional design.
7. **Observation:** a measure of the person's ability to remember details from his or her visual field.
8. **Verbal Memory:** a measure of the person's ability to remember material presented in written form.
9. **Tonal Memory:** a measure of the person's ability to remember material presented aurally.
10. **Rhythm Memory:** a measure of the person's ability to remember musical rhythm.
11. **Pitch Discrimination:** a measure of the person's ability to distinguish fine shades of difference in musical pitch.
12. **Number Memory:** a measure of the person's ability to remember non-associatively.
13. **Visual Speed and Accuracy:** a measure of the person's ability to move his or her eyes rapidly and accurately from one place to another.

14. **Manual Speed and Accuracy:** a measure of the person's ability to move his or her hands from one point to another quickly and accurately.
15. **Writing Speed:** a measure of the speed of the person's handwriting.
16. **Vocabulary:** not strictly an ability measure. This is more accurately an achievement measure. It is so important in career planning that it is included as part of the ability battery.
17. **Time Frame:** a measure of the person's natural sense of the amount of time to take into account when thinking about the future.
18. **Grip:** a measure of the person's willingness to keep trying on a problem when faced with frustration.
19. **Introvert-Extrovert:** a measure of the person's preference for being with others as opposed to being alone.
20. **Specialist-Generalist:** a measure of the person's propensity to come up with common responses to problems as opposed to unique responses.

A factor analysis was performed using data from approximately 2100 protocols. A Varimax rotation was used to identify the principal factors of the battery. This analysis showed 11 factors:

1. **Visual/Spatial Reasoning:** Spatial Relations/Visualization, Spatial, Relations/Theory, Design Memory, Concept Organization.
2. **Visual Memory:** Design Memory, Observation, Verbal Memory, Number Memory.
3. **Cognitive Reasoning:** Concept Organization, Classification
4. **Grip:** Grip
5. **Visual Speed:** Visual Speed.
6. **Visual Accuracy:** Visual Accuracy.
7. **Musical:** Rhythm Memory, Tonal Memory, Pitch Discrimination.
8. **Speed:** Idea Productivity, Time Frame, Writing Speed, Manual Speed.
9. **Extrovert-Introvert:** Extrovert-Introvert.
10. **Specialist-Generalist:** Specialist-Generalist.
11. **Vocabulary:** Vocabulary.

At the request of The Highlands Program, I have undertaken to go over extant research data on The Highlands Ability Battery, and propose a research program that will provide some indication of the reliability and validity of the individual tests of the battery, as well as the overall pattern of scores obtained by subjects. Much of the research that has been done in the past on the validity of the instruments is old, used small sample sizes, and was primarily nonparametric. Our plan is to start over again with the research and create a body of data that can shed more light on the true reliability and validity of the battery.

The overall plan of research is as follows:

1. Estimate the reliability of the separate instruments comprising the battery of tests.
2. Establishment norms for the separate instruments of the battery.

3. Provide evidence of divergent validity using the separate instruments of the battery.
4. Provide evidence of convergent validity using the separate instruments of the battery.
5. Provide evidence of validity of the pattern of scores on the battery by comparing fit of actual abilities and abilities required by tasks of actual job with reported job satisfaction to date.
6. Provide evidence of validity of the pattern of scores on the battery by comparing fit of actual abilities and abilities required by tasks of actual job with reported salary and age within a job group.
7. Provide evidence of validity of individual instruments of the battery by comparing scores on the instruments with scores on tests that are designed to measure the same ability of known psychometric properties.<sup>1</sup>

**As of the date of this proposal, the following has been completed:**

1. Estimate of reliability of the separate instruments.
2. Establishment of norms for the separate instruments.
3. Evidence of divergent validity.
4. Evidence of convergent validity.

See below for a brief summary of these findings.

**The following studies are in progress:**

5. Some work has been done previously in comparing job satisfaction and job success with ability fit for the job<sup>2</sup>. A follow-up was done on 259 high school students who had taken an ability battery similar in form and format to The Highlands Ability Battery. This study showed that ability scores over an eight year span did not predict what field a person would be likely to enter. This means that these subjects did not tend to choose occupations based on their ability scores. The study did show significant relationships between the subjects' rating of satisfaction with their jobs, and their rating of success on their jobs with the appropriateness of their ability scores to the job field they entered. Although there are some problems with this study, the findings are suggestive. We will undertake to show a more convincing connection between job and ability fit and job satisfaction and success.

Comparison of the fit between the subjects measured ability pattern and his or her present job position (the abilities required for a given job are taken from published job descriptions in the Index of Occupational Titles), with his or her reported job satisfaction.

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<sup>1</sup>The history and development of each of the tests comprising The Highlands Ability Battery is given in the The Highlands Program Technical Manual for each test. In addition, in each of these Technical Manuals is a summary of all past psychometric research on test development, reliability, and validity, as well as a discussion of the construct that the test was designed to measure. These Technical Manuals are available from The Highlands Program, Atlanta, Georgia.

<sup>2</sup>Bizot, E.B. and Goldman, S.H. (1992). Prediction of satisfactoriness and satisfaction: an eight-year follow-up. Private communication, The Ball Foundation, Glynn Eulyn, IL.

Job fit will be established for each general occupational field (Clerical, Technical, Skilled/Semiskilled, Sales, Supervisory/Administrative, etc.) by using published information to describe what abilities are required (Visual/Spatial, Cognitive Reasoning, act.) and to what extent (on a scale from 1-10). Abilities will be grouped in categories that are suggested by factor analysis. Fit will be established by ability category and by overall pattern by comparing a subject's actual ability scores with the job field ability description of the subject's reported job at the time of testing. We will thus be able to determine whether one or another category of ability is more important in job satisfaction than the others for a given job category, and whether the overall pattern of scores is more predictive than a single ability category.

It is theorized that a closer fit between the person's measured abilities and the abilities required by the job will lead to increased job satisfaction. Data will be collected on approximately 500-1000 subjects. Data collection will be complete by February 1. The analysis of this data will begin in February, 1995, and should be complete by March 1, 1995.

6. Comparison of the fit between the subject's measured ability pattern and his or her present job position with his or her salary. Salary will be grouped into categories by age and job area. Salary in this case is being used as a rough measure of success in a field. Ability fit will be determined as described above. It is theorized that the closer the fit between the person's abilities and the abilities required by his or her job, the more likelihood that the person will be successful in that job. Data collection for this study has just begun and should be complete by April 1, 1995.

7. The major components of The Highlands Ability Battery will be compared with other tests designed to measure the same factors.

As of the date of this proposal, the following work has been done on comparing the tests of The Highlands Ability Battery with other well-known batteries that purport to measure the same domain of abilities.

A. Background. The Ball Foundation, using its Ball Aptitude Battery (BAB)<sup>3</sup>, an ability battery that has 13 tests, 9 of which are identical tests administered in identical fashion as tests in The Highlands Ability Battery (Visual Speed and Accuracy, Idea Productivity, Classification, Writing Speed, Spatial Relations/Theory, Vocabulary, Grip, Concept Organization were identical to tests in The Highlands Ability Battery. The constructs measured by Spatial Relations/Visualization and Manual Speed and Accuracy were measured on the Ball Aptitude Battery by different tests) compared scores on the

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<sup>3</sup> Sung, Y.H. and Dawis, R.V. (1981). *Ball Aptitude Battery: Technical manual*. Glen Ellyn, IL: The Ball Foundation.

BAB with scores on Cattell's Comprehensive Aptitude Battery(CAT)<sup>4</sup>, the Differential Aptitude Tests(DAT)<sup>5</sup>, and the General Aptitude Test Battery(GATB)<sup>6</sup> for a limited sample of adults and students<sup>7</sup>. Results of this study showed correlations with equivalent tests between the BAB and the CAT, DAT, and GATB to range between .17 (for Classification) and .83(for Vocabulary). With the exception of Classification, all correlations were above .30. The authors of the study felt that there was no adequate equivalent in the other three batteries for this test. They concluded:

1. All convergent validity coefficients, except for the correlation of .17 for the Classification test, obtained practical as well as statistical significance.

2. Each BAB test exhibited higher convergent validity except for Classification than that between each BAB test and tests of different traits assessed by the CAB, DAT, GATB, and combined tests.

3. All convergent validity coefficients were higher than the corresponding correlations between a BAB test for a given trait and measures of different traits all assessed by the other BAB tests.

4. The pattern of correlations among the different traits was somewhat similar across the four batteries.

Using a test battery very similar in construction, format, and administration to The Highlands Ability Battery, the Ball Foundation found significant and practical correspondence of its scores with three standard ability batteries. In addition, the Ball study found adequate convergent and divergent correspondence between the BAB and the DAT, CAB, and the GATB. The interpretation of these results is limited because of the limited sample sizes, and the limited population from which the samples were drawn.

B. Validation Study. In 1994 The Highlands Program compared scores on selected tests of The Highlands Ability with tests measuring comparable abilities of the Employee Aptitude Survey (EAS)<sup>8</sup>. The EAS is a battery of ability tests that were developed for industrial application. They have been extensively used and validated. Two tests of the EAS are identical in form, format, and administration to two tests of The Highlands Ability Battery (EAS Test 4, Visual Speed and Accuracy is identical to The Highlands Ability Battery, Visual Speed and Accuracy; EAS Test 9, Manual Speed and Accuracy is identical to The Highlands Ability Battery, Manual Speed and Accuracy). EAS Test 1, Verbal Comprehension, a vocabulary test, was compared to Vocabulary on

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<sup>4</sup>Hakstian, A.R. and Cattell, R.B. (1976). *Comprehensive Ability Battery* (manual). Champaign, IL: The Institute for Personality and Ability Testing.

<sup>5</sup>Bennett, C.K., Seashore, H.G., and Wesman, A.G. (1974). *Differential Aptitude Tests* (manual). New York: The Psychological Corporation.

<sup>6</sup>United States Department of Labor (1970). *General Aptitude Test Battery* (manual). Washington, D.C.:U.S. Government Printing Office.

<sup>7</sup>Dong, H.K., Sung, Y.H., Goldman, S.H., and Dohm, T.E., (1986). The validity of the Ball Aptitude Battery. Relationship to CAB, DAT, and GATB. *Educational and Psychological Measurement*, 1986, 46. Sample sizes: DAT, 84 high school students; CAB, 151 adults; GATB, 116 college students.

<sup>8</sup>Ruch F. L. & Ruch, W. W. (1980). *Employee aptitude survey Technical report..* Los Angeles: Psychological Services, Inc.

The Highlands Ability Battery EAS Test 5 Space Visualization was compared to The Highlands Ability Battery, Spatial Relations/Visualization and Spatial Relations/Theory. EAS Test 7 Verbal Reasoning, was compared to The Highlands Ability Battery, Concept Organization. The following correlations were found:

EAS Test 1. Verbal Comprehension

<b>HAB Test</b>	<b>N=</b>	<b>r=</b>	<b>P=</b>
Vocabulary 1	200	.70	<.001
Vocabulary 2	200	.62	<.001

EAS Test 4. Visual Speed and Accuracy

<b>HAB Test</b>	<b>N=</b>	<b>r=</b>	<b>P=</b>
Visual Speed	200	.87	<.001
Visual Accuracy	200	.88	<.001

EAS Test 5. Space Visualization

<b>HAB Test</b>	<b>N=</b>	<b>r=</b>	<b>P=</b>
Spatial Relations/ Visualization/	200	.51	<.001
Spatial Relations/ Theory	200	.68	<.001
Concept Organization	200	.58	<.001

EAS Test 7. Verbal Reasoning

<b>HAB Test</b>	<b>N=</b>	<b>r=</b>	<b>P=</b>
Concept Organization	200	.36	<.001
Spatial Relations! Theory	200	.45	<.001
Vocabulary 1	200	.49	<.001
Vocabulary 2	200	.31	.001

EAS Test 9. Manual Speed and Accuracy

<b>HAB Test</b>	<b>N=</b>	<b>r=</b>	<b>P=</b>
Manual Speed	200	.89	<.001
Manual Accuracy	200	.93	<.001

It is apparent that the EAS Tests are measuring similar abilities as the tests from The Highlands Ability Battery. In addition, it is also apparent that the tests of the EAS Battery (10 in all) group themselves in a similar fashion as the tests of The Highlands Ability Battery. There is clearly a problem-solving, or cognitive reasoning factor, a spatial abilities factor, a Manual Speed and Accuracy factor, a Visual Speed and Accuracy factor, and Vocabulary factor.

**C. Proposed Validation Study.** Much is known about the structure of abilities as they have been measured by various instruments. Cattell's Universal Index, Thurstone's Primary Mental Abilities, and Guilford's Study of the Intellect all show quite similar groupings of factors.<sup>9</sup> In order to further study the overall structure as well as the individual tests of The Highlands Ability Battery, we propose to compare the tests of The Highlands Ability Battery with tests from the Factor Referenced Kit of the ETS<sup>10</sup>. Following the recommendations of the authors, we will use 2 tests in each factor. The following factors will be used:

- Speed of Closure (CS)
- Ideational Fluency (FI)
- Induction (I)
- Associative Memory (MA)
- Memory Span (MS)
- Visual Memory (MV)
- Perceptual Speed (P)
- Verbal Comprehension (V)
- Visualization (VZ)
- Figural Flexibility (XF)
- Flexibility of Use (XEJ)

We will collect data on approximately 200 subjects. The data collection should be complete by April 1, 1995. Analysis should be complete by May 1, 1995. These factors should match up well to the factors identified by The Highlands Program and by others who have studied ability measurement. We can see from this study how well the tests from The Highlands Ability Battery group into factors and how these factors match to those identified by the Factor Referenced Tests. In addition, we will have further evidence of the extent to which the tests of The Highlands Ability Battery match up to tests of abilities that have been extensively used and validated.

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<sup>9</sup>Ekstrom,R.B., French, J.W., Harmon, H.H., and Derman, D (1976). *Manual for Kit of Factor-Referenced Cognition Tests*. Educational Testing Service, Princeton, N.J.

<sup>10</sup>*Ibid.*

## **Summary of Completed Research**

### **II. Reliability of the separate instruments.**

The Highlands Program carried out a study of the reliability of the individual tests comprising The Highlands Ability Battery in 1994. This study was completed with 298 participants drawn from regular clients of The Highlands Program. They ranged in age from 15 to 66. There were 146 males and 152 females. Of the adults over 25, almost all were college graduates. Most of the participants who were younger than 25 were either college students or former college students.

The following table summarizes the findings from this Study:

**1994 Reliability Study Results:  
The Highlands Ability Battery**

<b>Worksample</b>	<b>Method</b>	<b>N</b>	<b><u>r</u></b>
Concept Organization	Split Half, By Response <sup>a</sup>	294	.95
Concept Organization	Standardized Item Alpha	294	.63
Concept Organization	Split Half, Odd-Even	294	.64
Classification	Split Half	297	.86
Design Memory	Split Half, By Response	297	.92
Design Memory	Split Half, Odd-Even, By Item	297	.70
Design Memory	Standardized ItemAlpha	297	.67
Grip	Alternate Form	1768	.95
Idea Productivity	Split Half	266	.88
Manual Accuracy	Split Half	251	.94
Manual Speed	Split Half	251	.87
Number Memory	Item Intercorrelation -- Alpha	296	.85
Observation	Split Half, By Response	295	.84
Observation	Item Intercorrelation — Alpha	295	.86
Observation	Split Half, Odd-Even	295	.78
Pitch Discrimination	Split Half	297	.87
Rhythm Memory	Split Half	297	.83
Spatial Relations/Theory	Split Half	297	.90
Spatial Relations/Visualization	Split Half	297	.84
Specialist-Generalist	Parallel Forms <sup>b</sup>	297	.85
Time Frame	Standardized Item Alpha	296	.86
Time Frame	Item Intercorrelation -- Alpha	296.	.83
Tonal Memory	Split Half	297	.93
Verbal Memory	Split Half	298	.92
Visual Speed	Split Half	296	.88
Visual Accuracy	Split Half	296	.86
Total Vocabulary	Parallel Forms	296	.88
Vocabulary 1	Split Half	296	.95
Vocabulary 2	Split Half	296	.87

<sup>a</sup>Split Half reliability estimated using equal length Spearman-Brown.

<sup>b</sup>Parallel forms reliability estimated using unbiased estimate of reliability.

These estimates of reliability show that the individual tests comprising The Highlands Ability Battery are sufficiently reliable to make scores on these tests meaningful for comparison. It will be noted that the Observation, Concept Organization, and Design Memory tests have relatively few items, although each of the items on these tests has several independent responses. Reliability was estimated using a straightforward odd-even correlation of items; however, a more accurate estimate of the true reliability of these tests was also calculated by considering each possible response as an individual item. Item alpha was also calculated based on item responses.

We therefore conclude that the reliability of the separate instruments that compose The Highlands Ability Battery is sufficiently established to make further study of norms and validity meaningful.

### **III. Establishment of Norms**

In 1993, The Highlands Program undertook a study to verify and update the norms on the individual tests of The Highlands Ability Battery. This study used some 2100 protocols from individuals who had sought ability testing from Ability Potentials, Inc. in Alexandria, Virginia, from 1987-1992. Ability Potentials was the company that owned The Highlands Ability Battery before The Highlands Program bought it to use with its programs of seminars and workshops.

The normative population consisted of 2100 individuals, ranging in age from 14 to 66. There were 1207 females and 894 males. Almost all above the age of 24 were college graduates, and almost all of those younger than 25 were either college graduates, in college, considering attending college, or had formerly attended college. Norms were established for males, females, and the following age groups - 15-22, 22-30, 30-39, 39 and over.

### **VI. Establishing Divergent and Convergent Validity**

Each test was correlated to the scores of all of the other tests on The Highlands Ability Battery. For the purposes of this analysis, we will follow Campbell and Fiske's<sup>11</sup> recommendations. A correlation is not considered of practical significance (as opposed to statistically significant) unless it is over .30. The results of this analysis are reported below:

#### **1. Classification**

Classification is a problem-solving test that loads on a holistic, right-hemisphere, non-logical problem-solving path. We would expect Classification to correlate well with other problem-solving tests. In addition, since the most efficient solution to the problem of the test is through a holistic, right-hemisphere problem-solving method, we would expect it to correlate well to other tests that load heavily on visual and spatial memory and visual and spatial problem-solving.

Given the construct that the test is measuring, we would not expect a high correlation to Introvert-Extrovert, Generalist-Specialist, Grip, Idea Productivity, Manual Speed and Accuracy, Number Memory, Pitch Discrimination, Rhythm Memory, Visual Speed and Accuracy, Vocabulary, or Writing Speed.

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<sup>11</sup>Campbell, D.T. and Fiske, D.W. (1959). Convergent and discriminant validation by multitrait-multimethod matrix. *Psychological Bulletin*, 56, 81-105.

Results are shown below:

<b>Classification</b>	<b>r=</b>	<b>N=</b>
Classification	1.000	2095
Concept Organization	.3 825	2090
Design Memory	.3853	2095
Extrovert-Introvert 1	.03 17	1544
Extrovert-Introvert 2	-.0570	554
Generalist-Specialist 1	-.0181	906
Generalist-Specialist 2	.0112	2094
Grip, Left	.1610	1777
Grip, Right	.1599	1773
Idea Productivity	.0984	2089
Manual Speed	.1103	2088
Manual Accuracy	.033 1	2089
Number Memory	.1574	2093
Observation	.2974	2093
Pitch Discrimination	.1455	2093
Rhythm Memory	.1726	2094
Spatial Relations/Theory	.3399	2090
Spatial Relations/Visualization	.2927	2092
Time Frame	.2130	2094
Tonal Memory	.1641	2094
Verbal Memory	.2066	2082
Visual Speed	.1512	2004
Visual Accuracy	-.1201	1909
Vocabulary 1	.0802	2020
Vocabulary 2	.0404	1620
Writing Speed	.0068	2095

Note: All correlations over .10 are significant.

As can be seen from these data, Classification corresponds at a relatively high level with the spatial tests, Spatial Relations/Theory and Spatial Relations/Visualization, the problem-solving test, Concept Organization, and the visual tests, Design Memory, and Observation. These correlations are practically, or nearly practically significant, and are ones that would be expected by the definition of the construct.

Classification does not correspond at a very high level to Introvert-Extrovert, Generalist-Specialist, Grip, Idea Productivity, Manual Speed or Accuracy, Pitch Discrimination, Rhythm Memory, Tonal Memory, Visual Speed or Accuracy, Vocabulary, or Writing Speed. This is as would be predicted by the construct.

The correlations of Classification with Time Frame and Verbal Memory are interesting. Both of these measures load on the person's ability to make difficult verbal associations.

The person high in Classification may be able to make these difficult associations somewhat more easily than the person low in this ability.

## 2. Concept Organization

Concept Organization is a problem-solving test that loads on the person's ability to make logical, linear, left-hemisphere rules for a series of presented facts. Concept Organization should correlate well with tests that call for logical problem-solving and verbal, left hemisphere tasks. In addition, the mechanics of taking this test involve holding a number of verbal and visual stimuli in mind while working out the task.

These correlations are presented in the table below:

<b>Concept Organization</b>	<b>r=</b>	<b>N =</b>
Classification	.3 825	2090
Concept Organization	1.0000	2094
Design Memory	.3 872	2094
Extrovert-Introvert 1	-.0704	1543
Extrovert-Introvert 2	-.0970	554
Generalist-Specialist1	.0098	908
Generalist-Specialist2	.0494	2093
Grip, Left	.0552	1775
Grip, Right	.0512	1772
Idea Productivity	.1627	2088
Manual Speed	.1103	2087
Manual Accuracy	-.0453	2088
Number Memory	.2305	2092
Observation	.34 16	2092
Pitch Discrimination	.2044	2092
Rhythm Memory	.2480	2093
Spatial Relations/Theory	.4974	2089
Spatial Relations/Visualization	.2993	2091
Time Frame	.1829	2093
Tonal Memory	.2392	2093
Verbal Memory	.3030	2081
Visual Speed	.2296	2003
Visual Accuracy	-.2106	1908
Vocabulary 1	.3039	2019
Vocabulary 2	.2135	1618
Writing Speed	.0936	2094

Note: All correlations over .10 are significant.

As can be seen from these data, Concept Organization correlates most strongly with Spatial Relations/Theory and Classification. Both of these tasks are problem-solving tasks that are most easily and efficiently solved using separate specialized abilities.

However, both of these tasks can be solved using the relatively less efficient (for the given task) linear, logical ability measured by Concept Organization. In addition, these correlations show a relatively strong relationship between Concept Organization and the visual abilities of Design Memory, Observation, and Visual Speed and Accuracy which may well be related to the mechanics of the test itself. There are also mild correlations to Vocabulary, and the memory tests of Verbal Memory and Number Memory. With the exception of Spatial Relations/Theory, none of these correlations are high; however, the spread of correlations suggests that Concept Organization is measuring an ability that is very widely useable in tasks that are not necessarily most efficiently solved with a logical, linear approach.

Concept Organization shows very low or non-significant correlations with such tests as Extrovert-Introvert, Specialist-Generalist, Manual Speed and Accuracy, Writing Speed, Idea Productivity, and Grip. This would be predicted from the construct. The correlations of Concept Organization with the musical tests of Tonal Memory, Rhythm Memory, and Pitch Discrimination are relatively low, but still interesting. Correlations in this range have also been found by other researchers in this area.<sup>2</sup>

### **3. Design Memory**

Design Memory is a test of visual memory for design. We would expect that it would correspond to other tests of different aspects of visual memory. We would also expect that it would correlate fairly well with other tests of different aspects of memory. This test can be approached as a problem-solving task (although this is not an efficient approach to the task), and so we would expect some correspondence to other tests of problem-solving. Since the most efficient method of approaching the task of Design Memory is to hold some kind of representation of the figure in one's mind, we could expect strong correspondence to Spatial Relations/Theory and Spatial Relations/Visualization, which are approached most efficiently by being able to hold representations of (three dimensional) space and objects in mind.

We would expect a relatively weak correlation between Design Memory and Extrovert-Introvert, Generalist-Specialist, Grip, Idea Productivity, Manual Speed and Accuracy, Time Frame, Visual Speed and Accuracy, Vocabulary, and Writing Speed, as none of these constructs should be related to the construct of Design Memory.

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<sup>12</sup> Daniel, Mark. Large-Sample Test Intercorrelations, Technical Report 1983-2, Human Engineering Laboratory, Chicago, 1983.

The actual correlations are reported below:

<b>Design Memory</b>	<b>r=</b>	<b>N =</b>
Classification	.3053	2095
Concept Organization	.3872	2094
Design Memory	1.0000	2099
Extrovert-Introvert 1	.0475	1548
Extrovert-Introvert 2	-.0282	554
Generalist-Specialist 1	-.1374	908
Generalist-Specialist 2	-.0567	2098
Grip, Left	.0982	1780
Grip, Right	.1029	1776
Idea Productivity	.0946	2093
Manual Speed ‘	.2063	2092
Manual Accuracy	.0101	2093
Number Memory	.3216	2097
Observation	.4719	2097
Pitch Discrimination	.1940	2097
Rhythm Memory	.2783	2098
Spatial Relations/Theory	.6035	2094
Spatial Relations/Visualization	.4234	2096
Time Frame	.1257	2098
Tonal Memory	.2603	2098
Verbal Memory	.3401	2086
Visual Speed	.2294	2007
Visual Accuracy	-.1785	1912
Vocabulary 1	-.0028	2024
Vocabulary 2	-.0272	1623
Writing Speed	.0165	2099

Note: All correlations over .10 are significant.

As these data indicate, the strongest correlations are between Design Memory and the two Spatial Relations tests, Theory and Visualization. In addition, there is a relatively strong correspondence to Observation, the other task in the battery that is almost purely visual in nature. Design Memory correlates relatively well with the other memory tests of the battery: Number Memory, Rhythm Memory, Tonal Memory, and Verbal Memory as would be expected since they are all measuring abilities in the same domain. In that Design Memory can be approached as a problem, or puzzle, we could expect some correspondence to problem-solving tasks, and there is mild correlation between Design Memory and Concept Organization and Classification. On the other hand, Design Memory does not correlate at a high level with other tests in the battery that are not related to it: Extrovert-Introvert, Generalist-Specialist, Grip, Idea Productivity, Manual Speed and Accuracy, Pitch Discrimination, Time Frame, Visual Speed and Accuracy, Vocabulary, or Writing Speed.

#### 4. Personality Measures: Extrovert-Introvert, Specialist-Generalist

Extrovert-Introvert is a personality dimension measured in the present battery by the Meyers-Briggs Type Indicator. An early version of the battery used another measure for Extrovert-Introvert that has since been discontinued. We would not expect a strong correlation between Extrovert-Introvert and any of the ability measures.

<b>Extrovert-Introvert 1</b>	<b>r=</b>	<b>N =</b>
Classification	-.0570	554
Concept Organization	-.0970	554
Design Memory	-.0282	554
Extrovert-Introvert 1	.8687	13
Extrovert-Introvert 2	1.0000	554
Generalist-Specialist 1	-.1263	554
Generalist-Specialist 2	-.1350	554
Grip, Left	.0150	536
Grip, Right	.0165	536
Idea Productivity	.0002	554
Manual Speed	-.0708	551
Manual Accuracy	.0317	551
Number Memory	.0242	554
Observation	.0421	554
Pitch Discrimination	.0032	554
Rhythm Memory	-.0872	554
Spatial Relations/Theory	-.1037	551
Spatial Relations/Visualization	-.0126	552
Time Frame	.0484	554
Tonal Memory	-.0603	554
Verbal Memory	-.0129	553
Visual Speed	-.0557	550
Visual Accuracy	.0385	552
Vocabulary 1	-.2697	554
Vocabulary 2	-.2455	471
Writing Speed	.0418	554

Note: All correlations over .12 are significant.

<b>Extrovert-Introvert 2</b>	<b>r=</b>	<b>N =</b>
Classification	.0317	1544
Concept Organization	-.0704	1543
Design Memory	.0475	1548
Extrovert-Introvert 1	1.0000	1549
Extrovert-Introvert 2	.8687	13
Generalist-Specialist 1	-.0598	365
Generalist-Specialist 2	-.0801	1548
Grip, Left	.0268	1249
Grip, Right	.0184	1245
Idea Productivity	.0723	1543
Manual Speed	.0518	1545
Manual Accuracy	.0779	1546
Number Memory	.0240	1546
Observation	.0513	1546
Pitch Discrimination	-.0659	1546
Rhythm Memory	-.0401	1547
Spatial Relations/Theory	-.0245	1547
Spatial Relations/Visualization	.0388	1548
Time Frame	.0961	1547
Tonal Memory	-.0408	1548
Verbal Memory	.0279	1537
Visual Speed	-.0234	1460
Visual Accuracy	.0322	1364
Vocabulary 1	-.3050	1475
Vocabulary 2	-.2458	1153
Writing Speed	-.0109	1549

Note: All correlations over .10 are significant.

As can be seen in the data above, the two measures of Extrovert-Introvert are consistent with each other. For both measures, there are virtually no strong correlations with the measures of ability. The only correlations that are mildly strong are between Extrovert-Introvert and the two Vocabulary measures - these are negative. Since the scores are reported in the Extrovert direction, there may be a tendency for Introverts to do better on measures of Vocabulary.

Generalist-Specialist is also a personality dimension. It is measured by means of a word association test developed by Johnson O'Connor. One test is presented orally and the other is presented in written form. We would not expect a high correspondence between Specialist-Generalist and any of the measures of ability.

<b>Generalist-Specialist 1</b>	<b>r=</b>	<b>N =</b>
Classification	-.0181	906
Concept Organization	.0098	908
Design Memory	-.1374	908
Extrovert-Introvert 1	-.0598	365
Extrovert-Introvert 2	-.1263	554
Generalist-Specialist 1	1.0000	908
Generalist-Specialist 2	.7371	907
Grip, Left	.0148	881
Grip, Right	.0130	880
Idea Productivity	-.0445	907
Manual Speed	-.0708	551
Manual Accuracy	-.0482	905
Number Memory	-.0595	907
Observation	-.0384	908
Pitch Discrimination	-.0148	908
Rhythm Memory	-.0644	908
Spatial Relations/Theory	-.0594	905
Spatial Relations/Visualization	-.0649	906
Time Frame	-.1355	908
Tonal Memory	-.0789	908
Verbal Memory	-.1026	902
Visual Speed	-.0538	898
Visual Accuracy	-.0095	870
Vocabulary 1	.0264	907
Vocabulary 2	.0871	754
Writing Speed	.0100	908

Note: All correlations over .11 are significant.

<b>Generalist-Specialist 2</b>	<b>r=</b>	<b>N=</b>
Classification	.0112	2094
Concept Organization	.0494	2093
Design Memory	-.0567	2098
Extrovert-Introvert 1	-.0801	1548
Extrovert-Introvert 2	-.1350	554
Generalist-Specialist 1	.7371	907
Generalist-Specialist 2	1.0000	2099
Grip, Left	.0401	1780
Grip, Right	.0395	1776
Idea Productivity	-.0380	2093
Manual Speed	-.0250	2092
Manual Accuracy	.0257	2093
Number Memory	-.0319	2096
Observation	.0142	2096
Pitch Discrimination	-.0257	2096
Rhythm Memory	-.0320	2097
Spatial Relations/Theory	-.0540	2094
Spatial Relations/Visualization	.0112	2096
Time Frame	-.1014	2097
Tonal Memory	-.0485	2098
Verbal Memory	-.0405	2085
Visual Speed	-.0191	2006
Visual Accuracy	-.0241	1911
Vocabulary 1	.0447	2024
Vocabulary 2	.0365	1624
Writing Speed	-.0306	2099

Note: All correlations over .10 are significant.

As can be seen in these data, there are no strong correlations between either version of Specialist-Generalist and any of the ability measures. This would be predicted by the construct. The two versions of Specialist-Generalist correlate at a high level with each other, as would be expected. The correlation is not perfect because the presentation uses different learning channels (hearing and reading), and we would expect some variation in scores due to variations in these abilities.

## 5. Grip

Grip is a measure of determination or ability to persevere with a task even when frustrated. The person is presented with a physically frustrating task and given three opportunities to attempt it. The person's score is the arithmetic total of the three attempts.

People who respond to the frustration by not trying any further score lower than those who keep trying, or who in fact increase their efforts in an attempt to complete the task. This test is one of two that have very low face validity. It does not appear to be measuring what it is in fact measuring. We would not expect this test to correlate at a high level to any of the other ability measures.

<b>Grip, right</b>	<b>r=</b>	<b>N =</b>
Classification	.1599	1773
Concept Organization	.0512	1772
Design Memory	.1029	1776
Extrovert-Introvert 1	.0184	1245
Extrovert-Introvert 2	.0165	536
Generalist-Specialist 1	.0130	880
Generalist-Specialist 2	.0395	1776
Grip, Left	.9458	1768
Grip, Right	1.0000	1777
Idea Productivity	-.1849	1773
Manual Speed	-.0212	1771
Manual Accuracy	.0841	1772
Number Memory	.0758	1775
Observation	-.0481	1774
Pitch Discrimination	.0876	1774
Rhythm Memory	.0082	1775
Spatial Relations/Theory	.1581	1773
Spatial Relations/Visualization	.3664	1774
Time Frame	-.0772	1776
Tonal Memory	.0426	1776
Verbal Memory	-.1338	1764
Visual Speed	-.1613	1686
Visual Accuracy	.0327	1594
Vocabulary 1	-.0133	1728
Vocabulary 2	-.0145	1415
Writing Speed	-.0823	1777

Note: All correlations over .10 are significant.

<b>Grip, left</b>	<b>r=</b>	<b>N=</b>
Classification	.1610	1777
Concept Organization	.0552	1775
Design Memory	.0982	1780
Extrovert-Introvert	.0268	1249
Extrovert-Introvert 2	.0150	536
Generalist-Specialist 1	.0148	881
Generalist-Specialist 2	.0401	1780
Grip, Left	1.0000	1781
Grip, Right	.9458	1768
Idea Productivity	-.2094	1777
Manual Speed	-.0234	1775
Manual Accuracy	.0894	1776
Number Memory	.0789	1779
Observation	-.0439	1778
Pitch Discrimination	.0993	1778
Rhythm Memory	.0012	1779
Spatial Relations/Theory	.1645	1777
Spatial Relations/Visualization	.3668	1778
Time Frame	-.0877	1780
Tonal Memory	.0383	1780
Verbal Memory	-.1360	1768
Visual Speed	-.1734	1690
Visual Accuracy	.0451	1599
Vocabulary 1	-.0303	1733
Vocabulary 2	.0022	1419
Writing Speed	-.0906	1781

Note: All correlations over .10 are significant.

Grip done with the right hand correlates at a very high level with Grip done with the left. This is entirely expected by the construct. There is a mild correlation of Grip with Spatial relations/Visualization. Spatial Relations/Visualization is a notoriously difficult task for a person to complete who does not have the ability strongly. It may be that there is a tendency for those with high Grip to persevere in this frustrating task even when they do not have a strong ability in Spatial Relations, thus increasing their scores. There is a mild negative correlation with Idea Productivity. It may be that people who are able to ‘let go’ somewhat do better on Idea Productivity than those who push ahead as hard as they can.

## 6. Idea Productivity

Idea Productivity is a measure of the rate of production of ideas. The measure is straightforward: the person is asked to write whatever he or she can about an imaginary topic within a five-minute time limit. This test has historically had a strong relationship to Writing Speed, and in fact the Writing Speed test is primarily given in order to provide the ability to eliminate this source of variance. In computing the final norms for Idea Productivity, different norms were developed for different levels of writing speed. In addition, Idea Productivity has historically had a strong relationship to Time Frame. The two tasks are somewhat similar: in Time Frame, the person is asked to name as many associations to a simple figure drawing as he or she can think of.

<b>Idea Productivity</b>	<b>r=</b>	<b>N=</b>
Classification	.0984	2089
Concept Organization	.1627	2088
Design Memory	.0946	2093
Extrovert-Introvert 1	.0723	1543
Extrovert-Introvert 2	.0002	554
Generalist-Specialist 1	-.0445	907
Generalist-Specialist 2	-.0380	2093
Grip, Left	-.2094	1777
Grip, Right	-.1849	1773
Idea Productivity	1.0000	2094
Manual Speed	.2106	2088
Manual Accuracy	-.0151	2089
Number Memory	.0716	2091
Observation	.1901	2091
Pitch Discrimination	.0971	2091
Rhythm Memory	.1342	2093
Spatial Relations/Theory	.0771	2089
Spatial Relations/Visualization	-.0412	2091
Time Frame	.3620	2092
Tonal Memory	.1159	2093
Verbal Memory	.1508	2080
Visual Speed	.2961	2001
Visual Accuracy	-.0495	1906
Vocabulary 1	.2141	2019
Vocabulary 2	.1301	1619
Writing Speed	.5330	2094

Note: All correlations over .10 are significant.

The expected relationships to Writing Speed and Time Frame occurred in this study. As noted above, the Writing Speed test is primarily given to eliminate the factor of sheer manual speed and dexterity in writing from consideration in the Idea Productivity test. There are also mild correlations with Visual Speed, Manual Speed and Vocabulary. The relationship to Vocabulary is interesting. The first Vocabulary test is primarily spoken vocabulary. It is this vocabulary that the person would probably draw from in the press of the Idea Productivity test.

## 7. Manual Speed and Accuracy

The Manual Speed and Accuracy test is a direct measure of the speed and accuracy with which a person performs a manual small-motor task. It does not relate strongly to any other of the abilities except for Writing Speed, which is a much more complex task. The correlations between Manual Speed and Manual Accuracy and the other tests of The Highlands Ability Battery are shown below:

<b>Manual Speed</b>	<b>r=</b>	<b>N =</b>
Classification	.1103	2088
Concept Organization	.1103	2087
Design Memory	.2063	2092
Extrovert-Introvert 1	.0518	1545
Extrovert-Introvert 2	-.0708	551
Generalist-Specialist I	-.0666	904
Generalist-Specialist 2	-.0250	2092
Grip, Left	-.0234	1775
Grip, Right	-.0212	1771
Idea Productivity	.2106	2088
Manual Speed	1.0000	2093
Manual Accuracy	.3958	2093
Number Memory	.0569	2090
Observation	.2183	2090
Pitch Discrimination	.1026	2090
Rhythm Memory	.1061	2091
Spatial Relations/Theory	.1452	2088
Spatial Relations/Visualization	.1152	2090
Time Frame	.1238	2091
Tonal Memory	.0940	2092
Verbal Memory	.1244	2079
Visual Speed	.2589	2000
Visual Accuracy	.0229	1905
Vocabulary 1	.0227	2018
Vocabulary 2	-.0407	1620
Writing Speed	.2310	2093

Note: All correlations over .10 are significant.

As can be seen from these data, the only correlations of any size are between Manual Speed and Manual Accuracy, Writing Speed, and Visual Speed. The correlation with Visual Speed would be expected from the factor analysis of the data.

<b>Manual Accuracy</b>	<b>r=</b>	<b>N=</b>
Classification	.0331	2089
Concept Organization	-.0453	2088'
Design Memory	.0101	2093
Extrovert-Introvert 1	.0779	1546
Extrovert-Introvert 2	.0317	551
Generalist-Specialist 1	-.0482	905
Generalist-Specialist 2	.0257	2093
Grip, Left	.0894	1776
Grip, Right	.0841	1772
Idea Productivity	-.0151	2089
Manual Speed	.3959	2093
Manual Accuracy	1.0000	2094
Number Memory	-.0063	2091
Observation	.0071	2091
Pitch Discrimination	-.0149	2091
Rhythm Memory	-.0306	2092
Spatial Relations/Theory	-.0011	2089
Spatial Relations/Visualization	.0709	2091
TinieFranie	.0084	2092
Tonal Memory	-.0683	2093
Verbal Memory	-.0198	2080
Visual Speed	-.0203	2001
Visual Accuracy	.0958	1906
Vocabulary 1	-.1242	2019
Vocabulary 2	-.1089	1621
Writing Speed	-.0590	2094

Note: All correlations over .10 are significant.

As can be seen from these data, there are no strong correlations of Manual Accuracy except with Manual Speed. Manual Speed and Accuracy are shown to measure relatively independent factors which is what would be expected from the construct of the ability.

## 8. Number Memory

Number Memory measures non-associative memory by giving the subject a list of numbers to memorize with very few stimuli. We would expect Number Memory to show some correspondence to other memory tests, but very little correspondence to the other tests of the battery.

The correlations of Number Memory with other tests of the battery are shown below:

<b>Number Memory</b>	<b>r=</b>	<b>N=</b>
Classification	.1574	2093
Concept Organization	.2305	2092
Design Memory	.3216	2097
Extrovert-Introvert I	.0240	1546
Extrovert-Introvert 2	.0242	554
Generalist-Specialist 1	-.0595	907
Generalist-Specialist 2	-.0319	2096
Grip, Left	.0789	1779
Grip, Right	.0758	1775
Idea Productivity	.0716	2091
Manual Speed	.0569	2090
Manual Accuracy	-.0063	2091
Number Memory	1.0000	2097
Observation	.2979	2095
Pitch Discrimination	.1154	2095
Rhythm Memory	.1609	2096
Spatial Relations/Theory	.2456	2092
Spatial Relations/Visualization	.1959	2094
Time Frame	.0478	2097
Tonal Memory	.1525	2096
Verbal Memory	.2935	2084
Visual Speed	.1631	2005
Visual Accuracy	-.1525	1910
Vocabulary 1	.0274	2022
Vocabulary 2	.0328	1622
Writing Speed	-.0029	2097

Note: All correlations over .10 are significant.

Number Memory shows mild correlation to Verbal Memory, Design Memory, and Observation. It shows low correlation to Tonal Memory, and Rhythm Memory. This indicates that the memory used for Number Memory is more in the visual field than in the aural or kinesthetic. Number Memory shows some correlation to Spatial Relations/Theory, although not in the range of correlation considered meaningful. This could indicate that part of the task involved in Spatial Relations/Theory is aided by non-associative memory.

## 9. Observation

Observation is a task involving visual memory for small objects and details in a visual field. We would expect Observation to correspond closely with visually loaded tasks such as Design Memory, Visual Speed and Accuracy, Spatial Relations/Theory, Spatial Relations/Visualization, and to some extent, Concept Organization. We would expect some relationship to other tests of memory, even if they are not visually loaded. We would not expect a strong relationship to other tests of the battery.

<b>Observation</b>	<b>r=</b>	<b>N =</b>
Classification	.2974	2093
Concept Organization	.3416	2092
Design Memory	.4719	2097
Extrovert-Introvert 1	.0513	1546
Extrovert-Introvert 2	.0421	554
Generalist-Specialist 1	-.0384	908
Generalist-Specialist 2	.0142	2096
Grip, Left	-.0439	1778
Grip, Right	-.0481	1774
Idea Productivity.	.1901	2091
Manual Speed	.2183	2090
Manual Accuracy	.0071	2091
Number Memory	.2979	2095
Observation	1.0000	2097
Pitch Discrimination	.1670	2095
Rhythm Memory	.2029	2096
Spatial Relations/Theory	.3502	2092
Spatial Relations/Visualization	.2481	2094
Time Frame	.1830	2096
Tonal Memory	.1720	2096
Verbal Memory	.3964	2084
Visual Speed	.2545	2005
Visual Accuracy	-.1720	1910
Vocabulary 1	.0447	2023
Vocabulary 2	-.0045	1622
Writing Speed	.0638	2097

Note: All correlations over .10 are significant.

Observation corresponds most closely to Design Memory, Verbal Memory, and Spatial Relations/Theory. It is also related to Concept Organization, Visual Speed, and Classification. The relationship with Classification is interesting and may shed some light on this ability. The construct of Classification is that it is an ability that loads on a problem-solving style carried out by the right hemisphere. The construct of Observation is that it, too, loads on the right hemisphere, and so we may be seeing a correspondence due to the relative strength or ease of access to right hemisphere functioning. The lack of correspondence with Visual Accuracy is also interesting. Historically, other groups that have used this basic battery of ability measures have not separated Visual Speed from Visual Accuracy, calling the construct Visual Dexterity.

Observation shows a low correspondence to the Visual Dexterity in other studies.<sup>13</sup> It may be that in not separating Visual Speed from Visual Accuracy important information has been lost. At any rate, the two concepts appear to function somewhat differently in their use of visual ability. As can be seen above, Observation does not correspond strongly to other tests of the battery, as would be predicted by the construct.

### 10. Musical Abilities: Pitch Discrimination, Rhythm Memory, and Tonal Memory

The musical abilities have historically shown a strong correspondence to each other, as would be expected, since they are measuring abilities in the same domain. Musical abilities have also historically shown a strong correspondence to Spatial Relations and again possibly pointing to a relationship between right hemisphere functioning and right hemisphere loaded tasks. From the construct of musical abilities, we would not expect a strong correspondence to the other abilities.

<b>Pitch Discrimination</b>	<b>r=</b>	<b>N =</b>
Classification	.1455	2093
Concept Organization	.2044	2092
Design Memory	.1940	2097
Extrovert-Introvert 1	-.0659	1546
Extrovert-Introvert 2	.0032	554
Generalist-Specialist 1	-.0148	908
Generalist-Specialist 2	-.0257	2096
Grip, Left	.0993	1778
Grip, Right	.0876	1774
Idea Productivity	.0971	2091
Manual Speed	.1026	2090
Manual Accuracy	-.0149	2091
Number Memory	.1154	2095
Observation	.1670	2095
Pitch Discrimination	1.0000	2097
Rhythm Memory	.3205	2096
Spatial Relations/Theory	.2553	2092
Spatial Relations/Visualization	.1715	2094
Time Frame	.1236	2096
Tonal Memory	.4949	2096
Verbal Memory	.1715	2084
Visual Speed	.0748	2005
Visual Accuracy	-.0830	1910
Vocabulary 1	.2010	2022
Vocabulary 2	.1944	1623
Writing Speed	.0952	2097

Note: All correlations over .10 are significant.

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<sup>13</sup> *Ibid*

<b>Rhythm Memory</b>	<b>r=</b>	<b>N=</b>
Classification	.1726	2094
Concept Organization	.2480	2093
Design Memory	.2783	2098
Extrovert-Introvert 1 ‘	-.0401	1547
Extrovert-Introvert 2	-.0872	554
Generalist-Specialist 1	-.0644	908
Generalist-Specialist 2	-.0320	2097
Grip, Left	.0012	1779
Grip, Right	.0082	1775
Idea Productivity	.1342	2093
Manual Speed	.1061	2091
Manual Accuracy	-.0306	2092
Number Memory	.1609	2096
Observation	.2029	2096
Pitch Discrimination	.3205	2096
Rhythm Memory	1.0000	2098
Spatial Relations/Theory	.2469	2093
Spatial Relations! Visualization	.1569	2095
Time Frame	.1234	2097
Tonal Memory	.5116	2097
Verbal Memory	.1901	2085
Visual Speed	.1024	2006
Visual Accuracy	-.1296	1911
Vocabulary 1	.1677	2023
Vocabulary 2	.1411	1622
Writing Speed	.1019	2098

Note: All correlations over .10 are significant.

<b>Tonal Memory</b>	<b>r=</b>	<b>N =</b>
Classification	.1641	2094
Concept Organization	.2392	2093
Design Memory	.2603	2098
Extrovert-Introvert 1	-.0408	1548
Extrovert-Introvert 2	-.0603	554
Generalist-Specialist 1	-.0789	908
Generalist-Specialist 2	-.0485	2098
Grip, Left	.0383	1780
Grip, Right	.0426	1776
Idea Productivity	.1159	2093
Manual Speed	.0940	2092
Manual Accuracy	-.0683	2093
Number Memory	.1525	2096
Observation	.1720	2096
Pitch Discrimination	.4949	2096
Rhythm Memory	.5116	2097
Spatial Relations/Theory	.2376	2094
Spatial Relations/Visualization	.1747	2096
Time Frame	.1152	2097
Tonal Memory	1.0000	2099
Verbal Memory	.1831	2085
Visual Speed	.0989	2006
Visual Accuracy	-.1218	1911
Vocabulary 1	.1782	2024
Vocabulary 2	.1375	1624
Writing Speed	.0793	2099

Note: All correlations over .10 are significant.

As can be seen in these data; the only practically significant correlations are among the three musical tests themselves, as would be expected by the constructs of the abilities being measured. In addition, we see consistently raised correlations with Design Memory, Concept Organization (again, indicating a possible visual component to this ostensibly logical and linear task), and Spatial Relations/Theory. Other correlations are consistently negligible, as would be expected by the constructs.

### **11. Spatial Relations: Theory and Visualization**

The two spatial relations abilities are strongly related to each other, as would be expected,

since they are measuring abilities in the same domain. We would also expect these two abilities to be related to such visual tasks as Design Memory and Observation, since both of the spatial relations tests use strongly visual stimuli. Spatial Relations/Theory also shows a relationship to the Cognitive Problem-Solving tasks of Classification and Concept Organization. As noted above, researchers have historically found a consistent relationship, although mild, between the spatial abilities and the musical abilities. The fact that we show this relationship between the musical abilities and Spatial Relations/Theory, but not with Spatial Relations/Visualization indicates that there is a predictable difference in the abilities being measured by the two tests. Spatial Relations/Theory is a more complex task that is more related to an abstract spatial relations ability. Spatial Relations/Visualization is a more concrete ability that is more related to the physical, tangible world. These constructs are consistent with the relationship of Spatial Relations/Theory to musical abilities, but not Spatial Relations/Visualization.

<b>Spatial Relations/Visualization</b>	<b>r=</b>	<b>N =</b>
Classification	.3399	2090
Concept Organization	.4974	2089
Design Memory	.6035	2094
Extrovert-Introvert 1	-.0245	1547
Extrovert-Introvert 2	-.1037	551
Generalist-Specialist 1	-.0594	905
Generalist-Specialist 2	-.0540	2094
Grip, Left	.1645	1777
Grip, Right	.1581	1773
Idea Productivity	.0771	2089
Manual Speed	.1452	2088
Manual Accuracy	-.0011	2089
Number Memory	.2456	2092
Observation	.3502	2092
Pitch Discrimination	.2553	2092
Rhythm Memory	.2469	2093
Spatial Relations/Theory	1.0000	2095
Spatial Relations/Visualization	.5401	2092
Time Frame	.1197	2093
Tonal Memory	.2376	2094
Verbal Memory	.2544	2081
Visual Speed	.1383	2002
Visual Accuracy	-.1819	1907
Vocabulary 1	.1019	2020
Vocabulary 2	.0212	1619
Writing Speed	-.0095	2095

Note: All correlations over .10 are significant.

As expected, Spatial Relations/Theory shows a strong relationship to the visual tasks, Design Memory and Observation. This test also shows a strong relationship to Concept Organization,

a logical problem-solving ability, and somewhat lower relationship with Classification, a non-logical problem-solving ability. This correspondence indicates that there is probably some amenability for this task to be solved through a problem-solving tactic rather than through use of a spatial-visual ability as proposed by the construct. Spatial Relations/Theory shows a small but consistent relationship to the musical abilities. Spatial Relations/Theory shows no or very small relationship to Writing Speed, Vocabulary, Visual Speed and Accuracy, Verbal Memory, Time Frame, Number Memory, Manual Speed and Accuracy, Idea Productivity, Grip, Introvert-Extrovert, or Specialist-Generalist, as would be predicted by the construct.

<b>Spatial Relations/Visualization</b>	<b>r=</b>	<b>N =</b>
Classification	.2927	2092
Concept Organization	.2993	2091
Design Memory	.4234	2096
Extrovert-Introvert 1	.0388	1548
Extrovert-Introvert 2	-.0126	552
Generalist-Specialist 1	-.0649	906
Generalist-Specialist 2	.0112	2096
Grip, Left	.3668	1778
Grip, Right	.3664	1774
Idea Productivity	-.0412	2091
Manual Speed	.1152	2090
Manual Accuracy	.0709	2091
Number Memory	.1959	2094
Observation	.2481	2094
Pitch Discrimination	.1715	2094
Rhythm Memory	.1569	2095
Spatial Relations/Theory	.5401	2092
Spatial Relations/Visualization	1.0000	2097
Time Frame	.0533	2095
Tonal Memory	.1747	2096
Verbal Memory	.1345	2083
Visual Speed	.0888	2004
Visual Accuracy	-.0626	1909
Vocabulary 1	-.0491	2022
Vocabulary 2	-.0813	1621
Writing Speed	-.0760	2097

Note: All correlations over .10 are significant.

Again with Spatial Relations/Visualization there is a strong correspondence between this ability and the visual abilities of Observation and Design Memory, as well as between this ability and the cognitive problem-solving abilities of Concept Organization and Classification. As noted above under Grip, the task for Spatial Relations/Visualization is notoriously difficult for people who are in fact low in this ability. It may be that the determination being measured by Grip is in fact keeping these people working on the task even when they are not doing well. Spatial Relations/Visualization does not show a strong relationship to other tasks that are not related to it: Extrovert-Introvert, Specialist-Generalist,

Idea Productivity, Manual Speed and Accuracy, Number Memory, Pitch Discrimination, Rhythm Memory, Time Frame, Tonal Memory, Verbal Memory, Visual Speed and Accuracy, Vocabulary, or Writing Speed.

**12. Time Frame**

Time Frame was originally constructed as an alternative way to measure Idea Productivity that would not be so highly related to Writing Speed. It does not correlate strongly enough to Idea Productivity to be a true alternative measure, and the construct it is believed to measure does not bear a strong relationship to any of the other ability measures.

<b>Time Frame</b>	<b>r=</b>	<b>N =</b>
Classification	.2130	2094
Concept Organization	.1829	2093
Design Memory	.1257	2098
Extrovert-Introvert 1	.0961	1547
Extrovert-Introvert 2	.0484	554
Generalist-Specialist 1	-.1355	908
Generalist-Specialist 2	-.1014	2097
Grip, Left	-.0877	1780
Grip, Right	-.0772	1776
Idea Productivity	.3620	2092
Manual Speed	.1238	2091
Manual Accuracy	.0084	2092
Number Memory	.0478	2097
Observation	.1830	2096
Pitch Discrimination	.1236	2096
Rhythm Memory	.1234	2097
Spatial Relations/Theory	.1197	2093
Spatial Relations/Visualization	.0533	2095
Time Frame	1.0000	2098
Tonal Memory	.1152	2097
Verbal Memory	.1937	2085
Visual Speed	.1722	2006
Visual Accuracy	-.0193	1911
Vocabulary 1	.1664	2023
Vocabulary 2	.1370	1622
Writing Speed	.2311	2098

Note: All correlations over .10 are significant.

Time Frame does show a mild relationship to Idea Productivity, as would be expected. In addition, it does not show a strong relationship to Writing Speed. Time Frame does not show a strong relationship, in fact to any of the other ability measures, as would be expected from the construct.

**13. Verbal Memory**

Verbal Memory is thought to be related to the person’s ability to remember information presented in writing. As such, it should be related, though not strongly to the visual abilities,

Design Memory and Observation, as well as the logical ability of Concept Organization. We might expect some correspondence to other tests of memory.

<b>Verbal Memory</b>	<b>r=</b>	<b>N=</b>
Classification	.2066	2082
Concept Organization	.3030	2081
Design Memory	.3401	2086
Extrovert-Introvert 1	.0279	1537
Extrovert-Introvert 2	-.0129	553
Generalist-Specialist 1	.1026	902
Generalist-Specialist 2	-.0405	2085
Grip, Left	-.1360	1768
Grip, Right	-.1338	1764
Idea Productivity	.1508	2080
Manual Speed	.1244	2079
Manual Accuracy	-.0129	553
Number Memory	.2935	2084
Observation	.3964	2084
Pitch Discrimination	.1715	2084
Rhythm Memory	.1901	2085
Spatial Relations/Theory	.2544	2081
Spatial Relations/Visualization	.1345	2083
Time Frame	.1937	2085
Tonal Memory	.1831	2085
Verbal Memory	1.0000	2086
Visual Speed	.1957	1994
Visual Accuracy	-.1337	1901
Vocabulary 1	.1169	2011
Vocabulary 2	.1228	1613
Writing Speed	.0887	2086

Note: All correlations over .10 are significant.

As would be predicted by the construct, Verbal Memory does in fact show a correspondence to Design Memory and Observation (as well as a somewhat weaker correspondence to Spatial Relations/Theory, which has a visual memory component), as, well as the logical ability of Concept Organization. Verbal Memory does not show strong correspondence to any of the other ability measures: Classification, Extrovert-Introvert, Specialist-Generalist, Grip, Manual Speed and Accuracy, Pitch Discrimination, Rhythm Memory, Spatial Relations/Visualization, Time Frame, Tonal Memory, Visual Speed and, Accuracy, Vocabulary, or Writing Speed. Verbal Memory does show some correspondence to Number Memory, although not at a level considered practically significant. The fact that both are visually presented, may account for this correspondence being somewhat higher than the memory tests presented in other modalities entirely, Tonal Memory and Rhythm Memory.

#### **14. Visual Speed and Accuracy**

Visual Speed is visually presented and should be related to the other strongly visually loaded

tests. In addition, factor analysis shows a group of tests that strongly load on speed to be related to one another. These include, in addition to Visual Speed, Manual Speed, Idea Productivity, and Writing Speed. Although other ability batteries join Visual Speed and Visual Accuracy in one score, Visual Dexterity, it has been the experience of The Highlands Program that these are separate constructs.

<b>Visual Speed</b>	<b>r=</b>	<b>N =</b>
Classification	.1512	2004
Concept Organization	.2296	2003
Design Memory	.2294	2007
Extrovert-Introvert 1	-.0234	1460
Extrovert-Introvert 2	-.0557	550
Generalist-Specialist 1	-.0538	898
Generalist-Specialist 2	-.0191	2006
Grip, Left	-.1734	1690
Grip, Right	-.1613	1686
Idea Productivity	.2961	2001
Manual Speed	.2589	2000
Manual Accuracy	-.0203	2001
Number Memory	.1631	2005
Observation	.2545	2005
Pitch Discrimination	.0748	2005
Rhythm Memory	.1024	2006
Spatial Relations/Theory	.1383	2002
Spatial Relations/Visualization	.0888	2004
Time Frame	.1722	2006
Tonal Memory	.0989	2006
Verbal Memory	.1957	1994
Visual Speed	1.0000	2007
Visual Accuracy	.0153	1906
Vocabulary 1	.1103	1932
Vocabulary 2	.0638	1555
Writing Speed	.3254	2007

Note: All correlations over .10 are significant.

As would be expected from factor analysis, Visual Speed shows some relationship to the other highly speeded tests, Manual Speed, Idea Productivity, and Writing Speed, the only correlation above .30. The correlations to Design Memory and Observation, though significant, are not considered high enough to have any practical significance.

<b>Visual Accuracy</b>	<b>r=</b>	<b>N =</b>
Classification	-.1201	1909
Concept Organization	-.2106	1908
Design Memory	-.1785	1912
Extrovert-Introvert 1	.0322	1364
Extrovert-Introvert 2	.0385	552
Generalist-Specialist 1	-.0095	870
Generalist-Specialist 2	-.0241	1911
Grip, Left	.0451	1599
Grip, Right	.0327	1594
Idea Productivity	-.0495	1906
Manual Speed	.0229	1905
Manual Accuracy	.0958	1906
Number Memory	-.1525	1910
Observation	-.1720	1910
Pitch Discrimination	-.0830	1910
Rhythm Memory	-.1296	1911
Spatial Relations/Theory	-.1819	1907
Spatial Relations/Visualization	-.0626	1909
Time Frame	-.0193	1911
Tonal Memory	-.1218	1911
Verbal Memory	-.1337	1901
Visual Speed	.0153	1906
Visual Accuracy	1.0000	1912
Vocabulary 1	-.1088	1846
Vocabulary 2	-.0590	1483
Writing Speed	.0074	1912

Note: All correlations over .10 are significant.

As can be seen in the data above, Visual Accuracy not only does not bear a strong relationship to Visual Speed, but does not bear a practically significant relationship to any of the other measures on The Highlands Ability Battery.

## 15. Vocabulary

Vocabulary is not a true ability; it is rather an achievement measure. As such, it is in a different fundamental domain than the other measures on The Highlands Ability Battery. We would not expect Vocabulary to correlate at a high level with any of the other measures, with the exception of Concept Organization, which measures a logical, analytical, linear problem-solving ability and so might be expected to make use of the same left hemisphere processes that would be in use if a person used a relatively large number of verbal categories.

<b>Vocabulary 1</b>	<b>r=</b>	<b>N =</b>
Classification	.0802	2020
Concept Organization	.3039	2019
Design Memory	-.0028	2024
Extrovert-Introvert 1	-.3050	1475
Extrovert-Introvert 2	-.2697	554
Generalist-Specialist 1	.0264	907
Generalist-Specialist 2	.0447	2024
Grip, Left	-.0303	1733
Grip, Right	-.0133	1728
Idea Productivity	.2141	2019
Manual Speed	.0227	2018
Manual Accuracy	-.2697	554
Number Memory	.0274	2022
Observation	.0447	2023
Pitch Discrimination	.2010	2022
Rhythm Memory	.1677	2023
Spatial Relations/Theory	.1019	2020
Spatial Relations/Visualization	-.0491	2022
Time Frame	.1664	2023
Tonal Memory	.1782	2024
Verbal Memory	.1169	2011
Visual Speed	.1103	1932
Visual Accuracy	-.1088	1846
Vocabulary 1	1.0000	2025
Vocabulary 2	.7352	1550
Writing Speed	.2401	2025

Note: All correlations over .10 are significant.

<b>Vocabulary 2</b>	<b>r=</b>	<b>N=</b>
Classification	.0404	1620
Concept Organization	.2135	1618
Design Memory	-.0272	1623
Extrovert-Introvert 1	-.2458	1153
Extrovert-Introvert 2	-.2455	471
Generalist-Specialist 1	.0871	754
Generalist-Specialist 2	.0365	1624
Grip, Left	.0022	1419
Grip, Right	-.0145	1415
Idea Productivity	.1301	1619
Manual Speed	-.0407	1620
Manual Accuracy	-.1089	1621
Number Memory	.0328	1622
Observation	-.0045	1622
Pitch Discrimination	.1944	1623
Rhythm Memory	.1411	1622
Spatial Relations/Theory	.0212	1619
Spatial Relations/Visualization	-.0813	1621
Time Frame	.1370	1622
Tonal Memory	.1375	1624
Verbal Memory	.1228	1613
Visual Speed	.0638	1555
Visual Accuracy	-.0590	1483
Vocabulary 1	.7352	1550
Vocabulary 2	1.0000	1624
Writing Speed	.1841	1624

Note: All correlations over .10 are significant.

The correlation between the two vocabulary measures themselves indicates that the two tests are substantially measuring the same thing. Vocabulary 1 also shows a relatively strong correlation to Concept Organization. Both Vocabulary tests show a relatively mild negative correlation to Extroversion (positive correlation to Introversion). It may be that Introverts show a higher Vocabulary score because they spend more time in such solitary pursuits as reading - long known to be the best overall way to build vocabulary.

## 16. Writing Speed

Writing Speed is purely a measure of speed and fine motor coordination. It has no problem-solving component, memory component, visual component or spatial component, and we would not expect it to relate to tests primarily measuring these.

Writing Speed	r=	N =
Classification	.0068	2095
Concept Organization	.0936	2094
Design Memory	.0165	2099
Extrovert-Introvert	-.0109	1549
Extrovert-Introvert 2	.0418	554
Generalist-Specialist 1	.0100	908
Generalist-Specialist 2	-.0306	2099
Grip, Left	-.0906	1781
Grip, Right	-.0823	1777
Idea Productivity	.5330	2094
Manual Speed	.2310	2093
Manual Accuracy	-.0590	2094
Number Memory	-.0029	2097
Observation	.0638	2097
Pitch Discrimination	.0952	2097
Rhythm Memory	.1019	2098
Spatial Relations/Theory	-.0095	2095
Spatial Relations/Visualization	-.0760	2097
Time Frame	.2311	2098
Tonal Memory	.0793	2099
Verbal Memory	.0887	2086
Visual Speed	.3254	2007
Visual Accuracy	.0074	1912
Vocabulary 1	.2401	2025
Vocabulary 2	.1841	1624
Writing Speed	1.0000	2100

Note: All correlations over .10 are significant.

As noted above, Writing Speed is primarily used to eliminate the factor of speed from the measure of Idea Productivity. In creating the norms for Idea Productivity, the level of Writing Speed partially determines the person's final score. In addition to Idea Productivity, Writing Speed is seen to be related to Visual Speed, and, although not as strongly, Manual Speed. There are no other practically significant relationships, and none would be expected from the construct.

## CONCLUSION

We conclude from this analysis that The Highlands Ability Battery has demonstrated a significant degree of consistency in the structure of the battery itself. The groupings of factors appear to be consistent with factor groupings of abilities proposed by Guilford, Cattell, and Thurstone in their work. There is adequate evidence of both convergent and divergent validity. The individual tests of the battery correlate to one another as would be expected from the constructs of the individual tests. Those that we would expect to be related are in fact related and those that we would not expect to be related show generally a very low relationship.