

# Report of the Research Department

Johnson O'Connor Research Foundation, Inc.  
Human Engineering Laboratory, Inc.  
Johnson O'Connor Research Support Corporation



# 2016

## Goals of the Research Department

1. The isolation of aptitudes and the study of their role in various occupations.
2. The development of accurate measures of aptitudes.
3. The investigation of the role of aptitudes in education.
4. The evaluation of age and sex differences and the effect of practice on test performance.
5. The study of the processes involved in the acquisition of knowledge.
6. The development of accurate measures of knowledge.
7. The communication of research findings to the public.



Dr. Linda S. Houser-Marko, Russell E. Burke, Dr. David H. Schroeder  
in our Chicago research conference room.

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## Letter from the Research Director

In a 2015 paper in the online journal *Frontiers in Psychology*, Rex Jung and his associates reported on a study using the Johnson O'Connor test of Foresight, Wks. 307 AQ, as a measure of divergent thinking to test Dean Keith Simonton's "equal-odds rule": that is, because the odds of any given idea or production being creative or not are equal, greater production of ideas should result in a greater number of creative ideas, or more simply, quantity yields quality. (See our 2015 report for details of this study.)

In comments on the paper, it was suggested that, because raters had seen the quantity of responses by each subject when making their creativity ratings, they might have been unconsciously biased toward giving higher ratings to those with more responses. In order to prevent this, it was suggested, it might be useful to enter all responses by all subjects into a spreadsheet, and have raters then assign creativity ratings to each response: each subject's responses could then be scored based on these ratings.

Rusty Burke, Research Director, and Kelsey Bakas, an Aptitude Consultant in the Washington, D.C. laboratory, initiated a project to act on those suggestions. In the first phase of this project, Bakas created an Excel spreadsheet to record all examinee responses on each item of the Foresight test. Dr. Jung and his associate, Ranee Flores, provided scans of the response sheets for all subjects in their study, and Bakas, along with Nick Newell (Atlanta), Lauren Cuningham, Emily Mitchell, and Cindy Rosner (Boston), Will Eells, Hannah Waldman, and Roger Rindge (Los Angeles), and Doug Hastings (Seattle),

entered all the responses into the spreadsheet. Bakas then created lists of all unique responses (that is, those given only once among all subjects), and non-unique responses (those given more than once among all subjects), and created for each non-unique response a "frequency score" based on how often it had been given among all subjects. These values were then used to calculate mean frequency scores for each subject, both for each test item and for the full test.

The 336 subjects in the study generated a total of 16,950 legible responses across all six items. When duplicate responses were combined, there were 6,283 distinct responses. Of those, 4,554 (72.5%) were given only once. We were somewhat surprised how few responses were given very frequently: only 56 responses were given by 10% or more of the subjects.

For the full test, the correlation between the number of responses given by a subject and the number of unique responses given by the subject was .67, and the correlation between the total number of responses and the mean frequency score for the subject was -0.59. These correlations were significant at the .001 level. Thus there does appear to be a fairly strong correlation between fluency (giving more responses on the test) and frequency (giving less frequent, or more "original" responses). Subjects who give more responses tend to give more uncommon ones.

Future work on this project will involve creating creativity scores, and correlating frequency and creativity scores with a measure of creative achievement.

*Rusty Burke*

March 31, 2017

A SPECIAL TRIBUTE IS IN ORDER FOR THE MOST SENIOR MEMBER OF OUR FOUNDATION, DIRECTOR OF RESEARCH EMERITUS ROBERT KYLE, WHO HAD SERVED THE VISION AND MEMORY OF OUR FOUNDER SOME TWO SCORE AND EIGHT YEARS. HIS ADVICE AND SAGE COUNSEL HAD BEEN GREATLY APPRECIATED.

BOB PASSED AWAY DURING THE NIGHT OF JULY 14-15, 2016. HE POSSESSED A SHARP WIT; HE WAS A RACONTEUR OF ELEANOR & JOHNSON STORIES WHEN INSPIRED; HE WAS A GUARDIAN OF THE BEST VALUES OF THE FOUNDATION TO PERFORM RESEARCH FOLLOWING THE MODEL OF OUR FOUNDER. HE DEVOTED HIS LIFE TO JOHNSON O'CONNOR FOR ALMOST A HALF CENTURY.

WE SHALL MISS HIM AND HIS TRENCHANT OBSERVATIONS EVEN THOUGH HE HAD BEEN RETIRED SINCE 2009 AND HAD BEEN LESS FREQUENTLY ENGAGED WITH US SINCE THEN. HIS CAREER AT THE FOUNDATION STARTED IN 1962. HE SERVED AS DIRECTOR OF THE CHICAGO OFFICE FROM 1964 TO 1982. HE WAS VICE PRESIDENT FROM 1981 AND DIRECTOR OF RESEARCH FROM 1982 UNTIL RETIREMENT.



Robert F. Kyle

## Observations & Announcements

### Yesterday, Today, looking forward to Tomorrow

In one fashion or another, I have opined in this report each year since 2003 when I became President. I want to allow myself some reflection on how we all have progressed. In 2004 the professional researchers wrapped up the new bargraph computer program and published two journal articles with Dr. Timothy Salthouse concerning aging with aptitudes, among other efforts. Aging in aptitudes continues — see page 6 for work by Dr. Linda Houser-Marko. We switched from audio-visual tests depending on slide projectors to then modern eMac computer presentation. In 2005 Dr. David Schroeder and Dr. Christopher Condon developed new presentation materials to enliven their research projects to help our summarizers. A research advisory committee consisting of several key directors participated in the planning and discussion for future research. By 2006-07 we enlarged the scope of O'Connor research with funding from our support corporation to sponsor projects by outside scholars using techniques not possible for us. First Dr. Richard Haier and Dr. Cheuk Tang and others completed and analyzed brain scans related to performance on aptitude tests. Intriguing results, although not ready yet for individual client application, came in waves with each succeeding scanning project. Some board members remember the Brain Institute at University of New Mexico where Dr. Rex Jung showed us the facility where further work continues with scanning.

By 2008 we knew we had to continue repairs and office design already underway in the Chicago testing space with an even more heroic effort to rebuild the research space. Over the next year under the guidance of tenant architect Michael Pado we completed a new suite of rooms which still serves us well. (Putting on a new roof and fixing the parapets and brick outer wall later helped.) The advisory committee was supplanted by appointing Rusty Burke as Research Director to provide guidance and support for the professional researchers. Diagrams and charts from their research were incorporated in our new book, *Understanding Your Aptitudes*, to help validate what we tell our clients.

For magnetoencephalography (MEG) imaging we had the fun of designing variants of two key aptitude tests — Inductive Reasoning and Paper Folding — to suit the constraints in movement for the examinee. Our recent annual reports cover the results of this and other scanning projects. Blending the new techniques with time-honored research to understand the genetic component of individual differences in ability led us to participate in funding twin studies to augment our own research comparing identical with fraternal twins.

By 2013 & 2014, yesterday was not so far away. Updating norms, improving test items, continuing to examine heritability and aging, measuring long-term test stability, along with auditory and theater validation led the way. Client satisfaction returned after a long hiatus, with reassuringly positive results.

In last year's report, there was much new and exciting talk about Foresight. Creativity joined long-term possibility imagining. Grasping again for a distant yesterday, I remember speculating about the august emperor Charles V, who abdicated great power to seek spiritual peace and aptitude fulfillment. Foresight now propels us beyond yesterday. Read p. 1 for the latest on the test. Read the following pages for other recent research.

And now, it is all about tomorrow. Possibilities abound. My time absorbing these research articles for the annual report, to include the typesetting and page layout, is finished with this issue. As of this spring, a new president will preside over the changes and future plans for Johnson O'Connor.

It is a great honor to introduce the President Presumptive, **Anne Steiner**, for this century the director of our Seattle testing center. She began life in Fairbanks, Alaska and continued on at the prestigious Williams College of Williamstown, Massachusetts. Well educated, high vocabulary (as we insist on), she is a well-informed generalist who will bring the perspective of literate, liberal education to inspire and broaden our research efforts going forward. We heartily welcome her promotion!



As I step down, I want to make the case for continuing to fund outside research by taking advantage of our support corporation to discover new aspects of aptitudes. Exciting things would come from funding graduate students or gaining professional guidance from consultants. I know there is also discussion of a re-designed bargraph program, integrating timing and scoring to the testing process, while keeping the value of individual attention and personal interaction in the interpretation of scores. New tests, new insights, new spirit; let's toast to the future! Oh, old aptituders never die, they just fade away...



**David Ransom, President 2003-2017**

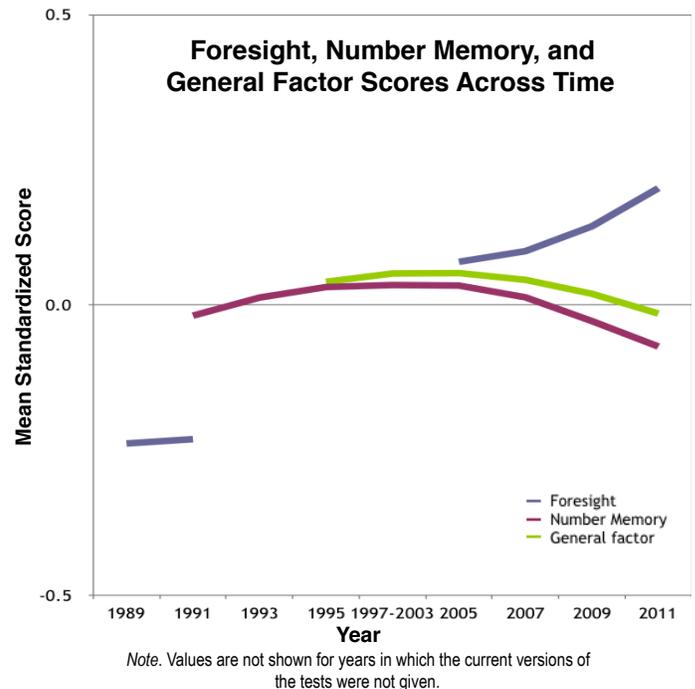
## Test Scores Across Time

In 2016, David Schroeder, Research Manager, continued to investigate trends in performance on our tests across time. Because we have been giving our standard battery for a number of years, we are well-positioned to identify broad trends in the aptitudes of the examinees whom we test.

Performance on tests across time has attracted particular attention in the scholarly community because of a finding referred to as the Flynn effect, which is the sharp rise in scores on IQ tests and other broad measures of ability over the past 100 years or so. In our data, Schroeder has found that, if one examines overall scores—that is, scores for a general statistical factor—for our cognitive aptitude tests, then those scores do tend to increase slowly until about 2000, at which point they appear to level off. Importantly, however, the pattern for the general factor obscures the fact that the trends for individual aptitudes vary widely, with Foresight and Memory for Design showing relatively large gains over time and Number Memory and Analytical Reasoning showing modest changes similar to the general factor in recent years (see the accompanying figure). So, this is an area that illustrates the value of our approach of emphasizing individual aptitudes rather than overall scores.

Schroeder made a presentation on our data at the annual meeting of the Association for Psychological Science (APS) in

2016, and he will elaborate on the relationship between the general-factor findings and the individual-test findings at the APS meeting in 2017.

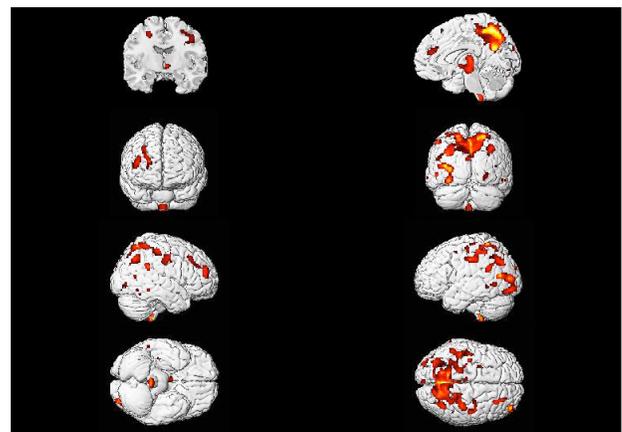


## Neuroimaging Study of Artistic Judgment

Also in 2016, we published an article on some findings from our neuroimaging research in the journal *Psychology & Neuroscience*. The article was written by Nikolaus Bezruczko, a former consultant to the Foundation who worked on our artistic judgment project (see, e.g., Technical Report 1998-1); Etienne Manderscheid, a recent Ph.D. in Neuroscience from the University of Chicago; and David Schroeder. In this article, we reported results for the Visual Designs test from the structural magnetic resonance imaging (sMRI) study that we conducted with Richard Haier a few years ago (see our annual reports for 2007-2011). Previously, we published several articles in scholarly journals on our findings from that study, but Bezruczko wanted to publish a report specifically on the data for our artistic judgment test, Visual Designs. In our sMRI study, we recruited 40 alumni of our testing program to undergo sMRI imaging, which enables one to assess the densities of gray matter in various areas of the brain. Haier and his team correlated scores on our tests with these regional brain densities.

In terms of results, the accompanying figure shows the brain areas for which gray-matter density correlated with our Visual

### Brain Areas Correlated With Scores on Visual Designs I



Designs I scale, which presents examinees with randomly-constructed designs and measures whether the examinees prefer simpler versus more-complex designs in this context. There were

a total of 21 brain clusters that correlated with our scale, and they are spread out across the brain, but they tend to be in the parietal lobe and in the right hemisphere. We were interested to discover that several of the areas, specifically areas associated with visual processing (visual cortex) and emotional response (insula), corresponded to areas identified in previous studies that used functional MRI to examine brain activation during the viewing of visual art.

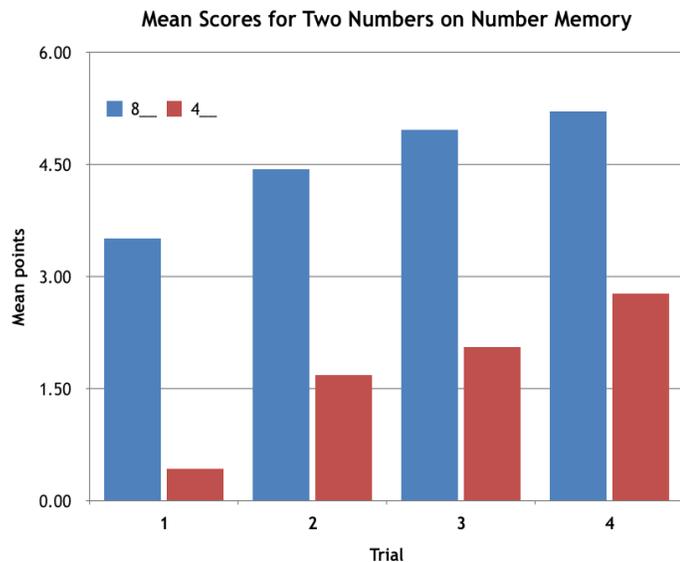
For the Visual Designs II scale, which contrasts less-uniform and more-uniform designs with artists preferring the less-uniform designs, there were fewer brain areas that showed correlations. Again, however, it was interesting that two of the brain clusters, the precuneus and the insula (as with Visual Designs I), had been highlighted in the functional MRI studies.

The article by Bezruczko, Manderscheid, and Schroeder appeared in the September 2016 issue of *Psychology & Neuroscience*. Bezruczko and Schroeder will also report our findings at the 2017 meeting of the American Association for the Advancement of Science, and Schroeder expects to review the research again in a 2017 Statistical Bulletin.

## Number Memory

In another 2016 study, David Schroeder performed an internal analysis of our Number Memory (NM) test. Although we have performed internal studies of most of our tests, we have largely overlooked NM until this time.

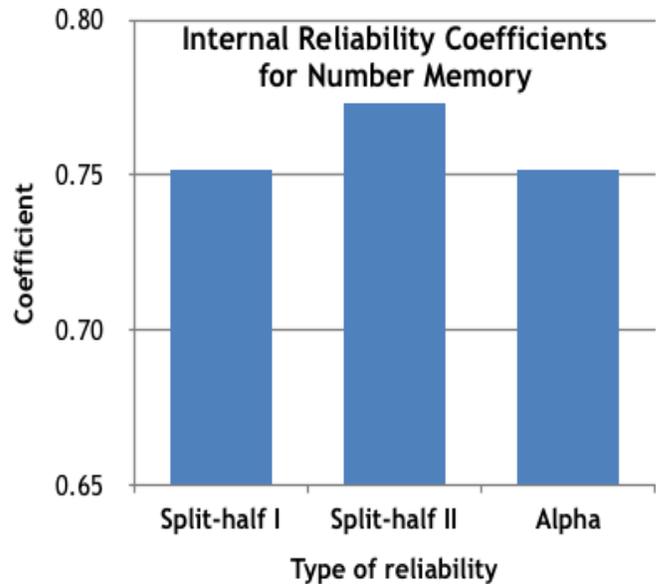
In 2015 we collected NM answer sheets for 603 examinees and created a data file of their responses. Schroeder found that examinees are able to memorize some of the numbers on the test much better than other numbers (see the accompanying figure).



For the number (starts with 8) that has a pattern with just two different digits, with the second one repeating three times (e.g. like 939333), performance on the first trial of the test is about three points better (on a 0 to 6 scale) than performance on a number (starts with 4) using five different digits, with a middle pair (like 520039). As one moves to the other three trials, performance on both numbers improves, but the former continues to be substantially easier than the latter. Repeating digits may well simplify the memorization, bringing a simple rhythmic pattern to bear.

In terms of item-total correlations, all eight of the numbers seem to perform reasonably well, with correlations ranging from .38 to .50.

With respect to reliability, one can use the scores for the eight numbers to estimate the internal reliability for Number Memory (see the accompanying figure). Specifically, when one calculates split-half reliabilities by correlating scores for four numbers with scores for the other four numbers, one finds values that tend to be in the .75-.77 range. When one employs the commonly-used alpha coefficient, the value is .752.



In general, the Foundation wants its tests to show reliabilities that are greater than .80, and so it appears that Number Memory is below our usual standard. Because Number Memory has an alternate form that is very comparable to the standard form, we plan to conduct an alternate-form reliability study and see if we find about the same level of reliability.

Schroeder reported his findings in Statistical Bulletin 2016-7, *Internal Analysis of Number Memory*.

## Where are they now?

### Follow-up studies of past clients

The follow-up studies of clients who had tested at the Foundation ten years ago continued through the work of Linda Houser-Marko, Researcher. The plan for these studies was to contact examinee-clients who had learned about their aptitudes several years ago and were further along in their occupational pursuits. By following up with our past clients, we can learn more about the connection between aptitudes and job choices. Further, we can learn more about how different jobs fit with different aptitudes and people, and then how an individual's sense of person-job fit is related to their job satisfaction.

Follow-up survey invitations were sent by e-mail to clients who tested at the Foundation in 2006. We were able to send them by e-mail this time, because for this year we had more e-mail addresses for clients. The e-mail invitation made it easier for former clients to respond to the online survey. We received 190 responses from this invitation to the ten-year survey, a 12% response rate for "delivered" invitations.

We also sent a survey invitation to clients for a five-year follow-up study. We had a great response for this request, and received 528 survey responses as of the end of the year, or a 15% response rate for "delivered" invitations.

With these surveys, we wanted to develop an understanding of how former examinees think about their aptitudes in general. For example, we wanted to know if aptitude testing had an influence on their choices and the direction of their occupation. Ideally, after a person learns about their aptitudes, they would be able to make informed choices and decisions about what direction they would want for their career, and would be able to find a position in which they could put their aptitude strengths to use.

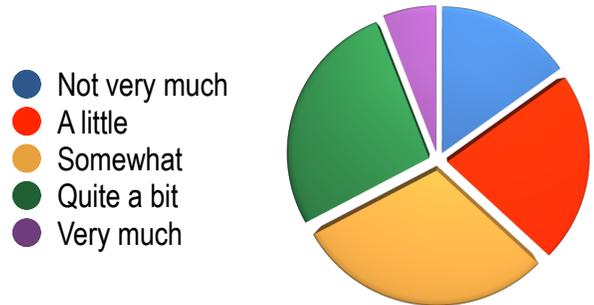
When they were tested, 30% of the respondents for these surveys were high school age, 14% were college age, 24% were early career age, 19% were mid-career age, and 13% were later career. Some respondents of the five-year survey were currently students, with 10% being college age. The average age for respondents of the ten-year survey was 38 years old and for the five-year survey was 33 years old.

Most of the respondents said that they personally wanted to come in and have their aptitudes tested. The majority (66%) of respondents said that they tested "Because I wanted to, or for my own reasons." At the same time, 47% of respondents also said that they tested "Because someone else thought I should." They could choose as many options as they thought applied to them. As might be expected, the examinees who were teenagers at the time of testing were more likely to say that they tested because someone else thought they should.

We were curious to find out whether aptitudes were part of the respondents' daily lives. We asked "To what extent do you think about, or talk about, aptitudes in your daily life?" and the mean response was 2.86, on a scale of "Not very much" (1) to "Very

much" (5), with the most frequently chosen options being "Somewhat" and "Quite a bit". There was not a difference between the ratings for people who tested five versus ten years ago.

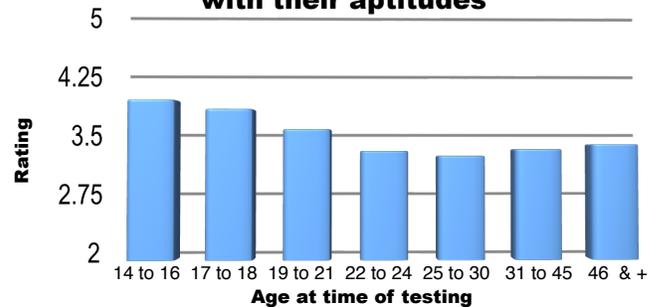
### How much former clients think about their aptitudes



About one-third (31%) of respondents said they can find ways to use their aptitudes in their work or hobbies. Some said that they "struggled" to find ways to use their aptitudes (11%), 5% said that they "rarely use" their aptitudes, 11% said that they were not sure how to use their aptitudes, and 5% said that they did not know (or remember) what their aptitudes were. While about a third of the group said that they find ways to use their aptitudes, a much smaller group said that they did not feel connected to their aptitudes.

We asked "To what extent do you think your \*college major\* fit(s) with your aptitudes or abilities?" on a scale of 1 to 5. The examinees who were not in college at the time of testing rated the fit of their college major with their aptitudes the highest, whereas examinees who were likely to be in college at the time of testing rated the fit a bit lower, and examinees who were 22 and older at the time of testing rated the fit as generally lower than the others. Notably, the youngest examinees learned about their aptitudes before they went to college, and so might have been able to choose a major that was a good fit for them.

### Self-ratings of how college major fit with their aptitudes



In order to get a better understanding of respondents' thoughts about how their aptitudes fit with their occupations, or "person-job fit," we asked more questions about their employment. For example, we asked if they thought their current job fit with their aptitudes and abilities.

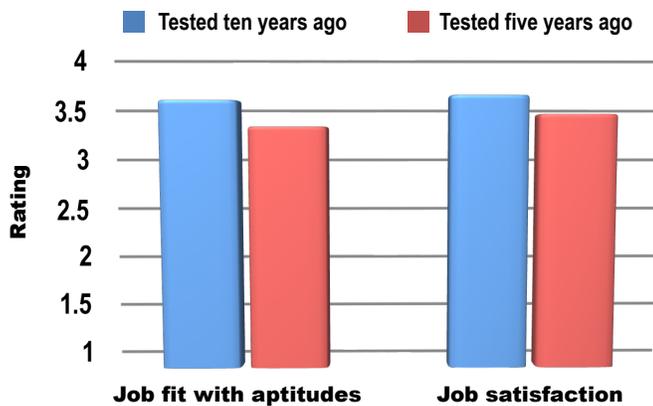
## Updated Test Norms

Many thought their current job fit with their aptitudes: 18% said they thought their job fit “very much” with their aptitudes, 34% said they thought it fit “quite a bit,” and 28% said they thought it fit “somewhat.”

Most people were satisfied with the tasks of their current job and 23% said the tasks and activities were “very satisfying,” 36% said they were “satisfying,” and 29% said they were “somewhat satisfying.” 9% said they were “somewhat dissatisfying,” and 3% said their job tasks were dissatisfying.

There was a survey year effect such that people tested ten years ago gave higher ratings of their job fitting with their aptitudes and overall job satisfaction, compared to those tested 5 years ago. Perhaps a person has to “grow into” their aptitudes, and finding the right occupation that fits with their aptitudes is more likely with time.

### Self-ratings of job fit and job satisfaction



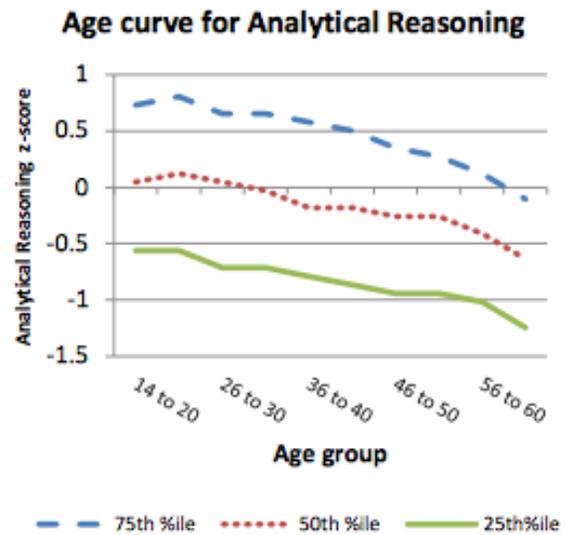
Then to look at these differences further, we looked at age when tested and the respondent’s current age. We found that there is a tendency for people who tested when they were younger, and are older now, to say that their occupation fits with their aptitudes more.

To consider all of these factors together, we created a statistical model with all of the factors that seemed related, in this study, to general job satisfaction. General job satisfaction was related to age when a person tested, their satisfaction with job tasks, not thinking their job was boring, and their sense that their job fit with their aptitudes. Even when strong factors like satisfaction with job tasks and not thinking their job was boring were included in the model, their sense that their aptitudes fit with their job was still a significant and important predictor of job satisfaction.

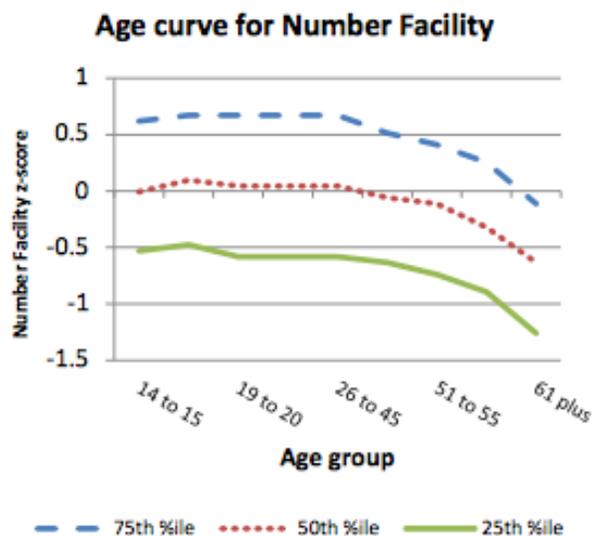
Houser-Marko plans to continue these follow-up surveys as part of a larger program of longitudinal research on clients of the Foundation.

We continue to periodically update norms for the tests in the Foundation battery. New norms were constructed this year for the tests of Analytical Reasoning and Number Facility by Linda Houser-Marko and David Schroeder.

The age curve for the Analytical Reasoning test is shown in the figure below. Compared to some of our other tests, the curve is a gentle slope. The peak of Analytical Reasoning scores is around the ages of 21 to 25, and then from there, scores gradually decline.



The figure below shows the age curve for the Number Facility test. There appears to be a plateau from age 16 to age 25, another plateau from 26 to 45, and then a gradual decline.



## Structural Visualization and STEM majors

A study called "Spatial Ability and the STEM Majors: Where do Females with High Spatial Ability Go?" was presented by Linda Houser-Marko at the 28th annual meeting of the Association for Psychological Science (APS) in May 2016. The following is a portion of a press release that described the study of the STEM majors and Structural Visualization/spatial ability:

In a recent study, the Johnson O'Connor Research Foundation, Inc., (JOCRF), has found that spatial ability was high for all STEM majors, with the highest levels for physical science, engineering and math majors, and computer science majors scoring above average.

However, of all the students in the study who had high spatial ability, only 20% of the females and 34% of the males were majoring in the STEM fields. Females with high spatial ability majored in physical science, engineering, and computer science at lower than expected rates commensurate with their abilities. According to Linda Houser-Marko, a Foundation researcher who conducted the study, "More students in general have the abilities to major in the STEM fields. There is a larger pool of both female and male students who have high spatial ability who have the potential to go into the STEM fields."

The study was conducted on a sample of 11,502 young adult (18 to 24 years old) JOCRF clients, of whom 16% had chosen to major in one of the STEM fields. The most were in the biological sciences (5.7%), with engineering (5.5%) also being a popular major in this sample.

According to Dr. Houser-Marko, "Being aware of one's strengths and weaknesses can help a person make better decisions, particularly for college and career directions. Knowing the important role of spatial ability in the STEM fields might help to increase interest in those fields, because not all students with high spatial ability are majoring in the STEM fields."



Photograph of the geneticist Riin Tamm, Estonian Biocentre. (wikipedia)

## Research Department Staff



**Russell E. Burke**, Director of Research, has also served as Director in Washington, D.C. He is our senior summarizer and writer interpreting research information to the staff. An autodidact by inclination following a degree in Religious Studies at the University of Tennessee, he joined the Foundation in 1983 in New Orleans and served as Director in Houston before moving to the nation's capital, living on Capitol Hill.



**David H. Schroeder**, Research Manager, joined the Research Department in August 1984. He has a B.S. from the University of Illinois and an M.S. from Colorado State University, as well as an M.A. and a Ph.D. in personality psychology from The Johns Hopkins University.



**Linda S. Houser-Marko**, Researcher, joined the Research Department in October 2010. She has a B.A. from Gustavus Adolphus College in Minnesota and a Ph.D. in social and personality psychology from the University of Missouri. She has published research on the self, identity, and motivation.

## Surveying Our Recently Tested Clients

Beginning in the spring of 2016, the Research Department began collecting information from clients in the form of an exit survey based on a version first designed and implemented by Amanda Summers, director of the Chicago office, and Lisa Cook, director of the Denver office. In the pilot stage of development, use of the survey was optional, and participation varied from lab to lab. That was the case until April, when administration of the survey was handed over to Alison White, Research Assistant, and all labs were asked to participate. Designed specifically for clients who have recently completed the testing program, this survey serves not only to provide the Foundation with valuable information about the client and their experience with us, it is also the first step in our post-testing relationship with our clients.

### Relationship development

The exit survey is the first in a series of planned interactions with former clients in the years to come. An invitation is sent by the lab where the client was tested soon after they sit down for their final appointment to go over their results with an Aptitude Consultant. Additionally, we have surveys for the five year and ten year mark, and a one year survey is currently in preparation. It is our hope that by checking in with clients every so often we can let them know we care about their success after testing, remind them of the services we provide, and gather longitudinal data pertaining to the way they use their aptitudes and choices they make over time.

The exit survey asks clients to rate different aspects of their testing experience, and gives them an opportunity to provide us with feedback. While the overwhelming majority of the

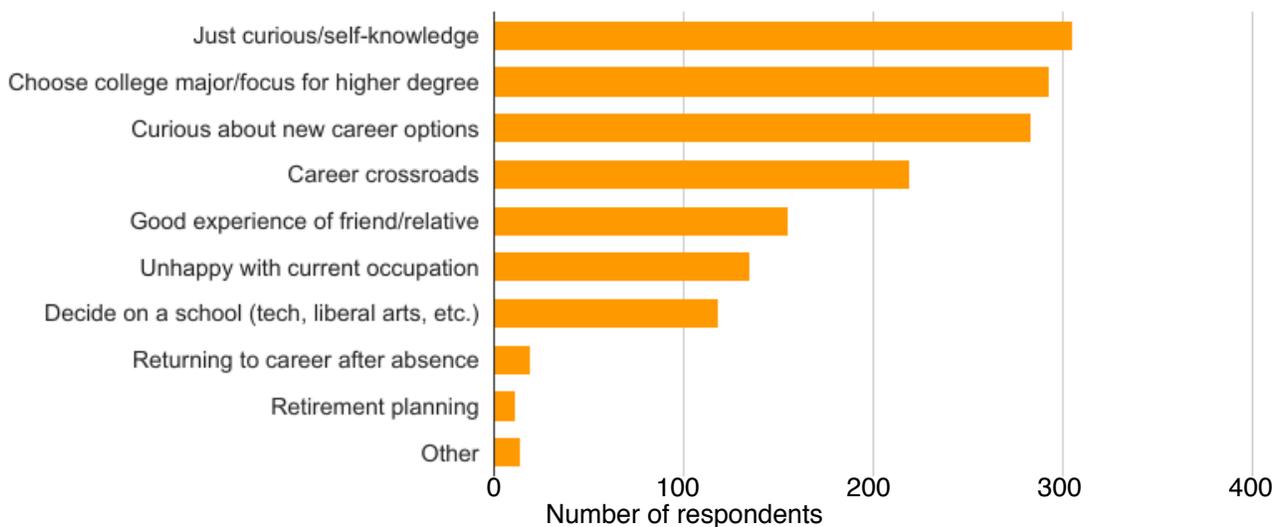
responses we've received have been positive, this survey also allows clients who may have left the lab hoping for more to let us know what they felt was missing. If clients need further assistance, they are invited to leave contact information, and advised that someone will reach out to them soon. This gives us a chance to follow up with those clients who thought of questions after leaving their final appointment and provide them with additional support, while reminding them to take advantage of their free follow up appointment once they've gone through their materials and completed some research on their own.

### Who takes the survey and why?

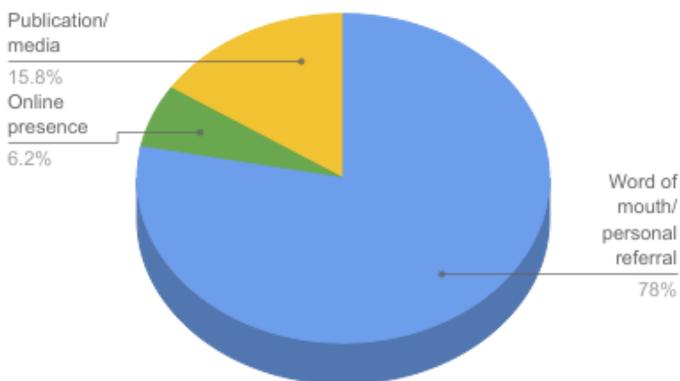
Of the 621 responses gathered between April and December of 2016, most surveys were taken by the clients themselves. However, there were instances where a parent, grandparent, or even a spouse chose to give feedback on behalf of the client. While clients of all ages participate, the largest group of respondents is between 14 and 23 years of age, a reflection of the fact that many of our clients are students in that age group.

In fact, a majority of clients come to us because they are trying to decide on a college major, or a focus for a higher degree. Other clients find themselves at a career crossroads, where they must make an important choice about the trajectory of their career. Some are unhappy with their current occupation, while others simply want to think beyond the options they've already considered. Clients of all ages and backgrounds indicate that they came out of curiosity; to gain a little bit of insight into themselves and to find out what their innate abilities are.

### Why did you decide to come in for testing?



## How did you hear about the Foundation?



### How do clients hear about us?

According to our survey where clients could choose all that apply, over three quarters of our clients walk through our doors thanks to the recommendation of others. This includes family member or friends who have tested, acquaintances, employers, therapists, and even some people who haven't personally been tested but who know of someone else who had a positive experience with the Foundation.

The majority of the remainder of our clients say they found out about us through a publication such as O Magazine, a podcast, a radio interview, or even blogs of past clients who decided to tell their followers about their experience. A small portion of clients come to us thanks to our accounts on social media, or because they discovered the Foundation while conducting an internet search. We hope to use information gathered through the survey to help us expand our reach in this final category. Providing quality services and valuable information to each client ensures that they will be likely to recommend us to others in the future, no matter how they first heard about us.

### How likely are clients to recommend us?

Based on the number of clients who come to us on a recommendation, it is perhaps not surprising that most clients indicate that they will in turn recommend us to others. Nearly 73% of surveyed clients would "Absolutely!" recommend us and over 20% say they "Probably" would. Of the remaining responses, a commonly reported concern is that the cost may be prohibitive to some people. Efforts to improve and expand scholarship testing and relationships with local sponsors may alleviate some of those concerns and further increase the percentage of clients who would readily recommend us.

## What's next for our clients?

Clients tell us that they hope to use their aptitudes in a variety of ways. Many clients plan on using their aptitudes in enriching hobbies or volunteer work, in informing day to day decisions, and even in improving the quality of their relationships with other people. We can expect to see that our clients apply their results most in their work, and in the education needed prior to entering the field of their choice.

As clients participate in the one, five, and ten year surveys, we will be able to see just how much they are able to engage their aptitudes for success and satisfaction in the workplace. We anticipate that the information we gather at each of these intervals will provide us with a snapshot as clients progress through various stages in their careers and apply their aptitudes in new ways. In turn, this will better inform the way we talk about the benefits of using certain aptitudes in various jobs, spawning a new generation of research and test development.

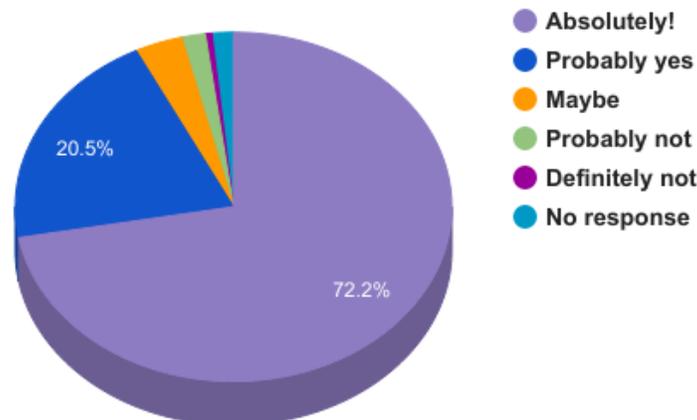
### Alison White

Research Assistant - Surveys

(recent test administrator  
Atlanta, Chicago, test trips)



## Would you recommend our service?



## Dissemination of Research Findings

In recent years we have made it a practice to present findings from our research in scholarly outlets such as professional conferences and journals. In 2016 we made two presentations at the annual meeting of the Association for Psychological Science, which was held in Chicago. Dr. Linda Houser-Marko presented “Spatial Ability and the STEM Majors: Where Do Females With High Spatial Ability Go?” In this presentation, she compared the rates of examinees in the STEM majors with the rates who have STEM-compatible aptitude patterns. Dr. David Schroeder presented “The Flynn Effect: Is It Continuing in the United States?” in which he addressed trends in mean scores over the last several decades. After the conference, Houser-Marko and Schroeder submitted their presentations to the Open Science Framework’s database, where they can be retrieved by other researchers. In addition, Houser-Marko [and associates at the Foundation] prepared a press release on her findings. See page 7.

Also in 2016, Drs. Nikolaus Bezruczko, Etienne Manderscheid, and Schroeder published an article in the journal *Psychology & Neuroscience*, which is published by the American Psychological Association. In this article, they reported on neuroimaging findings regarding brain areas related to our Visual Designs test.

Dr. Rex Jung and his research team, who have collaborated with us on research on aptitudes and neuroimaging, published a couple of journal articles in 2016 on studies that used our tests. One of the articles, “Fronto-Parietal Gray Matter and White Matter Efficiency Differentially Predict Intelligence in Males and Females”, appeared in the journal *Human Brain Mapping*. In this article, by Saphira Ryman and others, they looked at the relationships for gray-matter volume and white-matter efficiency with a general ability factor and used our vocabulary test in a small battery to identify the general factor. The other article, “Cognitive Specialization for Verbal vs. Spatial Ability in Men and Women: Neural and Behavioral Correlates”, by Ronald Yeo and others, appeared in *Personality and Individual Differences*, and it focused on a comparison of the relationships of brain

structure with spatial and verbal ability, respectively. Our Paper Folding and Vocabulary tests were among the spatial and verbal measures that they used. Previous articles by Dr. Jung and his associates on research that we sponsored have continued to receive attention in scholarly circles in 2016. The Jung et al. article in *Frontiers in Psychology* in 2015 has now been viewed 6,152 times and cited in 7 other scholarly articles. The 2014 PLoS ONE article by Dr. Jung and his team has been viewed by 3,016 persons and cited 9 times.

Other scholarly work sponsored by us continued to have impact in 2016. Our 2010 article with Dr. Richard Haier and his associates in *BMC Research Notes* has now been viewed by 12,275 persons and cited 18 times in other articles, while our 2012 *BMC* article by Dr. David Schroeder and others has been viewed by 1,653 persons and cited 3 times. In addition, our 2009 article with Haier and others in *Intelligence* has been cited 69 times, and our our 2010 article with Dr. Cheuk Tang and others in *Intelligence* has been cited 46 times.

With regard to earlier publications, Schroeder’s 2004 article with Drs. Timothy Salthouse and Emilio Ferrer in *Developmental Psychology* has now been cited in 113 scholarly publications, and his article with Salthouse in *Personality and Individual Differences* has been cited 64 times. Our 2001 *Intelligence* article by Dr. Scott Acton, a former research assistant in the Research Department, and Schroeder has been cited 58 times.

In 2017 Drs. Bezruczko and Schroeder will present “Artistic-Judgment Aptitude Factors Correlate Significantly With Increased Gray Matter” at the annual convention of the American Association for the Advancement of Science. Later in the year, Drs. Houser-Marko and Schroeder will make presentations titled “A Longitudinal Study of Abilities and Interests in STEM and People-Oriented Fields” and “Secular Trends in Specific Abilities: Understanding the Flynn Effect” at the annual meeting of the Association for Psychological Science.

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## Recent Technical Reports

2013-1	Sex Differences in Variability	D. Schroeder
2012-1	Aptitudes, Vocabulary, and Educational Attainment	D. Schroeder
2012-2	The Aptitudes of Engineering Students	C. Condon, D. Schroeder
2012-3	Four Studies of the Self-Directed Search	D. Schroeder
2008-1	Is the Flynn Effect Primarily a Rise in Structural Visualization?	C. Condon, D. Schroeder
2008-2	Memory for Design: Internal Characteristics and Validation Data	D. Schroeder, C. Condon

## Recent Statistical Bulletins

2016-1	Preliminary Results for the Cognitive Ability Scales From the Revelle/Condon Project Collaboration	Linda Houser-Marko
2016-2	Frequency and Creativity Scores for Foresight, Wks. 307 AQ	Rusty Burke, Kelsey Bakas
2016-3	Age Curve for the Analytical Reasoning Test	David Schroeder, Linda Houser-Marko
2016-4	Age Curve for the Number Facility Test	David Schroeder, Linda Houser-Marko
2016-5	Results from the Decade Study of Examinees from 2005	Linda Houser-Marko
2016-6	Poster Presentation for Association for Psychological Science Convention	Linda Houser-Marko
2016-7	Internal Analysis of Number Memory	David Schroeder
2015-1	Analysis of Experimental Inductive Reasoning Items, Wks. 164 X10 (2014)	David Schroeder
2015-2	Theatre Artists' Aptitudes Study: Results for WA and an Online Survey of Theatre Artists	Scott Barsotti Linda Houser-Marko, Rusty Burke
2015-3	Scores on Writing Speed Across Time	David Schroeder
2015-4	Analysis of Experimental Inductive Reasoning Items, Wks. 164 X11 (2014-15)	David Schroeder
2015-5	1-4 Versus 0-6 Scoring for Inductive Reasoning	David Schroeder
2015-6	Theatre Artists' Aptitudes Study: Aptitudes Of Theatre Professionals	Linda Houser-Marko, Scott Barsotti
2015-7	Analysis of Experimental Inductive Reasoning Items, Wks. 164 X12 (2015)	David Schroeder
2014-1	Inter-Trial Improvement of Scores on Silograms	Rusty Burke
2014-2	Sex Differences in Variability for Non-Cognitive Foundation Tests and SDS Scales	David Schroeder
2014-3	Mean Sex Differences for Foundation Tests and SDS Scales	David Schroeder
2014-4	Analysis of Standard Inductive Reasoning Items, Wks. 164 OA	David Schroeder
2014-5	Analysis of Latest Set of Experimental Inductive Reasoning Items, Wks. 164 X* (2013-14)	David Schroeder
2014-6	Heritability/Familiality Studies of the Foundation's Aptitude Tests	David Schroeder, Mikako Nakajima
2014-7	Mean Percentiles for Individual Test by Lab and Test Administrator	Linda Houser-Marko
2014-8	Sensory Discrimination in Relation to a General Factor of Cognitive Ability	David Schroeder, G. Scott Acton
2014-9	Poster Presentation at Behavioral-Genetics Conference	David Schroeder
2014-10	Long-Term Stability for English Vocabulary	David Schroeder
2014-11	Analysis of Experimental Inductive Reasoning Items, Wks. 164 X9 (2014)	David Schroeder
2014-12	Number of Aptitudes Per Examinee	David Schroeder
2014-13	The Distributions of Times for Color Discrimination	David Schroeder

## Recent Publications

- Bezruczko, N., Manderscheid, E., & Schroeder, D. H. (2016). MRI of an artistic judgment aptitude construct derived from Eysenck's K factor. *Psychology & Neuroscience, 9*, 293-325. doi: <http://dx.doi.org/10.1037/pne0000064>
- Ryman, S. G., Yeo, R. A., Witkiewitz, K., Vakhtin, A. A., van den Heuvel, M. P., de Reus, M., Flores, R. A., Wertz, C. R., & Jung, R. E. (2016). Fronto-parietal gray matter and white matter efficiency differentially predict intelligence in males and females. *Human Brain Mapping, 37*, 4006-4016. doi: 10.1002/hbm.23291
- Yeo, R. A., Ryman, S. G., Thompson, M. E., van den Heuvel, M. P., de Reus, M. A., Pommy, F., Seaman, B., & Jung, R. E. (2016). Cognitive specialization for verbal vs. spatial ability in men and women: Neural and behavioral correlates. *Personality and Individual Differences, 102*, 60-67. doi: 10.1016/j.paid.2016.06.037
- Jung, R. E., Wertz, C. J., Meadows, C. A., Ryman, S. G., Vakhtin, A. A., & Flores, R. A. (2015). Quantity yields quality when it comes to creativity: A brain and behavioral test of the equal-odds rule. *Frontiers in Psychology, 6*:864. doi: 10.3389/fpsyg.2015.00864
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- Schroeder, D. H., Haier, R. J., & Tang, C. Y. (2012). Regional gray matter correlates of vocational interests. *BMC Research Notes*, 5(1), 242. doi: 10.1186/1756-0500-5-242
- Haier, R. J., Schroeder, D. H., Tang, C. Y., Head, K., & Colom, R. (2010). Gray matter correlates of cognitive ability tests used for vocational guidance. *BMC Research Notes*, 3(1), 206. doi: 10.1186/1756-0500-3-206
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- Schroeder, D. H., & Salthouse, T. A. (2004). Age-related effects on cognition between 20 and 50 years of age. *Personality and Individual Differences*, 36, 393-404.
- Salthouse, T. A., Schroeder, D. H., & Ferrer, E. (2004). Estimating retest effects in longitudinal assessments of cognitive functioning in adults between 18 and 60 years of age. *Developmental Psychology*, 40, 813-822.

## Recent Presentations

- Houser-Marko, L. S. (2016, May). *Spatial ability and the STEM majors: Where do females with high spatial ability go?* Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.
- Schroeder, D. H. (2016, May). *The Flynn Effect: Is it continuing in the United States?* Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.
- Houser-Marko, L. S., & Schroeder, D. H. (2015, September). *Shedding light on intelligence, creative fluency, and creative achievement.* Paper presented at the annual meeting of the International Society for Intelligence Research, Albuquerque, New Mexico.
- Schroeder, D. H. (2015, September). *Heritability of specific cognitive abilities.* Paper presented at the annual meeting of the International Society for Intelligence Research, Albuquerque, New Mexico.
- Schroeder, D. H. (2014, June). *Resemblance for twins on a battery of ability tests.* Poster session presented at the annual meeting of the Behavior Genetics Association, Charlottesville, VA.
- Houser-Marko, L. S., & Schroeder, D. H. (2014, May). *Three musical ability tests as they relate to cognitive measures and musical experience.* Poster session presented at the annual meeting of the Association for Psychological Science, San Francisco.
- Houser-Marko, L. S., & Schroeder, D. H. (2012, December). *Cognitive abilities of engineers and computer scientists.* Poster session presented at the annual meeting of the International Society for Intelligence Research, San Antonio.
- Jung, R. E., Frantz, J., Ryman, S., Carrasco, J., Shamiloglu, S., Vakhtin, A., Burke, R. E., Schroeder, D. H., & Haier, R. J. (2012, December). *Subcortical correlates of aptitude.* Poster session presented at the annual meeting of the International Society for Intelligence Research, San Antonio.
- Jung, R. E., Ryman, S., Frantz, J., Carrasco, J., Shamiloglu, S., Vakhtin, A., Burke, R. E., Schroeder, D. H., & Haier, R. J. (2012, December). *Differentiation of intelligence, creativity, and aptitude via brain-behavior imaging.* Paper presented at the annual meeting of the International Society for Intelligence Research, San Antonio.
- Schroeder, D. H. (2012, December). *Gender differences in variability in ability factors over time.* Paper presented at the annual meeting of the International Society for Intelligence Research, San Antonio.
- Haier, R. J., Jung, R. E., Ryman, S. G., Frantz, J. A., Carrasco, J., Burke, R. E., & Weisend, M. (2012, December). *Sequence and speed of information flow among brain areas during problem solving in high and average intelligence individuals.* Paper presented at the annual meeting of the International Society for Intelligence Research, San Antonio.
- Houser-Marko, L. S., & Schroeder, D. H. (2012, May). *Cognitive abilities of males and females who work in STEM fields.* Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.
- Schroeder, D. H. (2012, May). *Gender differences in variability of specific cognitive abilities.* Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.

# Spatial ability and the STEM majors: Where do females with high spatial ability go?

Poster session presented at the annual meeting of the Association for Psychological Science, Chicago, May 2016.

Dr. Linda Houser-Marko's poster. See page 7 for coverage about this presentation.



## Spatial ability and the STEM majors: Where do females with high spatial ability go?

Linda S. Houser-Marko, PhD

Johnson O'Connor Research Foundation

Poster presented to the Association for Psychological Science 28<sup>th</sup> Annual Convention in Chicago, May 26-29, 2016

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### Introduction

Spatial ability appears to be an important aspect of working in and studying the science, technology, engineering, and math fields. Each field of STEM has a slightly different profile pattern of numerical, verbal, and spatial abilities.

Specific STEM majors have different profiles of numerical, verbal, and spatial abilities. Spatial ability was high for all STEM majors, with the highest levels for engineering and math majors. Females with high spatial ability go into physical science, engineering, and computer science at lower than expected rates, relative to their abilities.

### Method

#### Sample

- The sample was 11,502 18 to 24 year olds who had tested with the Johnson O'Connor Research Foundation for the purpose of vocational guidance. From our database, we also selected those who reported their college major. There were 54% males and 46% females. The mean and median of age was 21 years old.
- Of the overall sample, 16% indicated that they had chosen a STEM major. There were 5.7% in biological sciences, 1.7% in physical sciences, 2.2% in computer science, 5.5% in engineering, and 1.1% in math. Of the STEM majors, 31% were female.

#### Measures

**Numerical ability:** A combined score of two numerical tests (number series and number facility). Test reliabilities were .87 and .86.

**Spatial ability:** a combined score of two spatial tests (paper folding and wiggly block). Test reliabilities were .82 and .77.

**Verbal ability:** a test of vocabulary knowledge. Test reliability was .96.

Our first analytical approach started with the majors, and determined the profile patterns from those, assuming that the aptitudes of the students, on average, "fit" with the major that they had chosen.

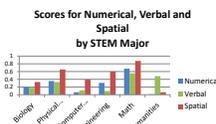
### STEM Majors

*What are the aptitude patterns, specifically numerical, verbal, and spatial ability, for STEM majors?*

We found that for biological, physical, and computer sciences, numerical and verbal abilities were "symmetrical," or in other words, about equally high within the person.

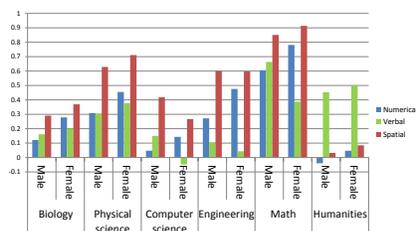
Engineering showed asymmetry in which numerical aptitude was higher than verbal aptitude.

Spatial ability had a unique pattern, in which math majors had the highest levels, followed by physical science and engineering, followed by biology and computer science.



### Comparing Males and Females

We looked at males and females specifically, to see if there were differences in the strengths of students in the STEM majors.



For engineering and math majors specifically, females showed the asymmetry of numerical aptitude being higher than verbal abilities, while male math majors had symmetrical (and high) numerical and verbal aptitudes. The levels of spatial ability for male and female engineering students were about the same.

Though the computer science students might look somewhat average on their numerical and verbal abilities, their spatial abilities were above average.

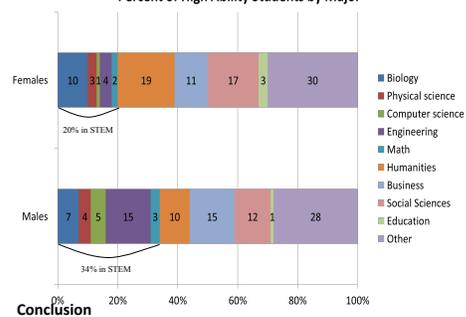
### Select Students with High Spatial and High Numerical Ability

*What majors do they go into?*

Second, we wanted to look more closely at spatial ability as it related to college major choice, particularly for females and males with similar levels of spatial and numerical ability. We selected participants who had high spatial ability and moderately high numerical ability from the sample.

Overall for those selected that were high in spatial ability and moderately high in numerical (n = 3041), 28% were in STEM.

### Percent of High Ability Students by Major



### Conclusion

Being aware of one's strengths and weaknesses can help a person make better decisions. Knowing the important role of spatial ability in the STEM fields might help to increase interest in those fields.

Future projects will look in more depth into the major choices of students who tested before they entered college to see if learning about spatial ability influenced them to chose STEM majors more often.

This research suggests that early exposure to STEM programs might positively impact students by introducing them to fields that they have the aptitudes for but might not otherwise have sought out.

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