



## Report of the Research Department

# 2022

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JOHNSON O'CONNOR RESEARCH FOUNDATION, INC.  
HUMAN ENGINEERING LABORATORY, INC.  
JOHNSON O'CONNOR RESEARCH SUPPORT CORPORATION

## 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.



Anne Steiner

## FROM THE PRESIDENT

It's been an exciting year at Johnson O'Connor, with a lot more changes on the horizon.

We made some personnel changes to the Research Department last year. We are delighted to welcome Ryan Barry as our new Research Associate. He has a background in both industrial/organizational psychology and quantitative psychology, and is working toward a PhD in I/O psychology. Dave Schroeder, our longtime Research Manager, has transitioned into a consulting role. We are grateful that he has remained with us to continue to offer his expertise and wealth of institutional knowledge. Also, Kathleen Voss, an Aptitude Consultant in the Dallas office, has joined the team as a part-time Research Assistant.

Last year, we took our first steps toward developing digital versions of our tests. We embarked on a six-month discovery project with Cloudberry Creative, a software development company, to analyze each test and assess the practicality of developing a digital version. We worked with them to create a prototype of one test, Analytical Reasoning, as a proof-of-concept.

The in-person version of Analytical Reasoning involves split-second timing and a lot of manual manipulation of test equipment. We wanted to test the feasibility of digitalization on a test that would present a challenge. After the prototype was complete, we administered it to a sample of clients on an experimental basis. You can read in detail about our process in these pages. I'd like to thank the staff at the Chicago, Dallas, and Atlanta offices, for administering this test in their offices, and also to Seattle and New York for helping with data entry. Our testing staff has always been, and will continue to be, an important part of the research process.

The result of the overall discovery process and the experimental Analytical Reasoning administration was very encouraging, and in 2023 we will be embarking on the next phase, the digitalization of 19 of our tests. The research department will be closely involved in this project. They will work on equating and analyzing the validity of the new, digital versions, collaborate with the developers to create a robust database system, and much more.

Digitalized tests, along with a new, sophisticated database, will help improve and streamline how we collect and analyze what is the lifeblood of any research department: data. Data collection at the Foundation has always been, by necessity, a slow, painstaking process. Digitalization will allow us to collect data and get it to our researchers much more quickly and in a much more usable format, and will also allow us to gather many more data points than are currently possible.

Another benefit is that it will become much more possible to add new, experimental items to existing tests, or to develop and administer entirely new tests. Currently, introducing experimental items or an experimental test involves, at the very least, printing and distributing test papers and score sheets, and possibly also finding a supplier or manufacturer to provide us with physical test equipment—plastic chips, pins, boards, and the like. A digital format will allow us to streamline this process, which will in turn allow us to expand and enhance our test battery and the quality of our research.

Speaking of adding tests, in 2022 we began the process of adding another personality measure to our battery. The Big Five personality approach is a well-respected personality test that has been well-validated by other psychology researchers. With the help of outside collaborators, we have done some research already on the relationship between aptitudes and personality traits, but developing and administering our own measure will allow us to explore this subject more deeply.

All in all, we are embarking on a transformation that will open up new and exciting avenues for research and further our ongoing mission, as stated in our charter: “to further by research, tests, measurements, publication, and teaching, an understanding of human beings and of their actions.”

The form of our tests may change, but our mission is timeless.

## RESEARCH TEAM



**David H. Schroeder**, Research Consultant, 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.

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**Susan Park**, Researcher, received her Ph.D. in psychometrics and quantitative psychology from Fordham University. She joined the Research Department in 2021 after working in research institutions that focused on education and career development as well as the intersection of technology and learning. Research topics in her past work have included psychometrics and the interplay among motivation, emotions, and goal pursuits, especially in career development. Prior to her career in psychology, Park worked as a vocational rehabilitation counselor.

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**Ryan Barry**, Research Associate, joined the Research Department in October of 2022. He has a dual M.S. degree in industrial/organizational and quantitative psychology from Illinois State University and will complete his Ph.D. in industrial/organizational psychology from the University of Tulsa this fall.

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**Kathleen Voss**, Research Assistant, joined the Foundation as a test administrator in Dallas in 2019, and was brought on as a contributor to the Research Department in 2022. She has a B.S. in psychology and child development and an M.S. in psychological sciences from the University of Texas at Dallas.

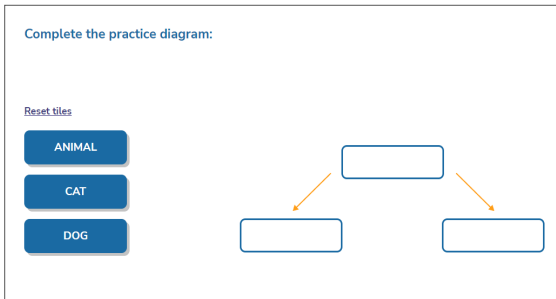
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**Holly Wilhelm**, Research Coordinator, joined the Foundation staff as a test administrator in the Atlanta office in 2005, and has since contributed to multiple writing, research, and training endeavors. She became the chair of the Research Committee when it was first established in 2019 to form a stronger link between the research and the testing arms of the Foundation.

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## NEW DIGITAL TEST FOR ANALYTICAL REASONING



Practice item screen from the digital Analytical Reasoning prototype, developed after a 6-month discovery period with Cloudberry Creative.

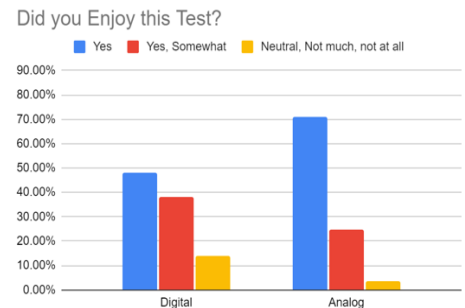
### User Experience

A significant component of our project discovery work with Cloudberry Creative was the development of a working prototype of a digital version of our Analytical Reasoning test. The test design was fairly straightforward, as we wanted the new test to be closely aligned with the analog version. To that effect, the visual layout is very similar to the analog test and the instructions almost exactly replicate those given in the analog version. The test was designed to work on a laptop or desktop, with users employing a mouse or a trackpad to interact with test content.

During the UX design process, various iterations were given in the first round of user testing to determine which worked the best. One version allowed the examinees to read printed instructions to themselves, while the other presented spoken instructions. The users in the first group tended to skim through or skip the instructions and did not have a clear idea of what they were to do on the test, so we determined that the spoken instructions were an important component of the interaction model. Another experiment related to the physical interaction with the word tiles on the screen. One group had to click a tile to select a word and drag it into place, while the other group was to click a tile to select and then click the desired location for it to be dropped. The “drag and drop” group seemed more comfortable with the task, and several of the “click and click” users attempted to drag the words across the screen. The average speed of the two groups was roughly the same, so “drag and drop” was selected as the most user-friendly option for the test interaction.

When the digital test was completed, the research department, led by Susan Park, worked with the testing staff, led by Tommy Jensen and Holly Wilhelm, to design a preliminary study to equate the digital test results with those from the analog test. From a test administrator perspective, the study went smoothly. Very few clients had any difficulties with the digital test. Results from the preliminary equating study are detailed elsewhere in this report and in the soon-to-be-published SB 2023-3.

Clients in both the digital and the analog group took a four-question survey designed to assess their understanding and enjoyment of the respective test versions. The survey results were generally positive, with the majority of clients in both groups stating that they understood the instructions, had no difficulty moving the chips, and found the test at least moderately enjoyable. There was a small difference in the level of enjoyment between the two groups. This may be because the absence of a test administrator and a hands-on element made the test less enjoyable, or it may be because the digital version was generally given later in the test appointment. It is possible that this group may have been more tired and may have had more tests to compare with Analytical Reasoning. In the future, efforts will be made to standardize administration in order to more accurately assess effects such as this. Future digital tests may also incorporate additional elements to increase clients’ enjoyment of the experience.



Client responses indicated a slightly higher level of enjoyment for the analog than the digital version of Analytical Reasoning.

## NEW DIGITAL TEST FOR ANALYTICAL REASONING (cont.)

### Equating Study

The Johnson O'Connor Research Foundation (JOCRF), with support from the Dalio Foundation, conducted an exploratory study on digitalizing the Analytical Reasoning test (AR) (Form 244 IC). The goal of this exploratory study was to conduct a preliminary equating on the digital form of the Analytical Reasoning test (Form 244 JC). Equating is a statistical process that makes sure that a score for a test taken on one form (i.e., analog) is equivalent to a score for another form (i.e., digital).

Table 1. *Sample Demographics*

	Analog Form		Digital Form		Total %
	n	%	n	%	
<b>Sex</b>					
Male	185	56	56	54	56
Female	146	44	47	46	44
<b>Age</b>					
14-20	193	57	63	61	58
21-25	66	19	17	16	19
26-30	28	8	12	12	9
31-35	14	4	4	4	4
36-40	13	4	3	3	4
41-45	8	2	1	1	2
46-50	2	1	0	0	1
51-55	9	3	3	3	3
56-60	2	1	1	1	1
61+	5	1	0	0	1
<b>Education</b>					
High school	164	49	59	56	51
Undergraduate	149	45	40	38	43
Graduate	21	6	7	7	6
<b>Lab</b>					
Chicago	28	8	28	26	12
New York	72	21	0	0	16
Dallas	45	13	38	36	18
Atlanta	124	36	40	38	37
Seattle	74	22	0	0	16

The JOCRF used this process because it is important that the score one receives means the same regardless of what form taken. Equating ensures that there is no advantage or disadvantage to taking the test in the analog form over the digital form, or vice versa.

The gathering of the scores occurred during the summer of 2022 at the labs located in Atlanta, Chicago, and Dallas. The equating design was treated as a random-groups design. Table 1 presents descriptive statistics of the samples taken from the analog form and the digital form of the AR test. The raw score distributions of the analog form and the digital form are shown in Table 2.

The possible minimum raw score is 14 and the possible maximum raw score is 104 for the analog form of the AR Test. The mean raw score for the digital form is about 12 raw score points lower than the analog form. Moreover, the highest observed raw score for the digital form is 56 points leading to the conclusion that responses on the digital form are slower.

Table 2. *Raw Score Distributions For Analog Form and Digital Form*

Statistics	Analog Form	Digital Form
	n = 343	n = 105
Mean	52.61	40.50
SD	13.03	7.90
Median	53.00	41.00
Skewness	0.10	-0.16
Kurtosis	2.83	2.37
Minimum	21.00	23.00
Maximum	90.00	56.00

Due to the exploratory nature of this preliminary equating study, results from the mean equating, linear equating, and equipercentile equating were evaluated. Those evaluations included examining, for example, bootstrapped standard errors of equating, bootstrapped 95% confidence intervals, and how closely the equated percentile rank solutions aligned with the analog percentile rank solutions. Based on these analyses, the linear equating and equipercentile solutions were the preferred solutions. In addition, the linear equating solution had an advantage in that it can be performed with a smaller sample size (about 400 cases per form) in comparison to equipercentile equating (over 1,500 cases per form).

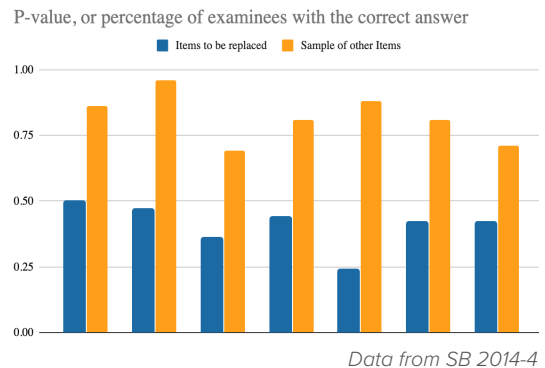
## INDUCTIVE REASONING CHANGES



In the 2010s, the Research Department went through extensive studies of the Inductive Reasoning test. A bank of over 100 new items was created and given to clients in experimental administrations between 2010 and 2015. Ten test items with relatively poor performance were replaced with newly created items in late 2012.

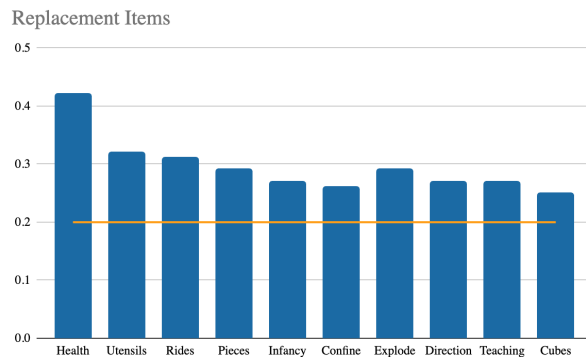
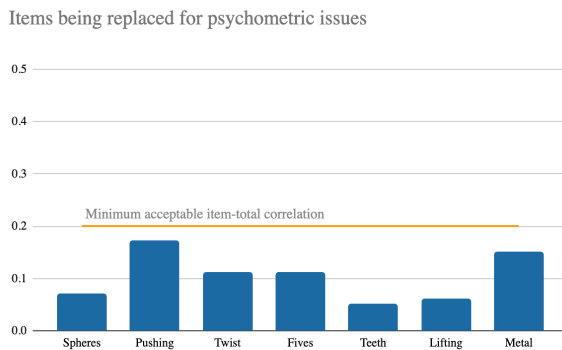
After this, as was reported in a 2014 analysis, we continued to find some items with low item-total correlations on the test (SB 2014-4). Additionally, several of these items were consistently missed by most examinees, which is frustrating for both clients and administrators.

While staffing challenges, image file availability, and a global pandemic slowed our progress, we resumed our efforts in late 2022 and created a newly revised test form using items from the 100-item test bank. We removed seven items with item-total correlations below .20, which was deemed the minimum acceptable level. We removed three additional items that have become dated for a variety of reasons.



We selected ten of the best-performing items from the item bank. All have been given to at least two groups of examinees, have consistently shown item-total correlations over .20, and have a higher percentage of clients selecting the right answer.

### Item Total Correlations



Data from SB 2010-1, SB 2013-4, SB 2014-4, SB 2014-5, SB 2014-11, SB 2015-1, SB 2015-4, SB 2015-7

Values are an average across administrations.

A more detailed explanation of the considerations and processes used in planning the changes will be provided in SB 2023-1 and SB 2023-2.

Offices will start giving the new version of Inductive Reasoning, form PA, in June of 2023. We are grateful for the efforts of Rusty Burke, Tim Fitzgerald, Kevin Fullam, David Ransom, and David Schroeder, who analyzed the experimental items' performance, and the many TAs who helped with the creation of the items.

## NEW PERSONALITY MEASURE – THE “BIG FOUR”



Another major development in the Foundation’s program involves assessing personality beyond the objective-subjective trait that our Word Association test measures. More specifically, outside research has identified five broad dimensions of personality (the “Big Five”) that provide wide coverage of the ways that people differ in personality. Although the Foundation has historically used performance tests to measure traits, outside research has identified effective self-report measures of the five dimensions, while attempts to develop performance measures of personality have shown rather limited success.

The outside research community, with leadership from Dr. Lewis Goldberg, has created the International Personality Item Pool (<https://ipip.ori.org>), which is a tremendous asset for people who are seeking to measure the Big Five personality dimensions. This public-access body currently contains over 250 scales and 3,000 individual items. We have selected Dr. John Johnson’s 120-item measure of the Big Five domains, which in turn was adapted from a longer instrument by Dr. Goldberg. We expect to assess four of the five dimensions and set aside the Neuroticism domain (in the language of the field, we will be administering the “Big Four” scales).

In 2023 we anticipate giving the Johnson measures on an experimental basis for several months, and this will enable us to construct initial age norms. We will also be assembling interpretive information in anticipation of adding Big Four results to our summary sessions with clients.



## DISSEMINATION OF RESEARCH FINDINGS

In recent years we have continued to present findings from our research in scholarly outlets such as professional conferences and journals. More specifically, in the 2010s, we collaborated with Dr. Rex Jung on a series of neuroimaging studies of aptitudes. Articles from this work continued to receive attention in scholarly circles in 2022. The Jung et al. article in *Frontiers in Psychology* in 2015 has now been viewed 25,460 times and cited in 53 other scholarly articles. The 2014 *PLoS ONE* article by Dr. Jung and his team has been viewed by 3,947 persons and cited 17 times.

Other scholarly work sponsored by us continued to have impact in 2022. Our 2010 article with Dr. Richard Haier, with whom we collaborated on earlier neuroimaging research, and his associates in *BMC Research Notes* has now been viewed by over 14,000 persons and cited 26 times in other articles, while our 2012 *BMC* article by Dr. Schroeder and others has been viewed by 2,542 persons and cited 8 times. In addition, our 2009 article with Dr. Haier and others in *Intelligence* has been cited 119 times, and our 2010 article with Dr. Cheuk Tang and others in *Intelligence* has been cited 94 times.

With regard to earlier publications, Dr. Schroeder's 2004 article with Drs. Timothy Salthouse and Emilio Ferrer in *Developmental Psychology* has now been cited in 205 scholarly publications, and his article with Salthouse in *Personality and Individual Differences* has been cited 117 times. Our 2001 *Intelligence* article by Dr. Scott Acton, a former research assistant in the Research Department, and Dr. Schroeder has been cited 109 times.

### Recent Statistical Bulletins

2022-1	Norm-Construction Procedures and Age Curve for Tweezer Dexterity	David Schroeder Susan Park
2020-1	Scoring Analysis of Memory for Design	Luke Robbins
2019-1	Updated Occupational Plots for the Foundation's Standard Test Battery	David Schroeder Ashley Brown
2019-2	The Foresight Aptitude and Creative Achievement	Linda Houser-Marko Rusty Burke
2019-3	Research Proposal: Video Game Designer Study	Alex Bureau
2019-4	Occupational Plots for the Self-Directed Search Scales	David Schroeder Ashley Brown
2019-5	Occupational Plots for Satisfied Versus Dissatisfied Examinees	David Schroeder Ashley Brown
2019-6	Age Curves for the Graphoria, Number Memory, and Color Discrimination Tests	Ashley Brown Linda Houser-Marko
2019-7	Occupational Plots for Art-Related Occupations	David Schroeder Ashley Brown
2019-8	Occupational Plots for the Grip Test	David Schroeder Ashley Brown
2019-9	How to Write a Statistical Bulletin	Amanda Summers Linda Houser-Marko Michele Ledbetter
2018-1	Long-Term Stability for Number Facility	David Schroeder
2018-2	Summary of Long-Term Stability Findings	Dave Schroeder

2018-3	Writing Speed: A Series of Analyses	David Schroeder
2018-4	Information About Norms for Each Test	Linda Houser-Marko
2018-5	Research Proposal: The Aptitudes of Translators and Interpreters	Will Eells

### Recent Technical Reports

2019-1	Occupational Plots for the Foundation's Standard Battery Displayed by Occupation	David Schroeder Ashley Brown
2017-1	Occupations in Education	Christopher Condon David Schroeder
2013-1	Sex Differences in Variability	David Schroeder
2012-1	Aptitudes, Vocabulary, and Educational Attainment	David Schroeder
2012-2	The Aptitudes of Engineering Students	Christopher Condon David Schroeder
2012-3	Four Studies of the Self-Directed Search	David Schroeder

### Recent Presentations

Brown, A. D. (2021, May). *Big 5 personality traits and broad versus narrow cognitive abilities*. Poster session presented at the virtual meeting of the Association for Psychological Science.

Houser-Marko, L. S., & Brown, A. D. (2019, July). *Cognitive abilities, divergent thinking, and the aspects of Openness*. Poster session presented at the annual meeting of the International Society for Intelligence Research, Minneapolis, Minnesota.

Schroeder, D. H. (2019, July). *A negative Flynn Effect in recent cognitive-ability scores*. Paper presented at the annual meeting of the International Society for Intelligence Research, Minneapolis, Minnesota.

Houser-Marko, L. S., & Brown, A. D. (2019, June). *Aging and the aspects of Openness: Unpacking cross-sectional patterns*. Poster session presented at the biennial meeting of the Association for Research in Personality, Grand Rapids, Michigan.

Houser-Marko, L. S. (2018, July). *Person-environment fit as seen in college majors and group-factor cognitive ability patterns*. Poster session presented at the annual meeting of the International Society for Intelligence Research, Edinburgh.

Houser-Marko, L. S. (2018, May). *Perceived person-job fit and relative abilities and interests for popular occupational fields*. Poster session presented at the annual meeting of the Association for Psychological Science, San Francisco.

Schroeder, D. H. (2018, May). *Declines in cognitive-ability scores: A negative Flynn Effect?* Poster session presented at the annual meeting of the Association for Psychological Science, San Francisco.

Houser-Marko, L. S., & Schroeder, D. H. (2017, May). *A longitudinal study of abilities and interests in STEM- and people-oriented fields*. Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.

Schroeder, D. H. (2017, May). *Secular trends in specific abilities: Understanding the Flynn Effect*. Poster session presented at the annual meeting of the Association for Psychological Science, Chicago.

Bezruczko, N., & Schroeder, D. H. (2017, February). *Artistic-judgment aptitude factors correlate significantly with increased gray matter*. Poster session presented at the annual meeting of the American Association for the Advancement of Science, Boston, MA.

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.

## 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

Jung, R. E., Ryman, S. G., Vakhtin, A. A., Carrasco, J., Wertz, C., & Flores, R. A. (2014). Subcortical correlates of individual differences in aptitude. *PLoS ONE*, 9(2): e89425. doi: 10.1371/journal.pone.0089425

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

Tang, C. Y., Eaves, E. L., Ng, J. C., Carpenter, D. M., Kanellopoulou, I., Mai, X., Schroeder, D. H., Condon, C. A., Colom, R., & Haier, R. J. (2010). Brain networks for working memory and factors of intelligence assessed in males and females with fMRI and DTI. *Intelligence*, 38, 293-303.

Haier, R. J., Colom, R., Schroeder, D. H., Condon, C. A., Tang, C. Y., Eaves, E., & Head, K. (2009). Gray matter and intelligence factors: Is there a neuro-g? *Intelligence*, 37, 136-144.

## **Trustees 2022**

Wendy Bigelow  
Richard Bowker  
Alice Campbell  
Chris Condon  
Timothy Fitzgerald  
Thomas Jensen  
Ellen Leifer  
David Ransom  
Anne Steiner  
Jeffrey Wyatt

## **Officers**

Anne Steiner, *President and Treasurer*  
Thomas Jensen, *Vice President*  
Holly Wilhelm, *Secretary*  
Timothy Fitzgerald, *Assistant Treasurer and Assistant Secretary*

## **Research Staff**

David Schroeder, Ph.D., *Research Consultant*  
Susan Park, Ph.D., *Researcher*  
Ryan Barry, *Research Associate*  
Kathleen Voss, *Research Assistant*  
Holly Wilhelm, *Research Coordinator*

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