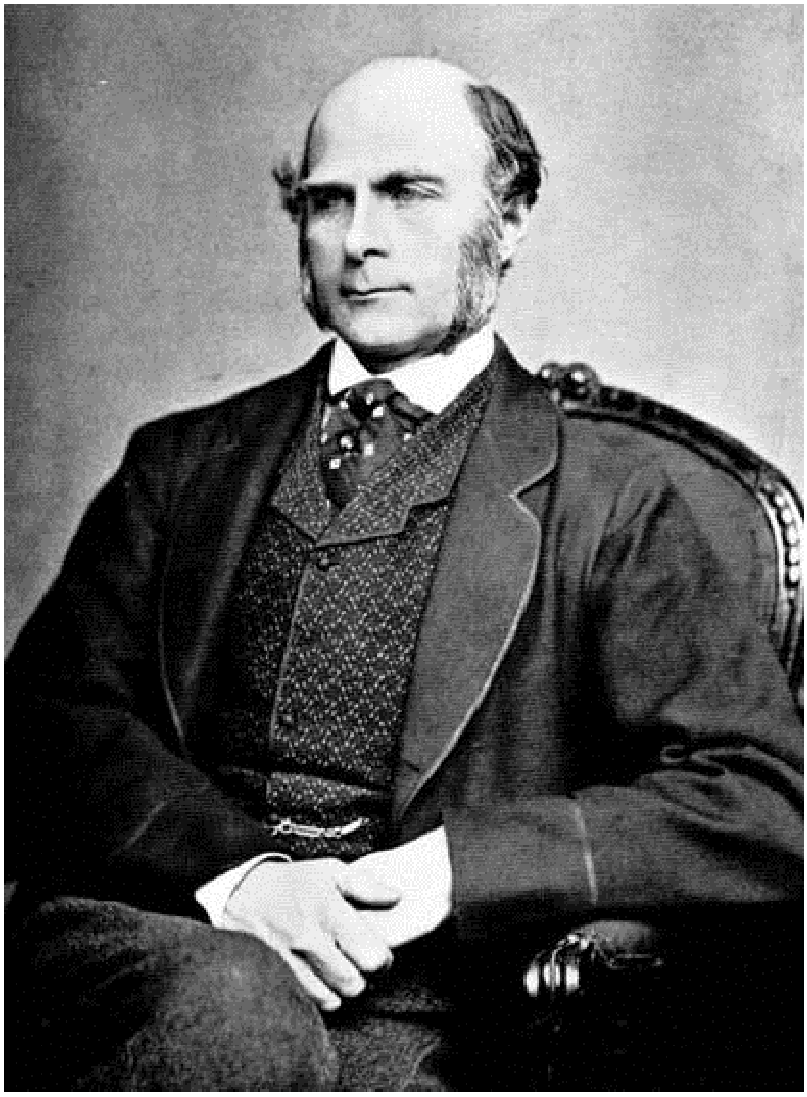
Thirteenth Annual Conference of the International Society for Intelligence Research (ISIR)
San Antonio, Texas, USA
December 13–15, 2012



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The Board would like to thank all the ISIR committees for their hard work in making this conference possible.

We also thank Elsevier for helping to sponsor the Reception.

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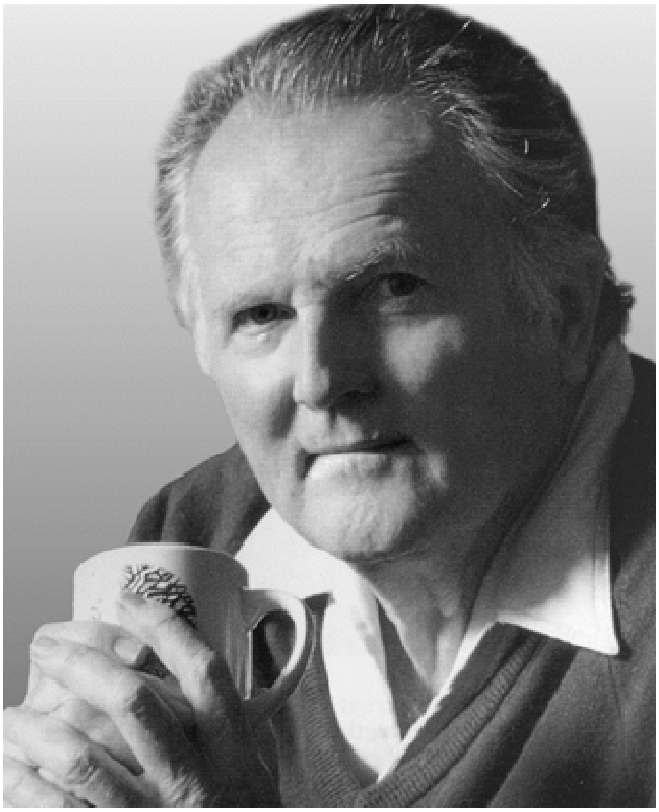

J. Philippe Rushton
1943-2012

Short schedule for ISIR 2012

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DAY 1: Thursday, Dec. 13

8:10–8:20	**Opening Remarks Lifetime Achievement Award: Timothy Salthouse**
8:20–9:40	**Kovas (66) Behav. Genetics Symp.**
8:20–8:40	Petrill (67) Math & Reading Skills
8:40–9:00	Rodic (68) Disoder & Norm. Ability
9:00–9:20	Voronin (69) Literacy, Numeracy, & g
9:20–9:40	Tosto (70) Math Cognition
9:40–10:10	**Break**
10:10–11:10	**Talks: heritability**
10:10–10:30	Briley (38) Genetics & Development
10:30–10:50	McGue (54) Heritability in Late-life
10:50–11:10	Johnson (48) Heritability & high SES
11:10–12:10	**Talks: genetic effects**
11:10–11:30	Hill (45) Molecular genetics
11:30–11:50	Plomin (57) Generalist Genes
11:50–12:10	Mõttus (55) Genes, IQ & Diabetes
12:10–1:40	**Lunch**
1:40–2:40	**Talks: processing**
1:40–2:00	Demetriou (43) Theory of the Mind
2:00–2:20	Dodonova (44) Response Times & IQ
2:20–2:40	Necka (56) Training & IQ
2:40–4:00	**Talks: structure & special abilities**
2:40–3:00	Benson (37) CHC Theory
3:00–3:20	Coyle (42) Non-g Residuals of SAT
3:20–3:40	Kell (50) Spatial Ability
3:40–4:00	Arden (36) *g* in Non Human Primates
4:00–4:30	**Break**
4:30–5:30	**Business Meeting**
5:30–6:30	**Interview: Rich Haier**
6:30–8:30	**Elsevier Reception, Poster Sessions (see the next page)**

DAY 2: Friday, Dec. 14

7:00–8:20	**Student breakfast with Lifetime Achievement Awardee Tim Salthouse**
8:20–10:00	**Thompson (71) Flynn Effect Symp.**
8:20–8:40	Must (71) Test-taking patterns
8:40–9:00	Shiu (72) Item-Level Effects
9:00–9:20	Meisenberg (73) International IQ gaps
9:20–9:40	Rindermann (74) Rise of Cogn.Competence
9:40–10:00	Woodley (75) Dysgenesis vs. Flynn effect
10:00–10:30	**Break**
10:30–11:30	**Talks: group differences**
10:30–10:50	Wai (63) Flynn Effect in Right Tail
10:50–11:10	Irwing (47) Female Achievement
11:10–11:30	Schroeder (62) Gender & Variability in IQ
11:30–12:30	**Holden Memorial Address on Science Writing: Dan Hurley (98)**
12:30–2:00	**Lunch Luncheon for Awardees**
2:00–3:20	**Haier (88) President's Symposium I**
2:00–2:20	Penke (89) White Matter Tract Integrity
2:20–2:40	Cole (90) Brain & Control
2:40–3:00	Konrad (91) Verbal IQ & Broca's Area
3:00–3:20	Langer (92) Network Efficiency & IQ
3:20–3:50	**Break**
3:50–5:30	**Talks: imaging**
3:50–4:10	Widaman (64) Brain Volumes & Cognition
4:10–4:30	Martinez (53) Gray Matter & Intelligence
4:30–4:50	Burgaleta (39) Training &Corpus Callosum
4:50–5:10	Jung (49) Imaging and Abilities
5:10–5:30	Román (61) Training & Brain Changes
5:30–6:30	**Keynote Speaker: Craig Ramey (97)**
7:00-9:00	**Conference Banquet**

DAY 3: Saturday, Dec. 15

8:00–9:20	**Figueredo (76) Life History & IQ Symp.**
8:00–8:20	Figueredo (77) Life History & SLODR
8:20–8:40	Garcia (78) Manifold Inconstancy Effects
8:40–9:00	Cabeza De Baca (79) Meliorism, IQ & Life History
9:00–9:20	Discussant: Woodley (80)
9:20–10:20	**Talks: measurement**
9:20–9:40	Condon (41) Internet-Based Assessmnent
9:40–10:00	Quiroga (59) Videogames & Intelligence
10:00–10:20	Low (51) Invariance of the ASVAB
10:20–10:50	**Break**
10:50–12:30	**Jaeggi & Colom (81) Improving IQ Symp.**
10:50–11:10	Hunt (82) When is IQ improved?
11:10–11:30	Colom (83) Working Memory Training
11:30–11:50	Stephenson (84) Visuospatial Component
11:50–12:10	Matzel (85) Dopaminergic Modulation
12:10–12:30	Jaeggi (86) Improving IQ
12:30–12:50	Haier (87) IQ & Cold Fusion
12:50–2:20	**Lunch**
2:20–3:40	**Haier (88) President's Symposium II**
2:20–2:40	Yu (93) Salience Network
2:40–3:00	Saggino (94) Neuro-Functional Basis of IQ
3:00–3:20	Langeslag (95) Connectivity & Child IQ
3:20–3:40	Haier (96) Information Flow in Brain
3:40–4:10	**Break**
4:10–5:30	**Talks: other associations**
4:10–4:30	Major (52) IQ & Personality
4:30–4:50	Protzko (58) Breastfeeding, SES, & IQ
4:50–5:10	Ritchie (60) Education & Later-Life IQ
5:10–5:30	Christainsen (40) IQ & Wealth of Nations
5:30–5:50	**Carroll Student Award**

International Society for Intelligence Research (ISIR) 2012 Program: Posters

Thursday. December 13

6:30 – 8:30 P.M.

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P1: Posters, generally about Structure and Measurement

P1.1: Are We Really Overfactoring Modern Cognitive Tests? Further Test of a Hypothesis via Plausible Simulated Data. *Jacqueline M. Caemmerer* & Timothy Z. Keith* (13)

P1.2: Age Changes in *Gf* and *Gc* when Similar, Verbal Tasks are Used to Measure each Construct. *Joseph F. Fagan & Cynthia R. Holland* (17)

P1.3: How Well Do the ASVAB and AFQT Measure *g* and Broad Abilities? *Alexandra L. Fisher* et al.* (18)

P1.4: The dimensionality of Raven's Advanced Progressive Matrices and its relation to deductive and inductive ability. *George Spanoudis & Michalis Talias* (32)

P2: Posters, generally about Processing Speed and Intelligence

P2.1: Decomposing Response-Time Variance: Component Scores Revisited. *Yulia A. Dodonova & Yury S. Dodonov* (16)

P2.2: Estimating Split-Half Reliabilities of Response-Time Measures and Their Confidence Intervals. *Yury S. Dodonov & Yulia A. Dodonova* (15)

P2.3: Different Sources of Timing Variability and How They Are Related to Intelligence. *Olympia Karampela* & Guy Madison* (24)

P2.4: The Relationship between Visual Inspection Time and Learning for both Implicit and Explicit Conditions. *Tabitha W. Payne & Clifford Eberhardt* (27)

P3: Posters, generally about Biological Basis of Intelligence

P3.1: Subcortical Morphology Correlates with Fluid and Spatial Intelligence but not with Crystallized Intelligence. *Miguel Burgaleta et al.* (12)

P3.2: Subcortical Correlates of Aptitude. *Rex E. Jung et al.* (23)

P3.3: Co-Variation of Abilities across Diverse Tests of Attention. *Bruno Sauce Silva* et al.* (30)

P3.4: Dopamine Signaling in the Prefrontal Cortex Predicts General Cognitive Abilities and Is a Target for Working Memory Training. *Christopher Wass* et al.* (34)

P4: Posters, generally about Creativity, Processing and Learning

P4.1: Ability to use peripherally presented cues in problem solving as a component of crystallized intelligence. *Evgeniya V. Gavrilova* & Sofya S. Belova* (19)

P4.2: ~~Divergent Productions of Metaphors: Combining Rasch Many Facet Modeling and Cognitive Psychology in the Assessment of Creativity. *Ricardo Primi* (28)~~

P4.3: ~~Learning in Completing Items of Noncognitive Measures as Predictor of Fluid Intelligence. *Karl Schweizer & Siegbert Reiss* (31)~~

P4.4: Using a cue in problem solving: the role of verbal abilities. *Ekaterina Lapteva* & Ekaterina Valueva* (25)

P4.5: Randomized Trial of Brain Boost: Combined Program to Enhance Cognition and Motivation. *David Lee et al.* (29)

P5: Posters, generally about Intelligence and Various Life Outcomes

P5.1: Is ignorance bliss? *Magda Chmiel* et al.* (14)

P5.2: Problems in deriving Italian Regional Differences in Intelligence from 2009 PISA data. *David Giofrè* et al.* (20)

P5.3: Cognitive Abilities of Engineers and Computer Scientists. *Linda S. Houser-Marko & David H. Schroeder* (21)

P5.4: Intelligence as a Factor in Criminal Offender Risk Assessment. *Ross Jacobucci et al.* (22)

P5.5: Moderation of Cognitive—Achievement Relations for Children with Learning Disabilities. *Christopher R. Niileksela & Matthew R. Reynolds* (26)

P5.6: Suicide Rates of Italian Regions as a Function of IQ and Biological Variables. *Donald I. Templer* (33)

Reception and poster sessions will be held together in the River Terrace, Level P2.

All poster sessions will run concurrently.

International Society for Intelligence Research (ISIR) 2012 Program: Talks

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Thursday, December 13 (Day 1)

8:10 – 8:20 AM	**Opening Announcements** **Lifetime Achievement Award:** *Timothy Salthouse*
8:20 – 9:40 AM	**Symposium 1: Applying behavioural genetic methodology to educationally relevant questions (66)** Organizer: *Yulia Kovas*; Discussant: *Sergey Malykh*
8:20 – 8:40 AM	S1.1: Multivariate Genetic Analysis of Math Cognition in the Context of Psychometric Math and Reading Skills. *Stephen A. Petrill et al.* (67)
8:40 – 9:00 AM	S1.2: From Genetic Disorder to Normal Variation: Do genetic markers associated with numerical and spatial cognition in known genetic disorders play a role in normal variation in mathematical ability? *Maja Rodic* et al.* (68)
9:00 – 9:20 AM	S1.3: Heritability of literacy and numeracy is higher than that of g in the early school years. *Ivan Voronin* et al.* (69)
9:20 – 9:40 AM	S1.4: The myth of maths: is there anything 'special' about it? *Maria Grazia Tosto* et al.* (70)
9:40 – 10:10 AM	**Coffee Break**
10:10 – 11:10 AM	**T1: Talks, generally about heritability** Chair: *Yulia Kovas*
10:10 – 10:30 AM	T1.1: Explaining the Increasing Importance of Genetic Variation for Cognitive Development: A Meta-Analysis of Longitudinal Twin and Adoption Studies. *Daniel A. Briley* & Elliot M. Tucker-Drob* (38)
10:30 – 10:50 AM	T1.2: Does the Heritability of General Cognitive Ability Change in Late-Life? *Matt McGue & Kaare Christensen* (54)
10:50 – 11:10 AM	T1.3: Can Assortative Mating Account for Greater Genetic Variance in IQ with Higher SES? *Wendy Johnson et al.* (48)
11:10 – 12:10 AM	**T2: Talks, generally about genetic effects** Chair: *Yulia Kovas*
11:10 – 11:30 AM	T2.1: Molecular genetic and neuronal origins of intelligence differences: Association of cognitive abilities and the postsynaptic proteome of central excitatory synapses. *W. David Hill* et al.* (45)

Thursday - cont.

11:30 – 11:50 AM	T2.2: Generalist Genes and Intelligence. *Robert Plomin* (57)
11:50 – 12:10 AM	T2.3: Diabetes and intelligence? No, genes, intelligence, and, then, diabetes. *René Mõttus et al.* (55)
12:10 – 1:40 PM	**Lunch**
1:40 – 2:40 PM	**T3: Talks, generally about processing** Chair: *Buz Hunt*
1:40 – 2:00 PM	T3.1: Processing, Gs, and Mentalese: An Overarching Theory of the Mind. *Andreas Demetriou* (43)
2:00 – 2:20 PM	T3.2: Increase in Response Times with an Increase in the Number of Response Alternatives: What if the Information Theory-Based Model is a Misconception? *Yulia A. Dodonova & Yury S. Dodonov* (44)
2:20 – 2:40 PM	T3.3: The effects of cognitive training on psychometric intelligence. *Edward Necka et al.* (56)
2:40 – 4:00 PM	**T4: Talks, generally about structure and special abilities** Ch: *Hunt*
2:40 – 3:00 PM	T4.1: Testing CHC Theory: Conjoint Confirmatory Factor Analysis of Test Batteries Used in the WJ-III Validity Studies. *Nicholas Benson et al.* (37)
3:00 – 3:20 PM	T4.2: Non-g Residuals of the SAT and ACT Predict Specific Abilities. *Thomas Coyle et al.* (42)
3:20 – 3:40 PM	T4.3: Spatial Ability: Its Unique Contribution to Creativity and Technical Innovation. *Harrison J. Kell et al.* (50)
3:40 – 4:00 PM	T4.4: Evidence for a g Factor in Non-Human Primates. *Rosalind Arden et al.*(36)
4:00 – 4:30 PM	**Coffee Break**
4:30 – 5:30 PM	**Business Meeting**
5:30 – 6:30 PM	**Interview with recipient of Distinguished Contributor Award:** *Richard Haier*
6:30 – 8:30 PM	**Elsevier Reception and Posters (11-34)** River Terrace, Level P2

Friday, December 14 (Day 2)

7:00 – 8:20 AM	**Student breakfast with Lifetime Achievement Awardee Timothy Salthouse**
8:20 – 10:00 AM	**Symposium 2: Flynn Effect (71)** Organizer: *James Thompson*
8:20 – 8:40 AM	S2.1: Test-taking patterns have changed over time. *Olev Must & Aasa Must* (71)
8:40 – 9:00 AM	S2.2: Item-Level Examination of the Flynn Effect. *William Shiu et al.* (72)
9:00 – 9:20 AM	S2.3: Are international IQ gaps shrinking? Evidence from TIMSS and PISA. *Gerhard Meisenberg* (73)
9:20 – 9:40 AM	S2.4: Continuing rise of cognitive competence in US NAEP 1971-2008. *Heiner Rindermann & James Thompson* (74)
9:40 – 10:00 AM	S2.5: Assessing the impacts of historical changes in IQ: Dysgenesis vs. the Flynn effect. *Michael A. Woodley & Aurelio José Figueredo* (75)
10:00 – 10:30 AM	**Coffee Break**
10:30 – 11:30 AM	**T5: Talks, generally about group differences** Chair: *Wendy Johnson*
10:30 – 10:50 AM	T5.1: The Flynn Effect in the Right Tail of the U.S. as a Function of Sex, Race/Ethnicity, and SES. *Jonathan Wai et al.* (63)
10:50 – 11:10 AM	T5.2: Are concerns over female underachievement in science misplaced? A meta-analysis of data from PISA and TIMMS. *Paul Irwing* (47)
11:10 – 11:30 AM	T5.3: Gender Differences in Variability in Ability Factors Over Time. *David H. Schroeder* (62)
11:30 – 12:30 AM	**Holden Memorial Address on Science Writing:** *Dan Hurley* **(98) Reporting on the Science of Intelligence When Intelligent Scientists Disagree**
12:30 – 2:00 PM	**Lunch**
	Luncheon hosted by ISIR officers for Lifetime Achievement Awardee, Distinguished Contributions Awardee, Keynote Speaker, and Holden Science Writer

Friday – cont.

2:00 – 3:20 PM	**President's Symposium I: Brain Imaging and Intelligence (88)** Organizer: *Richard Haier*
2:00 – 2:20 PM	PS1.1: Brain-wide white matter tract integrity is associated with information processing speed and general intelligence. *Lars Penke* (89)
2:20 – 2:40 PM	PS1.2: A role for the brain network mechanisms of flexible cognitive control in human intelligence. *Michael W. Cole* (90)
2:40 – 3:00 PM	PS1.3: VBM-DTI Correlates of Verbal Intelligence: A Potential Link to Broca's Area. *Andreas Konrad et al.* (91)
3:00 – 3:20 PM	PS1.4: Functional Brain Network Efficiency Predicts Intelligence. *Nicolas Langer et al.* (92)
3:20 – 3:50PM	**Coffee Break**
3:50 – 5:30 PM	**T6: Talks, generally about imaging** Chair: *Sherif Karama*
3:50 – 4:10 PM	T6.1: Modeling the Effects of Brain Volumes on Cognition Using Parcelated Whole Brain MRI. *Keith F. Widaman et al.* (64)
4:10 – 4:30 PM	T6.2: Imaging-derived gray matter measurements of the cerebral cortex and intelligence: A latent variable analysis of the P-FIT model. *Kenia Martínez* et al.* (53)
4:30 – 4:50 PM	T6.3: Adaptive Working Memory Training Increases Integrity of the Corpus Callosum *Miguel Burgaleta et al.* (39)
4:50 – 5:10 PM	T6.4: Differentiation of Intelligence, Creativity, and Aptitude via Brain-Behavior Imaging. *Rex E. Jung et al.* (49)
5:10 – 5:30 PM	T6.5: Brain changes induced by a challenging cognitive training: Can science evoke phenocopies of superior intelligence? *Francisco J. Román* et al.* (61)
5:30 – 6:30 PM	**Keynote Speaker:** *Craig T. Ramey* **(97)** **Improving Intelligence, Academic Achievement, and the Life Course for Children from Low-Resource Families: the Abecedarian Approach**
7:00 – 9:00 PM	**Conference Banquet** Rosario's 910 Alamo St. (walking distance) 210-223-1806 http://www.rosariossa.com

Saturday, December 15 (Day 3)

8:00 – 9:20 AM	**Symposium 3: Manifold Inconstancy Effects in Life History and Intelligence (76)** Organizer: *Aurelio José Figueredo*
8:00 – 8:20 AM	S3.1: Multiple Successful Tests of the Strategic Differentiation-Integration (SD-IE) Hypothesis: A Life History Strategy Analogue to Spearman's Law of Diminishing Returns. *Aurelio José Figueredo et al.* (77)
8:20 – 8:40 AM	S3.2: Evidence For Two New Cognitive and Conative 'Manifold Inconstancy' Effects. *Rafael A. Garcia* et al.* (78)
8:40 – 9:00 AM	S3.3: Meliorism, General Intelligence, and Life History Strategy: 'Clever Silly' or 'Crazy Like a Fox'? *Tomás Cabeza De Baca* et al.* (79)
9:00 – 9:20 AM	Discussant: *Michael A. Woodley* (80)
9:20 – 10:20 AM	**T7: Talks, generally about measurement** Chair: *David Lubinski*
9:20 – 9:40 AM	T7.1: Development and Initial Validation of a Public-Domain Cognitive Ability Resource. *David M. Condon* & William Revelle* (41)
9:40 – 10:00 AM	T7.2: Some videogames and intelligence tests measure the general factor of intelligence (g): Further proof for Spearman's principle of the indifference of the indicator. *M. Angeles Quiroga et al.* (59)
10:00 – 10:20 AM	T7.3: Invariance of the ASVAB across Race/Ethnicity and Sex. *Justin A. Low et al.* (51)
10:20 – 10:50 AM	**Coffee Break**
10:50 – 12:30 AM	**Symposium 4: Improving intelligence (81)** Organizer: *Susanne Jaeggi & Roberto Colom*
10:50 – 11:10 AM	S4.1: When is intelligence improved? *Earl Hunt* (82)
11:10 – 11:30 AM	S4.2: Can intelligence be improved by adaptive working memory (n back) training? *Roberto Colom et al.* (83)
11:30 – 11:50 AM	S4.3: Improving Intelligence (or Any Cognitive Ability) May Require a Visuospatial Component. *Clayton Stephenson & Diane Halpern* (84)
11:50 – 12:10 AM	S4.4: Variations in Intelligence: Working Memory and Dopaminergic Modulation. *Louis Matzel et al.* (85)

Saturday – cont.

12:10 – 12:30 PM	S4.5: Improving intelligence: Recent past, present, and imminent future. *Susanne M. Jaeggi et al.* (86)
12:30 – 12:50 PM	S4.6: Intelligence and Cold Fusion. *Richard Haier* (87)
12:50 – 2:20 PM	**Lunch**
2:20 – 3:40 PM	**President's Symposium II: Brain Imaging and Intelligence (88)** Organizer: *Richard Haier*
2:20 – 2:40 PM	PS2.1: The salience network contributes to individual capacity of fluid reasoning. *Chunhui Yu et al.* (93)
2:40 – 3:00 PM	PS2.2: Common and Unique Neuro-Functional Basis of Psychometrically Validated Cognitive Components of Fluid Intelligence. *Aristide Saggino et al.* (94)
3:00 – 3:20 PM	PS2.3: Functional Connectivity between Parietal and Frontal Brain Regions and Intelligence in Young Children: The Generation R Study. *S.J.E. Langeslag et al.* (95)
3:20 – 3:40 PM	PS2.4: Sequence and speed of information flow among brain areas during problem solving in high and average intelligence individuals. *Richard J. Haier et al.* (96)
3:40 – 4:10 PM	**Coffee Break**
4:10 – 5:30 PM	**T8: Talks, generally about associations with other variables** Chair: *Tom Coyle*
4:10 – 4:30 PM	T8.1: Nonlinear associations between general intelligence and personality in Project Talent. *Jason T. Major* et al.* (52)
4:30 – 4:50 PM	T8.2: Breastfeeding causes long-term increases in intelligence: p-score analysis and breastfeeding as an explanation of the SES intelligence gap. *John Protzko** (58)
4:50 – 5:10 PM	T8.3: Education is associated with higher later-life IQ scores, but not with faster cognitive processing speed. *Stuart J. Ritchie* et al.* (60)
5:10 – 5:30 PM	T8.4: IQ and the Wealth of Nations: How Much Reverse Causality? *Gregory B. Christainsen* (40)
5:30 – 5:50 PM	**Announcement of John B. Carroll Student Award**

POSTERS

Abstracts are organized in alphabetical order

Names of students eligible for the John B. Caroll Award for Research Methodology are marked with an asterisk

Subcortical Morphology Correlates with Fluid and Spatial Intelligence but not with Crystallized Intelligence

Miguel Burgaleta[1,2,3,], Penny A. MacDonald[4], Kenia Martínez[2,3], Francisco J. Román[2,3], Juan Álvarez-Linera[3,5], Sherif Karama[4], and Roberto Colom[1,3]

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Neuroimaging studies have revealed relations between intelligence and brain morphology. However, researchers have focused primarily on the anatomical features of the cerebral cortex, whereas subcortical structures, such as the basal ganglia (BG), have often been neglected despite extensive functional evidence on their relation with higher-order cognition. Indeed, to date only a few studies of morphologyhave shown correlations between BG volume and intelligence, with inconsistent results. However, basal ganglia are complex structures with functionally specialized regions, hence justifying the examination oftheir morphology at the regional level. In the present study

we applied a recently developed technique, the Bayesian Appearance Model (Patenaude et al., 2011), to understand how individual differences in BG local morphology account for variability in cognitive performance. Structural MRI was acquired in 102 normal subjects (44 men, 58 women, mean age = 19.83, SD = 1.64), and the outer surface of striatal structures (caudate, accumbens, and putamen), globus pallidus, and thalamus was estimated for each subject and hemisphere. Further, nine cognitive tests were used to measure fluid (Gf), crystallized (Gc), and spatial intelligence (Gv). Latent scores for these factors were computed and regressed against vertex-wise subcortical shape (local displacements of vertex position), controlling for age, sex, and total brain volume.After correction for multiple comparisons (FDR < 0.05), significant results were found for Gf and Gv, but not Gc, in subcortical structures of the right hemisphere. Specifically, the shape of ventral and anterolateral regions of right striatal sub-structures wasrelated to both Gf and Gv, whereas morphology of the right dorsolateral thalamus correlated with Gv only. Importantly, detected striatal areas are anatomical and functionally connected to the right dorsolateral prefrontal cortex and other intelligence-related prefrontal areas.Reported thalamic segments are likely responsible for integrating frontal and parietal information. Therefore, the notion that the basal ganglia play a relevant role in human intelligence is strongly supported.

Reference

Patenaude B, Smith SM, Kennedy DN, Jenkinson M (2011) A Bayesian model of shape and appearance for subcortical brain segmentation. *NeuroImage*, 56:907–922.

Are We Really Overfactoring Modern Cognitive Tests? Further Test of a Hypothesis via Plausible Simulated Data

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In 2007, Frazier and Youngstrom showed that there has been an increase in the number of factors extracted from newer individual tests of cognitive ability compared to previous versions of such tests. They argued that two methods for determining the number of factors using principal components analysis—Horn's parallel analysis (HPA) and Minimum Average Partial analysis (MAP)—produced more accurate estimates of the correct number of factors. When they reanalyzed modern intelligence tests using these criteria, they found a maximum of three factors per test (and generally 1-2), even though these tests purportedly measure 4-7 factors. They concluded that test publishers and others are "overfactoring" tests, and that they do not, in fact, measure as many abilities as intended. Frazier and Youngstrom concluded by arguing for briefer assessments of general intellectual ability or an increase in test length if the test is to measure additional cognitive factors.

At the 2010 ISIR conference, Keith and Reynolds reported the results of factor analyses of simulated data analysis using the HPA procedure. Data were simulated to conform to research on some of these same tests, with 16-20 tests measuring 5-8 factors. HPA results were compared to results from CFA and EFA using a variety of criteria for determining the number of factors to extract. Results suggested that CFA accurately recovered the correct factor structure, and that resulting structure fit better than other structures. In contrast, HPA repeatedly underestimated the correct number of factors and recovered only two factors across four different simulated data sets.

The purpose of this poster is to expand this research to the MAP procedure. The same five simulated datasets analyzed by Keith and Reynolds were analyzed using principal components analysis and the MAP procedure. Preliminary findings suggest that MAP also consistently underfactored these plausible simulated data, that is, that the procedure suggested fewer factors than were known to exist in the data. This finding is important because researchers continue to cite the Frazier & Youngstrom article as evidence that modern tests are being "overfactored." Our findings support the conclusion that modern tests are not being "overfactored," and may discourage the use of methods such as HPA and MAP to recover the correct number of factors in modern cognitive ability tests.

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Is Ignorance Bliss?

How Educational Attainment and Achieved Socioeconomic Status Mediate the Relations between Childhood Intelligence and Different Components of Subjective Well Being in Middle Adulthood

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Childhood intelligence has been shown to relate differently to individual components of adulthood subjective well being (SWB). Moreover, educational attainment and achieved socioeconomic status (SES) have also been shown to relate to both childhood intelligence and adulthood SWB. Thus, the present study investigates the possibility that educational attainment and SES mediate the relations between childhood intelligence and individual SWB components (life satisfaction, 8 domain satisfactions, positive and negative affect) in adulthood.

Data were obtained from a representative longitudinal study called MAGRIP, encompassing two waves of measurement over 40 years (N = 738, M = 51.8 years, SD = 6.6 months; 47.0% male).

The results of structural equation models showed that as the direct impact of childhood IQ was different for different SWB components, so were the mediation paths via educational attainment and achieved SES.

Specifically, one of the SWB components was not mediated at all (negative affect), while others were mediated completely (ex., health, free-time). Yet, for others the indirect impact of childhood IQ was larger than the direct one (ex. life satisfaction, family, work), or the strength of the direct effect of childhood IQ remained despite the existence of a quite substantial mediating effect (ex. positive affect, finance, housing or self)

The direct impact of educational attainment on adulthood SWB also varied between individual SWB components - form weak positive (ex. positive affect), through negligible (ex. health), to quite large negative effect (ex. self, housing, people or family).

Various possible explanations and implications for further research are discussed.

Estimating Split-Half Reliabilities of Response-Time Measures and Their Confidence Intervals

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When chronometric assessments of cognitive functioning are conducted in one wave of testing and therefore no test-retest data are available to a researcher, the only estimate of reliability of a response-time measure that is commonly reported is a split-half reliability. This estimate is obtained by splitting response times on all trials in a given speeded task into halves (e.g., by separating odd and even trials). A measure of performance, which can be an average response time, intraindividual variability in response times, or any sophisticated index such as the slope of response-time function over conditions, is obtained for each half of the trials and a computed correlation between the respective measures for two halves is examined.

However, an obvious limitation of this straightforward approach to estimating split-half reliabilities is that splitting the trials into halves is essentially arbitrary. Thus, different estimates of split-half reliability can be obtained for the same response-time data, depending on how the trials were divided. This, in turn, likely affects further analysis, as estimates of reliability are used directly to obtain disattenuated correlations between the response-time measures and other variables of interest.

In this poster presentation, we show how a more precise point estimate of split-half reliability for a response-time measure can be obtained. The proposed algorithm involves multiple repetitions of the entire procedure for computing the split-half reliability, using a different method of dividing the trials into halves for each repetition. As a result, a distribution of split-half reliability coefficients is obtained. Thus, a point estimate of the split-half reliability is characterized by location of the obtained distribution; the percentile-based confidence interval on this point-estimate can be computed by identifying n-percent limits of the obtained distribution.

We show empirical examples of the distributions of split-half reliability coefficients obtained for various speeded tasks with different numbers of trials and difficulty levels. We also provide an R code for performing the analysis described in this presentation.

Decomposing Response-Time Variance: Component Scores Revisited

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Since the 1970s, decomposing the variance of response times into a number of theoretically tractable components and analyzing individual differences in the component scores rather than in average response times seemed to be a promising analytical approach, the one that could bridge the gap between cognitive and differential psychology and advance studies on individual differences in information processing. However, methods used for estimating component scores were quite crude and time-consuming, it is claimed that component scores themselves had only low reliable variance, and findings concerning their associations with other variables such as cognitive ability scores are contradictory. Largely due to several commonly admitted methodological concerns and inconsistent results accumulated in the field, this research tradition has received scant attention over the last decade.

In this talk, we revisit the issue of response-time component scores. We base our arguments on the analysis of response-time data obtained from different cognitive tasks, including those requiring enumeration, mental rotation, rearranging letters, comparing meaningless figures, and discriminating shapes and colors.

First, we show that modern statistical methods have much to offer when analyzing response times and decomposing their variance. Possible advancements in analytical techniques start with using robust measures in calculating response times for each experimental condition (or difficulty level) instead of an arithmetic mean or median. Next, change in response time over conditions can be analyzed within structural equation modeling framework instead of subtraction-based or regression analyses, a step that allows for estimating component scores and their associations with external variables at the latent level. Finally, advanced modeling techniques place no limitations on the shape of a function that relates response times to experimental conditions; nonlinear structured latent curve modeling can help to estimate even those individual parameters of response-time change over conditions that enter the model nonlinearly. This also means that any prior data transformations (such as semi-log and log transformations) that served solely to achieve linearity are no longer required.

Applying modern methods to the data obtained from different tasks, we revise the assertion that the components describing change in response time over conditions have low reliability and only explain residual individual difference variation, a claim first explicated by Lohman (1994) and commonly referred to thereafter. In addition, we analyze the associations between response-time components derived from different cognitive tasks and cognitive ability measures. The comparative power of these components in predicting ability scores differs across tasks, with the components that describe response-time change over conditions (slopes) frequently being better predictors of cognitive ability than the components representing constancy over conditions (intercepts). We therefore argue that another widely accepted belief — that response-time intercepts produce higher correlations with cognitive ability scores than slopes do — arising mainly from studies employing Hick's and mental rotation tasks, by no means applies to the entire variability of cognitive tasks.

Age Changes in *Gf* and *Gc* when Similar, Verbal Tasks are Used to Measure each Construct

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An ongoing theoretical question is whether intelligence is best conceived of as a general (*g*) factor or as two kinds of intelligence; fluid (G*f*) and crystallized (G*c*) The fact that fluid intelligence peaks at an earlier age and later declines at an earlier age than does crystallized intelligence has been taken as confirmation that *Gf* and *Gc* are separable entities. However, measures of fluid intelligence and crystallized intelligence are typically based on very different sorts of tests. In a cross-sectional study involving 1500 participants ranging from 18 to 80 years of age, measures of the ability to acquire new verbal information (as measures of *Gf*) and measures of extant verbal knowledge (as measures of *Gc*) were based on similar verbal tasks. The ability to acquire new verbal information (*Gf*) declined with age while extant of verbal knowledge (*Gc*) increased with age. Thus, task differences in kind as causes of the differential form of changes over age with regard to fluid and crystallized intelligence appear unlikely. A related theoretical concern is how best to determine the stability of the general or *g* factor of intelligence over age given declines over age in *Gf* and increases or stability over age in *Gc.* To see if the relation between new learning ability and extant knowledge remained the same for younger participants as well as for older participants, the correlation between new learning ability and extant knowledge for the participants between the ages of 18 and 38 years was compared to that same relationship for participants between the ages of 39 and 70 years. While, as noted, new learning ability declined with age and knowledge increased with age, the correlations between new learning ability and knowledge acquired to that age were of the same magnitude for each age group.

How Well Do the ASVAB and AFQT Measure g and Broad Abilities?

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Within the last ten years, there have been over fifteen (15) articles published in the journal Intelligence using the AFQT (Armed Forces Qualification Test) or the ASVAB (Armed Services Vocational Aptitude Battery) as a measure of *g*. The AFQT is a composite score derived from the ASVAB (Herrnstein & Murray, 1994). Although the AFQT scores may represent a psychometrically sound test of IQ as it is highly correlated with *g* (Herrnstein & Murray, 1994), factor analyses have revealed that the AFQT measures a limited range of lower-order broad abilities. Further research, examining the factor structure of the ASVAB, has been conducted by Carroll (1993); Roberts, Goff, Anjoul, Kyllonen, Pallier, & Stankov (2000); and Wothke, Bock, Curran, Fairbank, Augustin, Gillet & Geurrero, (1991).

Wothke et al (1991) administered the full ASVAB in addition to forty-six additional tests chosen from the ETS Kit of Factor-Referenced Cognitive Tests (the Kit). From the ASVAB they extracted three factors: school attainment, speed, and technical knowledge. When Wothke et al (1991) conducted an exploratory factor solution for the ten ASVAB and forty-six Kit tests, the results suggested the four subtests used in the AFQT loaded only on a verbal memory factor.

Roberts et al (2000) also examined the factorial composition of the ASVAB within the context of the Gf-Gc theory and the three-stratum theory of intelligence. The authors concluded that only the paragraph completion test could be considered a stratum II test, loading onto two CHC domains: predominantly Gc and some Gs. The remaining three subtests loaded onto CHC stratum I domains. Roberts et al (2002) concluded that the ASVAB subtests of Math Knowledge and Arithmetic Reasoning are measures of RQ (quantitative reasoning, which in turn is a measure of Gf); Carroll's (1993) factor re-analysis of the ASVAB subtests revealed a RQ factor and a KM (Knowledge of Mathematics- a stratum I ability) factor which in turn is a measure of Gq (Quantitative Knowledge- stratum II).

Despite these various analyses, it is still not clear what is measured by the ASVAB tests. Because the ASVAB and the AFQT are still used as a measure of *g* in research, this research will reanalyze the classic dataset used by Carroll (1993), Roberts et al (2001) and Wothke et al (1991). Using structural equation modeling we will examine how well the ASVAB measures general intelligence; which broad abilities are measured by the ASVAB; and which subtest do the best job of measuring both *g* and the broad abilities.

Ability to Use Peripherally Presented Cues in Problem Solving as a Component of Crystallized Intelligence

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In the CHC framework of intelligence research crystallized intelligence is defined as "a person's breadth and depth of acquired knowledge of the language, verbal information and concepts of a specific culture, and the application of this knowledge" (McGrew, 2009). As a tradition various verbal tests of reasoning and knowledge are usually used to operationalize this construct.

However, some recent studies found significant interaction between verbal abilities and effectiveness of implicit learning (Kaufman et al., 2010), and significant influence of verbal intelligence on usage of peripheral stimuli in problem solving (Gavrilova, Ushakov, 2010). Thus correlations between general intellectual abilities and abilities to process information presented peripherally need to be further examined. The present study was conducted taking the above mentioned aim into account.

In our study we aimed at constructing a confirmatory model of intellectual abilities to analyze their relations to the ability to use peripheral information in cognitive task solving. The sample consisted of 139 students (mean age was 15, SD = 0.5). Abstract, spatial and verbal abilities were measured by a number of specially constructed psychometric instruments. Two independent measures of ability to use peripheral information were constructed.

The hierarchical confirmatory factor analysis was applied. A three factor model of general abilities was confirmed with a G-factor on top and two first-order factors. The abstract and spatial intelligence subtests formed a first-order factor of fluid intelligence, while two verbal intelligence subtests formed another first-order factor of crystallized intelligence. A significant loading of crystallized intelligence factors on two manifest variables represented by usage of peripheral stimuli (β = .64, p = 0.00 – for the first variable; β = .38, and p = .05 – for the second) were revealed. The model showed a good fit to empirical data (Bollen-Stine bootstrap = .70; χ^2 = 6,045; p = .642; GFI = .986; AGFI = .963; CFI = 1,000; RMSEA = .000).

The results of our study reveal that the ability to use peripheral information in problem solving forms a part of the structure of crystallized intelligence. We discuss our findings in terms of the present theories of cognitive abilities.

Problems in deriving Italian Regional Differences in Intelligence from 2009 PISA data

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Even though cognitive ability and academic achievement are distinct constructs and specific cognitive factors are important to explain specific aspects of achievement, it is unquestionable that measures of reading comprehension and mathematical achievement offer good approximations of the individual's intelligence levels. Recent results of international assessment programs (e.g., PISA) have shown a large difference in high school students' performance between northern and southern Italy. On this basis, it has been argued that the discrepancy reflects differences in average intelligence of the inhabitants of regions and is associated with genetic factors (Lynn, 2010a; 2012). This paper provides evidence in contrast of this conclusion by arguing that the use of PISA data to make inferences about regional differences in intelligence is questionable, and in any case, both PISA and other recent surveys on achievement of North and South Italy students offer some results that do not support Lynn's conclusions. In particular, a 2006-2009 PISA data comparison shows a relevant decrease in the North-South difference in only three years, particularly evident in the case of a single region (Apulia), that cannot accounted by the Lynn's theory. Furthermore, other large surveys (including INVALSI-2011) offer different results and age differences suggest that schooling could have an important role.

Cognitive Abilities of Engineers and Computer Scientists

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There is currently much interest in the Science, Technology, Engineering, and Mathematics (STEM) fields and the educational systems needed to support growth for young people in those fields. There is expected to be an unmet demand for workers in the technology and engineering fields in the U.S. in the near future (President's Council of Advisors on Science and Technology, 2012). We took a closer look at the abilities of people working in the fields of engineering and computer science/information technology to better understand the cognitive characteristics of these people.

We compared scores on several measures of cognitive abilities for adults working in engineering, computer science versusother employed adults, and for males versus females in these fields. We expected that people working in engineering and computer science would be similar to each other, but would have greater spatial and numerical abilities compared to adults in general. We had no particular hypothesis about gender within the fields of engineering or computer science.

Participants were a sample of clients of the Johnson O'Connor Research Foundation, who took a testing battery to gain information about their abilities that they might use in making academic and occupational decisions. We selected college graduates between the ages of 23 and 65 who had worked in their current occupation for at least 3 years. There were 13,598 participants in our database from 1988 to 2010 who fit these specifications (mean age was 40 years old). We categorized the participants by occupation, using the Dictionary of Occupational Titles coding system. There were 1,082 adults from our sample who were working in engineering (28% female) or computer science/ information technology (41% female).

We focused on numerical ability, spatial ability, verbal-associative memory, and vocabulary. First, we compared thetechnical occupations and other working adults, as well as by sex. In a 3 x 2 ANOVA, there was a differential pattern in which female engineers and both male and female computer scientists had the highest numerical ability compared to male engineers and other adults in general.

Engineerswere higher in spatial abilitycompared to computer scientists and other adults, andthere was also a main effect that males in generalwere higher than females in spatial ability.On the other hand, computer scientists were higher in verbal-associative memorycompared to the other occupations, and females were higher than malesin general for verbal-associative memory. Computer scientists in general were slightly higher in vocabulary compared to the other occupations.

We found similar results in logistic regression models that considered all of the abilities together as they were associated with category membership in each field and sex versus all others. These models help to conceptualize the abilities as a set for individuals in each field. The importance of numerical ability for females in both engineering and computer science is notable. Further, the differences between engineering and computer science, in particular in spatial and verbal-associative memory is informative for those interested in the fields. Future research should consider cognitive abilities as well as unique features of each field, in light of these findings.

Intelligence as a Factor in Criminal Offender Risk Assessment

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The purpose of the study was to determine the role of intelligence in predicting the number of violent or non-violent crimes, and compare its relationship with other measures commonly used in prison. Archival data analysis was conducted at a medical and classification center and prison in Iowa. As expected, significant differences existed between groups of ethnicity, with White/Caucasian scoring the highest(small number Asian Americans in the sample). Scores on the Beta-III showed a negative relationship with number of crimes, both non-violent and violent, along with symptoms of mental illness. Violent offenders had lower IQ scores than non-violent offenders. Consistent with current research (White & Batty, 2012), intelligence was positively correlated with number of substance abuse charges. Compared to achievement test scores, IQ scores added little unique variance in the prediction of risk for recidivism.In conclusion, IQ was shown to differ significantly in offender groups and among ethnic groups. Achievement test scores proved to be a better predictor for risk of recidivism, while IQ showed a non-significant relationship. This study has implications for the use of IQ scores in offender settings, specifically informing its clinical utility.

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Subcortical Correlates of Aptitude

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Numerous studies now exist, designed to articulate particular brain-behavior relationships, using such techniques as functional magnetic resonance imaging (fMRI), structural magnetic resonance imaging (sMRI), and Diffusion Tensor Imaging (DTI). The vast majority of these studies focus on the cortical gray matter (i.e., cell bodies-dendrites volume) and underlying white matter connectivity (i.e., axon-myelin integrity) predictive of standard cognitive measures including intelligence, working memory, and attention. While these measures are of keen interest to the cognitive neurosciences, the study of individual differences is broader, focusing on more diverse measures of human ability, including measures of aptitude (Haier et al., 2010), personality (Ryman et al., 2011), and even creativity (Arden et al., 2010). Similarly, the contribution of subcortical gray (e.g., caudate, putamen, globuspallidus) and white matter hubs (e.g., corpus callosum) is vastly understudied as compared to cortical studies. We sought to measure aptitude abilities in a human sample, with the purpose of linking such measures to subcortical volumetric measures in an exploratory manner. The sample consisted of 26 young subjects (age range 16 – 20, mean = 18.6 +/-1.4; 13 male), all of whom were scanned with a 3 Tesla scanner, obtaining MPRAGE structural images. Behavioral measures included Wechsler Abbreviated Scale of Intelligence (WASI), andJohnson O'Connor Foundation measures of a wide range of aptitudes– Vocabulary, Word Association, Ideaphoria, Paper Folding, Foresight, Inductive Reasoning. Subcortical volumes were extracted, in an automated manner, with FreeSurfer (Fischl et al., 2002). Subcortialvolumes extracted included bilateral volumes of: caudate, putamen, globuspallidus, nucleasaccumbens, thalamus, hippocampus, amygdala, and 5 segments of the corpus callosum (genu, anterior midbody, midbody, isthmus, splenium). Multiple regression was used, controlling for sex and Full Scale Intelligence Quotient, with all volume measures entered, in a stepwise manner, to predict each of the aptitude measures. We found that higher right putamen volume predicted Word Association ($F=2.6$, $p=.015$, $r2=.25$); lower left nucleus accumbens predicted Ideaphoria ($F=6.9$, $p=.002$, $r2=.48$), and higher isthmus of the corpus callosum volume predicted Paper Folding ($F=17.9$, $p<.001$, $r2=.71$). The current results are consistent with previous studies showing inverse relationships between measures of creative cognition and both measures of cortical thickness (Jung et al., 20010a) and white matter integrity (Jung et al., 2010b), as well as studies showing positive relationships between isthmus integrity and measures of intelligence (Luders et al., 2007). As the nucleus accumbens is a major GABA pathway associated with the experience of pleasure and reward, the inverse relationship between the size of this structure and measures of creative cognition would support a model of disinhibitory networks underlying creative drive.

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Different Sources of Timing Variability and How They Are Related to Intelligence

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Negative relation has been reported betweenpsychometric intelligence and timing variability in a simple motor timing task. What is the nature of this relation? Do these correlations reflect top–down mechanisms, such as attention, or bottom–up mechanisms, such as basic neural properties?

Here, we provide a summary of the correlation results between intelligence (Raven SPM Plus) and performance in isochronous serial interval production task (ISIP) for two different variability components; Local variability (between neighboring intervals) and Drift variability (fluctuation across multiple intervals).Local and Drift might be variably associated with intelligence since they represent two different components which are dissociated in a number of different accounts. Specifically local appears to be related to bottom up mechanisms and be controlled by automatic processes whereas drift appears to be related to top down mechanisms.

ISIP is a simple timing task which consists of first synchronizing movements with an isochronous sequence of sounds to induce the desired interval, and then to continue those movements to produce intervals without an external pacing signal. The nature of the ISIP task makes it possible to distinguish the contribution of the different variability component in the relation between intelligence andtemporal variability.

We have found that Local variability is correlated more strongly with intelligence than Drift variability and that was the case for all the different IOIs (inter-onset-intervals), with the highest correlations found between 400 and 900 ms.These results suggest that intelligence-timing variability relations may be two-fold. First, the correlation between psychometric intelligence and Local variability involves bottom-up processes concerning timing, such as random neural noise.On the other hand, the relation between psychometric intelligence and Driftvariability reflects top-down functions such as short-term memory and attentional resources.

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Using a Cue in Problem Solving: The Role of Verbal Abilities

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Studies of using a cue go back to the K. Dunker and N. Maier experiments where cue acquisition led to better problem solving. Most studies of using cues in problem solving focus on such issues as similarity of a task and a cue, type of processes required for task solving and cue encoding etc. Relatively few studies have dealt with individual differences in sensitivity to cues, most merely investigate the role of creativity in the peripherical information processing. The trouble with these studies is the verbal nature of the tasks & cues used and the verbal creativity test as well (Remote Associations Test). The question is: whether there is a universal ability related to a cue sensitivity or it is modality-dependent? What kind of ability should it be?

We ran two experiments with a varying main task: verbal (to compose words using letters of a 12-letter word) and non-verbal (to complete circles into pictures). Both experiments had the same design: the main task -> incubation -> continue with the main task. The incubation task was to identify the wrong stimulus (distorted word or rotated picture) of the two on the screen. The experimental group (EG) received cues among incubation stimuli. EG1 received verbal cues and EG2 received picture cues. In addition, participants completed verbal intelligence tests (Amthauer's IST verbal subscale and RAT) and creativity tests (the Alternate Uses Test and Test for Creative Thinking – Drawing production). The mean z-score was computed for both ability groups.

In both experiments cues were processed in a different way than the neutral stimuli in the incubation task. For the verbal main task picture cues were processed slower than neutral pictures and verbal intelligence positively correlated with RT for picture cues ($r=0.54^{**}$, controlled for general speed). For the non-verbal main task both types of cues exhibited longer RT. Efficiency was higher for verbal cues in the verbal main task and didn't differ in the non-verbal main task. Verbal intelligence correlated positively with the efficiency of picture cues ($r=0.28^{*}$) in the verbal main task (nothing with verbal cues). In non-verbal main task the joined cue efficiency correlated positively with verbal intelligence ($r=0.26^{*}$).

Summarizing the given results, verbal abilities were related to the efficiency of cues used when processing of non-verbal material was required: non-verbal cues in the verbal task, and cues together in the non-verbal task. It is suggested that verbal intelligence facilitates the acquisition of the stimulus meaning (or special traits), and thus, its encoding to a unitary (appearingly semantic) network. Therefore high verbal abilities provide multi-sided stimulus encoding with abundant bindings between encoded elements. Hence the retrieval of the required elements is facilitated. Verbal abilities are considered as a measure of crystallized intelligence which is responsible for organizing knowledge structures. Thus verbal abilities may claim to be the universal mechanism, underlying the cue usage by the forming-up the organized knowledge network.

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Moderation of Cognitive—Achievement Relations for Children with Learning Disabilities

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Introduction: Research on cognitive—achievement relations has been used to better understand howdifferent cognitive abilities are related to academic skill development (McGrew &Wendling, 2010). This knowledge has also been used to help understand how cognitive abilities may be related to different types of specific learning disabilities (SLDs, Flanagan, Fiorello, & Ortiz, 2010). Most of the research on cognitive—achievement relations has been conducted with normally developing youth. The question of whether children with SLDs show similarities or differences in cognitive—achievement relations has not been extensively investigated. The purpose of this study was to investigate similarities and differences incognitive—achievement relations for children with and without SLDs.

Method: Participants for this study were obtained from the Woodcock-Munoz Foundation using data from the Woodcock-Johnson—Third Edition (WJ-III; Woodcock, McGrew, & Mather, 2007). The clinical sample included children and adolescents with SLD in reading (n = 181), SLD in math (n = 231), and SLD in writing(n = 149). Multi-group structural equation modeling (MG-SEM) was used to examine similarities and differences in cognitive—achievement relations. A three-stratum model that included *g*, broad, and narrow cognitive abilities based on Cattell-Horn-Carroll (CHC) theory was used in the analysis. The relations between the broad and narrow cognitive abilities and Basic Reading Skills, Reading Comprehension, Math Calculation Skills, Applied Math, and Written Expression were investigated.

Results: Results indicated that SLD group membership moderated some cognitive—achievement relations for each academic skill area:

1. *Basic Reading Skills (BRS):* BRS was by Knowledge (K0), Short-term Memory (Gsm), and Quantitative Reasoning (RQ) for all groups. For individuals with SLD in reading, Perceptual Speed (PS) was also an important predictor of BRS.
2. *Reading Comprehension (RC):*RC was predicted by K0 and RQ for all groups, although the relation between RQ and RC was stronger for individuals with SLD in reading.
3. *Math Calculation Skills (MCS):*MCS performance was predicted by PS and Gsm in all groups, and RQ predicted MCS for all groups except those with SLD in math.
4. *Applied Math (AM):*RQ and K0 predicted AM performance for all groups. Visualization (VZ) also predicted AM performance, but only for individuals with SLD in math and SLD in writing.
5. *Written Expression (WE):*WE was predicted by Gc, RQ, VZ, Memory Span (MS), and Rapid Naming (RN). The only difference between groups was those with SLD in math relied slightly more on Gc.

Conclusion: The results suggest that SLD group membership moderated the relations between cognitive abilities and academic skills. There were some similarities in cognitive—achievement relations among groups, but there were also several differences that suggested that children and adolescents with SLDs may utilize different processes to compensate for difficulties in academic skills.

The Relationship between Visual Inspection Time and Learning for both Implicit and Explicit Conditions

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The goal of this study was to investigate a relationship between mental speed and learning. Previous research has found that while working memory capacity assessments are predictive of performance on serial reaction time tasks that involved learning for location, this relationship was found only for explicit learning conditions, in which participants are aware that a serial pattern has been repeated, and not on implicit conditions (Unsworth & Engle, 2005). The current research endeavor was aimed to further investigate factors that predict learning by investigating the role of mental speed, measured by visual inspection time tasks. Unlike working memory capacity, we hypothesized that perhaps mental speed may be important in both types of learning, with individuals capable of accurately processing very briefly presented information being better at noticing and identifying visual patterns in a serial location learning task, even when not expecting that a pattern is present. Three types of computerized visual inspection time tasks were administered: speeded letter detection, identification, and simultaneous discrimination tasks. Each speed measure varied presentation duration of letters in blocks (80, 50, 30, 20, & 10ms). For the serial location learning task participants pressed a computer key corresponding to one of 4 locations on the screen as soon as an "*" appeared in that location (Frensch & Miner, 1995). For the implicit condition, which was administered first, participants were not informed of a pattern of locations that were repeated in the middle of the task. To assess learning of the pattern, participants were asked to identify the pattern of locations that repeated. In the explicit condition, participants were informed prior to performance that the task would include a repeating pattern, and again, learning was assessed by participants' ability to identify the pattern. Reaction times were also recorded to assess learning by decrease in time for repeated patterns of locations. Results revealed that that those who could identify a pattern on the implicit version of the task performed better on all 3 mental speed tasks, whereas being able to identify the correct pattern on the explicit version is only associated with one type of speed: discrimination. Thus, faster processing may be associated with a higher likelihood of becoming aware of patterns under learning conditions in which one is not expecting a pattern present prior to performance.

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Divergent Productions of Metaphors: Combining Rasch Many Facet Modeling and Cognitive Psychology in the Assessment of Creativity

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It is presented a new method for the assessment of creativity by asking people to produce metaphors like "The camel is the boat of the desert". In the original items the underlined word is left blank and subjects are asked to produce novel metaphors (up to four for each item). This implies the execution of basic cognitive processes, like analogical reasoning and remote associations, which are linked to the creativity. Based on these principles we developed the Metaphors Creation Test (MCT) supported on the assumption that divergent production of metaphors can be used in the assessment of creative potential. A database of 975 persons that gave 12418 ideas to nine items was analyzed. Two to ten raters scored the quality of each metaphor on a 4-point scale. Raters were counterbalanced in a judge-linking-network to permit equating of different "test forms" implied in combinations of raters. A Many-facet-Rasch rating scale model was applied to estimate subjects scores, item difficulty and severity of judges. The general questions that this paper addresses are: How reliable is this measure as compared to other subjective scoring methods that have been recently proposed? How much is the correlation of this quality measure of metaphors with fluency? How is this new measure correlated with intelligence and other traditional measures of creativity? In answering this question this study employs the Many-Facet Rasch model with these types of assessments investigating its utility in solving the problem of equating judges. The purpose of this study was to test the reliability and validity of this new method to assess creativity and to explore the application of the Many-Facet Rasch model in research on creativity that uses subjective scoring of divergent thinking tasks.

Randomized Trial of Brain Boost: Combined Program to Enhance Cognition and Motivation

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Presented is the initial randomized trial of a program to enhance cognition and motivation, Brain Boost. Brain Boost was offered after school for 10 weeks to 4th through 8th graders at two diverse Southern California schools. Control students received an after-school homework help program for the same 10 weeks. Sixty-nine students participated in the trial, 34 in treatment, 35 in control. By training working memory, reasoning, vocabulary, and motivation (growth mindset) concurrently, it was thought that Brain Boost would produce strong, transferable effects. Positive effects were seen for working memory (d=.69) in elementary students and mindset (d=.80) and English/Language Arts achievement test scores (d=.88) in middle school students. Positive trends were found for all other measured variables save academic self-efficacy in elementary students—receipt of homework help increased academic self-efficacy. Results have implications for enhancement and transferability of cognitive and non-cognitive skills.

Co-Variation of Abilities across Diverse Tests of Attention

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Working memory is a cognitive system comprised of two principal components: storage and processing. The processing component of working memory (in part comprised of selective attention) is responsible for maintaining/updating relevant information under conditions of interference, and is believed to be a critical determinant of general intelligence. In previous studies, we found that as much as 48% of mice's performance across diverse test of learning and reasoning is explained by a single factor, and in this respect is analogous to human general intelligence. Furthermore, mice's performance on an analog of the human Stroop Test correlated highly with the animals' general cognitive performance. However, single tests of attention tend to ignore aspects of this process that are shared across diverse situations. To address this issue, we assessed the performance of 26 outbred CD-1 mice across four different tests of attention: a mouse Stroop Test, t-maze reversal, coupled latent inhibition, and a dual radial-arm maze. These tests involved unique combinations of non-attentional variables, such as learning, navigation, retrieval, and emotional reaction, as well as attentional variables, such as the degree of working memory's processing vs. storage, and the source of interference (internal or external). Using an exploratory factor analysis, we found that 46% of performance across tasks was accounted for by a single factor, i.e., general attention. The mouse Stroop Test and the dual radial-arm maze task were the most powerful predictors of general attention (loads < 0.80). Since the former is a relatively process-pure test of attention while the latter taxes both attention and storage, this suggests that both components of working memory were correlated, in agreement with the evidence that storage and processing usually overlap. Also, both of these tasks had external distractors as their main source of interference. In comparison, the T-maze reversal and the coupled latent inhibition (loads of 0.67 and 0.07 in general attention, respectively) loaded strongly on a second factor of a varimax rotation, and both required attention against exclusively internal sources of interference. Therefore, mice's attentional performance might have differed across tests due to the source of interference (internal vs. external). In conclusion, our results can aid in understanding the different requirements of attentional processes, and may aid in efforts to create standardized measurements of general attention. Overall, the present work contributes toward future research exploring the relationship of attention and general intelligence.

Learning in Completing Items of Noncognitive Measures as Predictor of Fluid Intelligence

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Recent advancements in the statistical investigation of the items of reasoning measures led to the identification of learning as a source of the position effect (Embretson, 1991; Ren, Goldhammer, Moosbrugger, & Schweizer, 2012; Verguts & De Boeck, 2000). Since the position effect has not only been observed in cognitive but also in personality measures, there is the question whether learning can also be identified as source of the position effect in noncognitive measures. Furthermore, if learning is actually the source of such an effect, the corresponding indicator should correlate with measures of intelligence. In order to investigate this research question, in a sample of 275 high school students items representing achievement motivation, anxiety and self-efficacy were investigated by means of fixed-links models. These models enable the identification of effects characterized by either an increase in the consistency of responding or the contrary, a decrease in consistency. An increase is regarded as a position effect due to learning. The corresponding part of the model is addressed as learning component. The investigation revealed a substantial learning component in the anxiety items. As expected, the learning component showed a substantial correlation with fluid intelligence. Furthermore, there were contributions to the prediction of fluid intelligence by the purified components representing achievement motivation, anxiety and self-efficacy.

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The Dimensionality of Raven's Advanced Progressive Matrices and Its Relation to Deductive and Inductive Ability

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The proposed taxonomies of the Raven´s Advanced Progressive Matrices test (APM; Raven, 1962) vary in the number and the nature of the extracted factors (Vigneau & Bors, 2008). Some studies tried to define the factor structure of the test using factor analyses (exploratory or confirmatory); others applied cognitive methodologies to induce the rules required for the solution of the test items and others utilized the Rasch model. More recently, some investigators (Schweizer, Schreiner, & Gold, 2009) have proposed a two-dimensional structure including an ability-specific and a position-specific components. The aim of the present study was to elucidate the factor structure of the APM by relating it to deductive and inductive reasoning ability. The study sample consisted of 1026 young male adults. The participants were randomly assigned into one of two groups: one group was tested with the original test form and the other solved the items that were arranged in a different order. On the two test forms a mixed Rasch model was used to examine the latent class structure of the ability measurement. For both test forms the relatively best solution was a three-class solution indicating that the position-specific component was not significant. Structural equation modeling enabled us to specify that APM was moderately correlated with deductive but not with inductive reasoning. The results generally supported the hypothesis that processing differences between participants in solving APM items had impact on the construct validity of measurement.

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Suicide Rates of Italian Regions as a Function of IQ and Biological Variables

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The purpose of the present research was to relate suicide rate of the Italian regions to IQ and other variables. Higher suicide rate was associated with higher IQ, higher cephalic index, lighter eye and hair color, higher rates of schizophrenia and multiple sclerosis, higher latitude, and lower murder rates. The findings were related to previous international research and to the suggestion that suicide fits closer to the K than to the r end of the Rushton r-K evolutionary theory continuum.

Dopamine Signaling in the Prefrontal Cortex Predicts General Cognitive Abilities and Is a Target for Working Memory Training

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An individual's performance across diverse tests of cognitive ability tends to co-vary, indicative of a common source of underlying variance (i.e., "general intelligence"). Evidence indicates that the processing efficacy of working memory predicts the level of general intelligence in humans and general cognitive abilities (GCA) in non-human animals. One component of working memory, namely selective attention, has been reported to highly co-vary with general intelligence, and evidence suggests that dopamine D1 signaling in the medial prefrontal cortex (mPFC) critically modulates attentional abilities. Here, we characterized the GCA of 48 CD-1 outbred mice based on their aggregate performance across five diverse tests of learning. Using immunohistochemical techniques following administration of a D1 agonist (SKF82958, 1 mg/kg), we examined the relationship between GCA and endogenous sensitivity of D1 receptors in the mPFC, the dlPFC, and the striatum. Results indicate a differential sensitivity of D1 receptors in the mPFC (but not the dlPFC or striatum) between animals of high GCA and low GCA. Subsequently, we assessed whether the imposition of a working memory training regimen (with a high demand on selective attention) modulates the same dopaminergic signaling that was associated with innate GCA in a sample of 85 CD-1 outbred mice. Results indicated that working memory training promoted an increase in animals' GCA and enhanced the sensitivity of D1 receptors in the mPFC. These findings suggest that D1 receptors in the mPFC may both regulate GCA and may be target for working memory training that promotes GCA.

POSTERS

TALKS

INDIVIDUAL PRESENTATIONS

Abstracts are organized in alphabetical order

Names of students eligible for the John B. Caroll Award for Research Methodology are marked with an asterisk

Evidence for a *g* Factor in Non-Human Primates

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Here we report the first evidence of a general intelligence factor in rhesus macaques. Cognitive abilities overlap in people, giving rise to a *g* or general factor. This *g* factor is how intelligence is operationalised in most scientific research since it is more reliable than a single IQ-type test. Whether *g* exists in other primates has been controversial. Here we show in a sample of N=60 rhesus macaques (aged 5 to 26 years, 20 female, 40 male)who were administered four tests of cognitive ability (learning, spatial memory, object memory and set-shifting), that a *g* factor, derived from the first principal component, explains 47% of the variance among the test scores. This magnitude mirrors the *g* factor found among tests administered to human adolescents. Further, the *g* factor was positively correlated with total cholesterol (r=.38, p=.004, N=55) in the macaques. A positive correlationbetween intelligence and total cholesterol has also been found in humans. This is the largest study of *g* in a single non-human primate species tested with reliable measures each comprising more than a single item. The finding is important because *g* in humans is a potent predictor of ageing, health and longevity. The association between *g* and ageing has given rise to the new field of cognitive epidemiology, yet animal models of *g* are scarce and there are none in other primates. Learning about *g* in other animals is an essential component of exploring the evolution of intelligence in our own species.

Testing CHC Theory: Conjoint Confirmatory Factor Analysis of Test Batteries Used in the WJ-III Validity Studies

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Intelligence must be measured using a carefully selected, theoretically-based sample of representative indicators, as it is impractical to directly observe an adequate criterion (Cronbach & Meehl, 1955). The Cattell-Horn-Carroll (CHC) theory (McGrew, 2005; Schneider & McGrew, 2012) has become a prominent working theory in contemporary intellectual assessment, one that test developers commonly rely upon when selecting indicators of intelligence. In fact, almost all individually administered intelligence tests published within the past 10 years are consistent with the structure explicated by CHC theory (Keith & Reynolds, 2010).

CHC theory has been likened to a "periodic table" (Horn, 1998, p. 58). Like elements in the periodic table, CHC abilities are assumed to possess invariant configurations and properties. If CHC abilities are invariant, scores derived from different test batteries should be on the same measurement scale and the probability of obtaining a given observed score should be independent of the test administered. Unfortunately, intelligence is rarely measured without an appreciable amount of error, so it is unlikely that scores obtained from different measures will be completely invariant. Efforts to test invariance are aided by sophisticated sampling and statistical techniques, as issues such as attrition and fatigue place practical constraints on the number of tests researchers can administer to large groups of participants (Keith & Reynolds, 2012).

One approach for examining correspondence of scores across test batteries is to administer a reference battery to link multiple samples, each of which have been administered a subset of several test batteries that will subsequently be included as variables in a conjoint confirmatory factor analysis (McArdle, 1994). This approach previously was used to examine the invariance of CHC abilities across five different test batteries, using the Kaufman Assessment Battery for Children-Second Edition (KABC-II; Kaufman & Kaufman, 2004) as a reference battery to link samples from respective studies of test validity (Reynolds, Keith, Flanagan, & Alfonso, 2010). The present study builds upon existing research by employing a different reference battery, the Woodcock-Johnson III (WJ-III; Woodcock, McGrew, & Mather, 2001), and five tests administered with the WJ-III during respective studies of test validity. Invariance tests were conducted to examine the cross-sample equivalence of scores derived from the reference battery, which helped clarify the effects of sampling error (e.g., differences in the time frame of data collection, sampling procedures, or fidelity of administration and scoring procedures).

This study addresses four research questions. First, do indicators sampled from a diverse collection of test batteries map onto the CHC structure in a manner consistent with the abilities they are purported to measure? Second, are structural relations (i.e., the second-order loadings on psychometric g) similar to those found in previous research? Third, is a higher-order g factor sufficient to account for covariance among broad abilities (i.e., first-order factors)? Fourth, do different approaches for handling missing data yield similar results when combining raw data from multiple samples in order to test the invariance of CHC ability scores across test batteries?

Explaining the Increasing Importance of Genetic Variation for Cognitive Development: A Meta-Analysis of Longitudinal Twin and Adoption Studies

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Genetic influences account for increasing proportions of variation in cognitive ability over development.This is somewhat surprising as children are born with their complete genetic material and build up experiences with the environment over the course of development. There are two possible explanations for the finding. First, it is possible that that early genetic influences on intelligence are amplified over time.That is to say, genetic influences at an earlier time point come to account for a larger amount of variance in cognitive ability at later time points. Second, it is possible that as children mature, innovative genetic influences not present at earlier time pointsemerge. To distinguish between these possibilities, we conducted a meta-analysis of longitudinal behavior genetic studies spanning the age range from infancy to adolescence. Our literature search uncovered 16 articles with 11 unique samples that met the inclusion criteria for the project. Articles were required to report raw within- and cross-time group correlations or behavior genetic models from which these could be obtained. In total, these articles sampled 4047 monozygotic twin pairs, 7169 dizygotic twin pairs, 141 adoptive sibling pairs, and 143 non-adoptive sibling pairs that were all reared together and below age 18 at the initial time point. A total of 125 unique pairs of time points and measures were derived from these studies. Our analyses made use of Cholesky decompositions to focus on the extent to which early genetic influences carried over in time and the extent to which innovative genetic influences arose with time.Results indicated that in very early childhood, innovative genetic influences predominate, but these influences very quickly diminish, and amplified influences account for increasing heritability following age 8 years.

Adaptive Working Memory Training Increases Integrity of the Corpus Callosum

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The integrity of white matter connections (WMI) is crucial for human intelligence, as it allows for fast and reliable transfer of information between brain areas. Recent research has suggested that WMI, as measured by diffusion tensor imaging (DTI), maybe sensitive to cognitive training under laboratory conditions. However, to date only two papers have focused on WMI changes after intelligence-related training: Takeuchi et al. (2010) reported WMI changes after working memory training, butthis study lacked a control group; and Mackey et al. (2012) showed that reasoning training might significantly increase structural connectivity, although they failed to find an increase in the most commonly used WMI index, fractional anisotropy. Therefore, generalization of available evidence is limited. Here we studied WMI changes after working memory training in two groups (training and control) of 28 female participants each(mean age = 18, SD = 1.09), who were selected and matched for their general mental ability scores and demographic variables. The training group completed an intensive adaptive training program based on the visual, auditory, and dual modalities of the n-back task in24 sessions distributed over12 weeks. DTI data was acquired before (T1) and after (T2) training, and changes in the training group were compared to those observed for the control group. Training significantly increased fractional anisotropy in the corpus callosum of the training group, compared to the control group (FWE < 0.05). No significant increases were found in the control group relative to the training group. Finally, white matter integrity at T1 predicted attainment level in the task, although at a trend level only (FWE < 0.1). The potential impact of these structural changes for working memory and intelligence is discussed (see also Colom et al., ISIR 2012).

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IQ and the Wealth of Nations: How Much Reverse Causality?

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This paper uses regression analysis to try to isolate the impact of living conditions on IQ scores. Data are used from more than 130 test administrations worldwide. Many, but not all, of the test administrations are referenced in Lynn and Vanhanen (2012). It is hypothesized that insofar as living standards have an impact on IQ, early-life conditions are critical. Thus, the regressions emphasize conditions at birth. Alternatively, there is an attempt to capture conditions in the year before birth (with an eye toward prenatal effects) and up to the year when test-takers became 5 years old. Significant and enduring differences in average test scores across major racial groups are already present at ages 3-4.

Early-life conditions may affect subsequent test scores. On the other hand, current IQ, while it can affect the generation of wealth, *cannot* affect *past* living conditions. By entering living conditions into the regressions in*lagged* form, the present study hopefully limits any confounding of cause and effect. Rindermann et al. (2012) offer a useful path analysis that highlights some of the possible relationships amongst the variables, but their main explanatory variable reflecting living conditions (the UN's Human Development Index)enters their regressions in a manner that is contemporaneous with their dependent variable (i.e., national cognitive ability)..Rindermann et al.'s dependent variable combines the use of achievement tests with IQ tests, the outcomes on the former being more subject to the influences of school quality, families, and communities than the latter (as in, e.g., the case of Argentina)..

Living conditions in the present study are reflected in measures of per capita gross domestic product, rates of malnutrition, and the under-five mortality rate – which turns out to be highly correlated with school enrollments as well as the presence of diseases affecting young children.To better isolate the role of test-takers' region of ancestry, the study focuses on test administrations in countries inhabited primarily by their indigenous peoples.

For sub-Saharan Africa the paper uses test administrations of the Raven's Standard Progressive Matrices from Table 2 of Wichertset. al. (2010).The dependent variable in the regressions is the average score at a test administration (not Lynn's and Vanhanen's "national IQ"). To capture a test-taker's region of ancestry, a set of dummy variables is used, with the main question being where to set the boundaries of each region. Sensitivity analysis is used to assess the impact of changing boundaries.

It is understood that the data used consist of convenience samples, with any biases they may contain. Tests and corrections are offered for at least some of the biases present. In any case, *region of ancestry dominates the regression results. Reverse causality is found to be present and statistically significant, but not large in magnitude.*

Development and Initial Validation of a Public-Domain Cognitive Ability Resource

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For all of its versatility and sophistication, the extant toolkit of cognitive ability measures lacks an appropriate method for large-scale, remote data collection. This oversight has prevented intelligence research from expanding beyond clinical and laboratory settings in a manner commensurate with the widespread use of internet-based assessments in other domains of personality, vocational and social psychological research (Gosling, Vazire, Srivastava, & John, 2004). This circumstance results from a fundamental incompatibility between large-scale, un-proctored assessments and the administration protocols for intelligence measures which are designed to preserve test security through reliance upon copyright enforcement and restricted test-taker access to external resources.

As an alternative to the nearly exclusive use of copyrighted measures in intelligence research, we report on the development of cognitive ability items which are maintained in the public domain and were designed for use in large-scale, internet-based assessments. Subsets of these items have been administered to more than 200,000 participants over several years. The validation analyses are based on two recent samples. In the first case ($n > 70{,}000$), the items were administered using the Synthetic Aperture Personality Assessment technique (Revelle, Wilt, & Rosenthal, 2010) in conjunction with public domain measures of temperament (the 100-Item Set of Big-Five Factor Markers from the International Personality Item Pool) and vocational interests (the 92-item Oregon Vocational Interests Scales). Demographic variables include educational and occupational outcomes and self-reported achievement test scores. The second sample consists of 140 undergraduates who were also administered a brief commercial IQ test (Shipley-2).

Results show a range of moderate-to-high correlations between scores on a sample test constructed from our items, self-reported achievement test scores, and scores on the commercial IQ test. Scores on these items are also consistent with a variety of ecological correlates, including gender, level of educational attainment, parental education, and choice of academic major. With regards to the latter, the results of group-level IRT analyses demonstrate the discriminant validity of specific item types as might be expected, for example, with items assessing spatial ability in STEM (Science, Technology, Engineering and Math) and non-STEM majors.

Based on these results, these items and methods are well-suited for a variety of additional applications such as (i) large-scale explorations of the relationships between g and other sources of individual differences, and (ii) attempts to identify small effect sizes like those proposed between various lower-order abilities. We believe that further development of this public domain resource will facilitate efforts to extend intelligence research beyond the confines of the laboratory.

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Non-g Residuals of the SAT and ACT Predict Specific Abilities

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This research concerns the SAT and ACT, two college admission tests. Both tests are strongly related to g, the variance common to mental tests. g contributes strongly to the validity of tests, which typically lose their predictive power after g is removed (Jensen, 1998). In contrast, the SAT and ACT retain their predictive power after removing g: Non-g residuals of the SAT and ACT, obtained after removing g, predict first-year college GPA (Coyle & Pillow, 2008).

Why do non-g residuals of the SAT and ACT predict GPA? One possibility is that non-g residuals from the tests' verbal and math sections tap domain-specific factors with predictive power. Consistent with this possibility, non-g residuals of the Cognitive Abilities Test (CAT) showed domain-specific relations with school grades (Calvin et al., 2010): Non-g residuals of the math CAT were positively related to math grades but negatively to verbal grades, whereas the opposite pattern was found for the verbal CAT. Effect sizes were generally small (~ .10).

The present research examined whether non-g residuals of the SAT/ACT verbal and math subtests predicted specific abilities. The non-g residuals were correlated with academic abilities (verbal and math) and non-academic abilities (speed and mechanical). Consistent with Calvin et al. (2010), non-g residuals of the SAT/ACT math subtests were predicted to be positively related to math ability and negatively to verbal ability, whereas the opposite pattern was predicted for the verbal (reading) subtests. Non-g residuals from both sets of subtests were expected to be weakly related to non-academic abilities, which measure different constructs.

Subjects (N = 1,950) were selected from the National Longitudinal Study of Youth if they had scores for the SAT or ACT subtests and the 12 tests of the Armed Services Vocational Aptitude Battery (ASVAB). Structural equation modeling estimated the following constructs using the ASVAB (sample tests): verbal ability (word knowledge), math ability (math reasoning), speed ability (coding), and shop/auto ability (shop knowledge). g was based on these abilities plus the SAT/ACT subtests. Non-g residuals of each SAT/ACT subtest, obtained after removing g, were correlated with the ASVAB abilities.

Results supported the predictions (mean standardized effects): Non-g residuals of the SAT/ACT math subtests were positively related to math ability (.29) but negatively to verbal ability (-.32). Non-g residuals of the SAT/ACT verbal subtests were positively related to verbal ability (.29) but negatively to math ability (-.25). Non-g residuals of all SAT/ACT subtests were weakly related to speed and shop abilities (-.02, n.s.), demonstrating discriminant validity. g was moderately to strongly related to all SAT/ACT subtests and ASVAB abilities (.46 to .76).

The results indicate that non-g residuals of the SAT/ACT subtests predict academic abilities, with effect sizes being larger than in prior studies. The results support an investment theory with tradeoffs: Investing in non-g skills in one area (math) leaves less time for investing in non-g skills in competing areas (verbal), resulting in negative correlations between non-g residuals and non-complementary abilities. Ongoing research examines whether such effects increase with time, as additional investment in non-g skills may produce stronger effects.

Processing, Gs, and Mentalese: An Overarching Theory of the Mind

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This presentation summarizes an overarching theory of the developing mind, based on a series of empirical studies yielding very consistent patterns about the relations between age, processing speed, working memory (WM), fluid intelligence (gf), and metacognition from infancy to adulthood. Structural modeling indicated, on the one hand, that a four-fold architecture (domain-specific processes, general processing functions, general inferential functions, and consciousness) is always valid. However, relations between processes vary with development. Representational (WM) and inferential processes (gf) tend to get increasingly differentiated and inferential and metacognitive processes tend to get increasingly integrated with age. In this process some functions are better developmental indicators and some other processes are powerful markers of individual differences. Specifically, speed is a powerful covariate of age (~-.6 to -.7) from 4 to 13 years, declining thereafter (to ~-.2), reflecting the developmental possibilities of successive age phase. With speed and age controlled, WM is almost fully commensurate with gf (~.9), operating as a strong factor of individual differences in learning and rate of change. Change over time originates from within the processes themselves and G. Speed is a strong indicator of G-driven change in phases of transition and WM is a strong indicator of individual differences in realization phases following transitions. The role of metacognition becomes important in these phases. An overarching developmental model from infancy to adulthood accommodating processing, representational, inferential, and metacognitive possibilities is summarized. The implications for cognitive, developmental, and differential theories are discussed.

Increase in Response Times with an Increase in the Number of Response Alternatives: What if the Information Theory-Based Model is a Misconception?

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Hick's (1952) proposition that an increase in response times with an increase in the number of equally likely response alternatives can best be understood within the information-theory framework, which implies that response times increase as a binary logarithm of the number of response alternatives (or as a linear function of bits of information), has commonly been treated as a law thereafter. For the area of individual differences, this means that the response times of each subject on tasks similar to those used by Hick are believed to increase as a linear function of information. Consequently, only a linear function is commonly fitted to individual response-time data; estimates of the intercept and slope are regarded as two indexes that describe individual performance on this task, and their associations with cognitive ability have been extensively examined in several studies. Hardly any function other than the logarithmic function proposed by Hick has ever been fitted to individual response-time data obtained on Hick's task.

The logarithmic function is commonly accepted to provide a good fit to empirical data, as indicated by the R-squared, which is the only reported goodness-of-fit statistic in most cases. In this presentation, we revise the indexes of fit reported for the logarithmic function to discuss whether such indexes are truly that high to conclude the correspondence between the model and the data. We also subject covariance matrices reported in studies on the Hick paradigm to nonlinear structured latent curve modeling to examine the fit of a logarithmic model within a structural equation modeling framework. We then look for possible alternative functions that would have a theoretical rationale other than that suggested by the information theory framework but could still describe the data at least no worse than the information theory-based logarithmic model. We illustrate our assertions by fitting several functions both to average data obtained in the Hick paradigm, which involves direct curve-fitting, and to covariance matrices, which is possible in structural equation modeling.

Therefore, we consider a possibility that the interpretation of the relationship between response times and the number of response alternatives proposed within the information-theory approach is a misconception, and hence a logarithmic function is not necessarily the best choice for fitting individual response-time data. Using simulated data sets, we show the possible consequences of choosing a wrong function for studies that analyze individual differences in the parameters of a function fitted to individual data and their relations with other variables. We primarily focus on how this can affect the estimates of reliability and sample variability of those parameters that describe an increase in response times over conditions, because low reliability and low variance are the two most common claims concerning the slope parameter of the Hick function.

We argue that preferring a single function for the individual-level modeling of response-time change with an increase in the number of response alternatives without even considering other possible models requires strong theoretical arguments and a firm background. This is because the cost of improper choice of the function is especially high in studies on individual differences in function parameters. For the increasing trend of response times as a function of the number of response alternatives, we therefore strongly suggest the questioning of whether its substantiation in terms of information theory that was first suggested by Hick is powerful enough to accept the logarithmic relationship as a law.

Molecular Genetic and Neuronal Origins of Intelligence Differences: Association of Cognitive Abilities and the Postsynaptic Proteome of Central Excitatory Synapses

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General cognitive ability accounts for around half of variation in any large battery of cognitive tests (Carroll, 1993; Jensen, 1992), and is predictive of important life events (Gottfredson, 2004), including health. However, despite its substantial heritability, no single gene has been reliably associated with general intelligence. Recent evidence from studies of genome-wide single nucleotide polymorphisms (SNPs) indicates that unknown causal variants in linkage disequilibrium with these common variants explain 40-50% of the variance in intelligence differences (Davies et al., 2011). This suggests that information in current SNP-chips should provide a window on the molecular pathways underlying intelligence differences. Testing for associations between cognitive abilities and specific gene networks or pathways might give a substantial increase in power, thus reducing the sample sizes required for pathway discovery. In this study, we tested networks of genes previously linked to long–term synaptic potentiation/depression for association with phenotypes of general fluid cognitive ability, crystallized cognitive ability, memory, and speed of processing in a total of 3,511 individuals drawn from five cohorts. All were genotyped on the Illumina610-Quadv1 platform. The human postsynaptic proteome (PSP) comprises over 1000 proteins organized into complexes regulating both innate and learned behavioural responses (Migaud et al., 1998). In humans, mutations in these genes result in over 130 neurological disorders, many with deleterious effects on cognition. We tested 1121 well established/characterised postsynaptic genes (Collins et al., 2006) as well as 4 more-specific subsets; the post-synaptic density, α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor complex (ARC), metabotropic glutamate (mGluR5) receptor complex and the N-methyl-D-aspartate receptor signaling complex (NRSC). Enrichment of these gene sets for cognition was tested using the GSEA program (Subramanian et al., 2005) revealed a significantly enriched association signal from the N-methyl-D-aspartate receptor signaling complex (p= .002, FDR = .24. This association was tested for replication in two independent

samples, with a significant result in one (p=.0478, FDR = .0478). Together, the results suggest that genes related to synaptic function may be associated with fluid cognitive ability.

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Are Concerns over Female Underachievement in Science Misplaced? A Meta-Analysis of Data from PISA and TIMMS

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There has been considerable recent concern with respect to women's underrepresentation in science (e.g. Ceci, Williams, & Barnett, 2009). However, to our knowledge there has been no systematic analysis of the two largest and arguably most methodologically sound international databases on this issue: PISA and TIMMS (previously IEA). Here we report data on standardized assessments of school based scientific knowledge and problem solving for 9, 11, 14 and 18-year olds, for the years 1973, 1988, 1995, 1999, 2003, 2007 (TIMMS), and for 15-year olds, for the years 1995, 2000, 2003, 2006, 2009 (PISA). Analysis of variance of 592 *d*-scores based on more than 2.7 million pupils, showed significant effects due to Year (20.3%), Age (3.7%), Region (3.9%) and a Year by Region interaction (12.2%). A separate analysis showed a significant effect due to study (PISA v. TIMMS) of 13.2%. Considering PISA, there is no overall sex difference in scientific literacy (d = 0.002, Z = 0.24, p = 0.811), and while there are differences across year, they are of negligible magnitude. For TIMMS there is a significant male advantage at all ages, but this is largest for 18-year olds (d = 0.496), and smallest for 9-year olds (d = 0.033). However, there is a trend over time, best captured by the data for 14-year olds (df = 217), whereby a male advantage in 1973 (d = 0.446), turned into a female advantage (d = -0.123) by 2007. There is considerably less data for 18-year olds, but males enjoyed an advantage which is arguably decreasing over time (Q = 555.2, df = 2, p = .000) such that the *d*-scores were 0.667, 0.386, 0.380 for 1973, 1988, and 1995 respectively. Considering overall data for 14 and 15-year olds, there are regional effects such that females have an advantage in Africa (d = -0.25), and the Middle East (d = -0.17), there is no difference in North Africa, Central America and South East Asia, while in the rest of the world there is a small male advantage. Considering only the most recent data (2007, 2009), while there is still a female advantage in Africa and the Middle East, in all other regions differences are negligible.

To put these findings in context, thirty years ago, males showed both higher levels of academic achievement in secondary school and higher levels of educational attainment, while today females in most industrialized countries receive higher grades on average throughout the educational system. Moreover, for 44 countries in the regions of Europe, the Americas, and the Middle East for every male an average of 1.88 females graduated with a first degree, as of 2007. More specifically, in the U.S, since 2000, females have obtained at least half of all Bachelor's degrees in science and engineering. In the overall context of these trends and data, arguably concern over female underachievement in science may be slightly misplaced. Clearly female advances in educational achievement deserve celebration; but at another level perhaps a more pressing issue is why the level of under attainment in males is so high.

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Can Assortative Mating Account for Greater Genetic Variance in IQ with Higher SES?

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Several studies have observed that genetic variance in children's IQ independent of parental socioeconomic status (SES) tends to be greater with higher parental SES, though this finding has not been universal. These studies have not, however, taken into consideration the correlations among IQ, education, and socioeconomic status. They also have not taken into consideration that there is often if not generally assortative mating for IQ, though the assortative process may more directly involve education and socioeconomic status than IQ. The Minnesota Twin Family Study offers an opportunity to explore how assortative mating may be involved in the observation of greater genetic variance in IQ with higher SES because parents as well as their twin offspring completed IQ tests. In both the 11- and 17-year-old cohorts, assortative mating for IQ was over .3, which meant that dizygotic twins likely shared more like 60% of the segregating genes for IQ than the generally assumed 50%. Recognizing this, genetic variance in IQ independent of SES was greater with higher parental SES, and also with greater mid-parent education and mid-parent IQ in the 11-year-old cohort whether IQ was assessed at ages 11, 17, or 25. This was not true, however, in the 17-year-old cohort with IQ assessed at age 17. In both cohorts, people of higher IQ were more likely to have 'married down' for IQ than people of lower IQ were to have 'married up'. The pattern was apparent in both sexes but tended to be stronger in men than in women. It was also stronger in the 17-year-old cohort than in the 11-year-old cohort. This assortative mating pattern would create greater genetic diversity for IQ in people of higher IQ than in people of lower IQ. As IQ is associated with SES, greater tendency for those with higher IQ to 'marry down' for IQ than for those with lower IQ to 'marry up' for IQ may be one reason for the observation of greater genetic variance in IQ independent of SES with greater parental SES in several samples. The absence of this pattern in the 17-year-old cohort is, however, inconsistent with this explanation. I discuss how and to what degree genetic variance common to IQ and SES might help to reconcile the inconsistency.

Differentiation of Intelligence, Creativity, and Aptitude via Brain-Behavior Imaging

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The interface between the cognitive constructs of intelligence, aptitude, and creativity is of keen interest to both psychologists and neuroscientists who wish to both identify and cultivate these attributes in the human brain. A vast literature indicates that most measures of human mental behavior conform to a general factor identified as "g" (Jensen, 1998). However, it would be important to identify abilities that complement this general factor. We sought to measure several abilities in a large human sample, with the purpose of linking such measures to brain attributes as measured by structural imaging. We hypothesized that "g" would predominate the test scores, but that factors of aptitude and creativity could be meaningfully extracted from this general factor. Similarly, we sought to differentiate brain correlates of aptitude and creativity from those of intelligence as described previously (Jung & Haier, 2007). The sample consisted of 95 young subjects (age range 16 – 20, mean = 18.7 +/-1.2; 52 male), 32 of whom were scanned with a 3 Tesla scanner, obtaining MPRAGE structural images. Behavioral measures included measures of intelligence (Wechsler Abbreviated Scale of Intelligence - WASI; Johnson O'Connor Foundation JOCF - Vocabulary), aptitude (JOCF –Word Association, Ideaphoria, Paper Folding, Foresight, Inductive Reasoning), Creativity (Torrance Test of Creative Thinking TTCT – Circles, Unusual Uses; Remote Associates Test; Creative Achievement Questionnaire CAQ), and implicit learning (Digit Symbol Coding – delayed recall, Similarities – delayed recall, Foresight – delayed recall). Factor analysis was used (principal component, no rotation, eigenvalue >1) to reduce variables. Six factors were extracted from the behavioral battery, the first unrotatedfactor being consistent with "g" (JOCF Vocabulary - .82, WASI Similarities - .72). The second factor appeared to load for creativity (CAQ - .34; TTCT Circles Originality – .39, Foresight – .47; TTCT Unusual Uses Originality – .83). The third factor appeared to extract a"written fluency" factor (Ideaphoria - .41, Digit Symbol Coding - .49, Circles Fluency - .49). These three factors were regressed against structural imaging measures in the subset of 32 subjects using voxel based morphometry, demonstrating:1) "P-FIT" regions associated with "g" (Jung & Haier, 2007), 2) predominantly frontal regions associated with "creativity" (Jung et al., 2009), and 3) orbitofrontal and posterior (e.g., motor) regions associated with "written fluency." Factor analysis provides a meaningful method by which to extract behavioral variables relevant to specific brain networks associated with creativity and aptitude. While "g" is unlikely to be significantly modified by environmental influences (despite recent excitement), identified factors – including measures of originality and written fluency – may be more amenable to efforts at manipulation. As demonstrated by the current technique, structural imaging provides a potential measurement window into the results of such intervention efforts.

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Spatial Ability: Its Unique Contribution to Creativity and Technical Innovation

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In the late 1970s, 563 intellectually talented 13-year-olds (identified by the SAT as in the top 0.5% of ability), were assessed on spatial ability. Over 30 years later, their peer-reviewed publications and their patents were each classified into three groups. Spatial ability added incremental validity to the differential prediction of these accomplishments, beyond the SAT's mathematical and verbal reasoning subtests. Findings support spatial ability's unique role in the development of creativity, relative to traditional measures used in educational selection, counseling, and industrial-organizational psychology. In addition to modeling creativity and tracking intellectually talented youth over the lifespan, these findings reinforce prior evidence suggesting that assessing spatial ability is required for studying how intellectual development unfolds more generally. Spatial ability plays a key and unique role in structuring many important psychological phenomena, and warrants more widespread use across the applied and basic psychological sciences.

Invariance of the ASVAB across Race/Ethnicity and Sex

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The Armed Services Vocational Aptitude Battery (ASVAB) is sometimes used in intelligence research to measure *g*, perhaps due to its inclusion in the National Longitudinal Survey of Youth (NLSY) – 1979 dataset. Accordingly, many of the previous studies using the ASVABas a measure of *g*, including confirmatory factory analyses and studies of gender and ethnic/race invariance, have been based on the previous version of the ASVAB.

The NLSY – 1997 dataset, however, includes scores from the updated, computer-based version of the ASVAB. In addition to the new format, the ASVAB now contains the Assembling Objects subtest to measure visual spatial abilities. Given these changes, psychometric research is warranted to examine the properties of the updated ASVAB, especially if it is to be used in intelligence research. And, while several studies provide information regarding the psychometric properties of the updated ASVAB, research is still needed regarding the factor structure of the new ASVAB across gender and ethnicity.

The current research is an invariance study of the factor structure of the ASVAB across sex and ethnicity/race. Preliminary results suggest that the ASVAB does not demonstrate intercept invariance for sex or ethnicity/race indicating that the measure has different "zero points" for different groups.

Nonlinear Associations between General Intelligence and Personality in Project Talent

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Research on the relation of personality traits to intelligence has primarily been concerned with linear associations. Yet, there are no a priori reasons why linear relations should be expected over nonlinear ones, which represent a much larger set of all possible associations. Using structural equation modeling we tested and compared linear and quadratic effects of *g* on ten personality scales in Project Talent, a nationally-representative sample ofover 440,000 American high school students from 1960. Preliminary results showed that quadratic effects explained substantially more variance than linear effects in several personality traits (including sociability, vigor, maturity, and leadership), while linear effectswere predominantfor other traits (such as calmness, self-confidence and impulsiveness). For example, we observed a negative quadratic effect of gon sociability, which accounted for over three percent of the variance. This effect constituted a medium effect size (Cohen's d = .5) when comparing individuals of average *g* to individuals two standard deviations above the mean. In addition, we used an extension of general linear models called generalized additive models (GAMs) to explore smooth nonlinear effects of any shape (beyond quadratic effects) that *g* might have on the personality traits.The models showed that some personality traits had complex non-linear associations with *g*. Our results may have important implications in understanding the personality-intelligence interface.

Imaging-Derived Gray Matter Measurements of the Cerebral Cortex and Intelligence: A Latent Variable Analysis of the p-FIT Model

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A group of 98 young adults (mean age = 19.84, SD = 1.66) completed an intelligence battery measuring three intelligence factors: fluid/abstract (Gf), crystallized/verbal (Gc), and spatial intelligence (Gv). Each factor was measured by three tests and correlations among factors ranged from .43 to .74. 3D T1 images were also obtained and processed bytwo imaging protocols from different labs (CIVET and BrainSuite-SVreg) that yielded three gray matter indices: cortical volume (CV), cortical surface area (CSA) and cortical thickness (CT). CSA and CT are clearly distinguishable brain indices and they are also genetically uncorrelated, whereas CVis a functionofthesetwomorphometricdescriptors.Each gray matter index was averaged at several regions of interest (ROIs)selected based on the parieto-frontal integration theory (P-FIT) of intelligence (Jung and Haier, 2007). These ROIs were: insular cortex, rostral middle frontal gyrus, pars triangularis, paracentralgyrus, supramarginalgyrus, angular gyrus, superior temporal cortex, and fusiformgyrus. Resulting variables were submitted to confirmatory factor analysis, in which left and right regions defined first-order factors for each structure and these factors were predicted by a higher-order factor representing general cortical volume (gCV), surface area (gCSA) or thickness (gCT). Obtained regression weights for intelligence and for gray matter measurements were fixed before fitting the SEM relating brain and psychological latent factors. Models for each hemisphere were also computed separately. These were the main findings. First, gCVwas highly correlated with gCSA(above .90) and less so with gCT (around .70). Second, gCSA and gCT showed a moderate correlation (around .40). Third, gCV was the most stable measure across imaging protocols ($r > .90$) and it was related to Gv and Gc but not to Gf. Finally, gCTandgCSAwere not significantly related with intelligence factors, but values showed substantial increments when both hemispheres were considered separately. The main analyses were repeated using randomly selected ROIs. Consistencies and discrepancies between the obtained models are discussed.

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Does the Heritability of General Cognitive Ability Change in Late-Life?

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Various theories in gerontology lead to the expectation that the heritability of general cognitive ability should change in late-life, depending on the theory either decreasing or increasing. Recently, we showed using cross-sectional data on more than 2000 pairs of twins age 46-96 that the heritability of general cognitive ability was remarkably stable, at least through age 80 (McGue & Christensen, *Behavior Genetics*, in press). Here we attempt to further investigate the question of age changes in the heritability of general cognitive ability using data from a unique longitudinal sample of Danish twins. The Middle-Age Study of Danish Twins (MADT) includes over 2400 twins (and 816 twin pairs) assessed twice, first at an average age of 57 years and second approximately ten years later at an average age of 67 years. As part of their assessment, the twins completed a brief battery of four cognitive ability tests, from which we derived an overall composite. As expected, cognitive composite scores decreased over the ten-year retest interval (by nearly ½ of an SD). However, we found no evidence that individual differences in rate of cognitive change was heritable, and the heritability of the cognitive composite was nearly the same at follow-up (57%) as it was at intake (62%). Results are discussed in light of theories about the nature and implications of cognitive aging.

Diabetes and Intelligence? No, Genes, Intelligence and, Then, Diabetes

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It is widely believed that having diabetes has a detrimental effect on one's cognitive abilities and, as a result, there is an established and vibrant research tradition, which aims to understand why this might be the case. Yet, from the many findings of cognitive epidemiology we know that some of the health conditions that are believed to impair cognitive functioning are, in fact, predicted by low pre-morbid cognitive ability. Such cases are often referred to as reverse causation. To find out if reverse causation also applies to the diabetes-cognitive ability association, we grouped the members of the Lothian Birth Cohort 1936 (LBC1936) based on whether or not they had diabetes at age 70 and compared mean intelligence test scores of the two groups at ages 11 and 70. Having diabetes already at age 11 was unlikely and therefore the age-11 intelligence scores of those with and without diabetes at older age were expected to be similar, unless reverse causation was in operation. The results showed that those with older-age diabetes scored lower in cognitive ability than those without diabetes roughly by the same amount at ages 11 and 70 (about $d = 0.3$). These results, showing that the cognitive ability differences between people with and without diabetes was in place long before the typical diabetes onset age, support the reverse causation explanation for the association (of course, there also remains the possibility of confounded association).

In a separate study, we investigated whether low cognitive ability measured in childhood interacted with genetic risk for type 2 diabetes in predicting diabetes diagnosis or a high glycated hemoglobin (HbA1C) level in older age (the cut-off of HbA1C $\geq$ 6.5% is currently used to diagnose diabetes). The rationale for this research question was two-fold. First, it is possible that the negative effect of low cognitive ability on diabetes is more likely to occur when the organism is already predisposed to develop the disease, whereas low genetic predisposition for the disease may provide people with immunity against the negative effect of low cognitive ability and its consequences. Second, it is possible that cognitive ability and its socioeconomic or life-style consequences may moderate the realization of genetic risk such that, for example, high ability may buffer high genetic risk.

We tested this hypothesis in LBC1936. Polygenetic risk for type 2 diabetes was estimated by applying the previously found meta-analytic associations of thousands of single-nucleotide polymorphisms (SNPs) with type 2 diabetes to each participant's genome. Several polygenetic risk scores were created by employing different combinations of SNPs based on the strength of their meta-analytic associations with diabetes. The risk scores did not interact significantly with childhood intelligence scores when predicting self-reported diabetes diagnosis, possibly due to a relatively low number of participants with the diagnosis. However, childhood cognitive ability and the polygenetic risk scores interacted significantly in the prediction of HbA1C levels. Specifically, the association between low cognitive ability and high HbA1C levels tended to be stronger for those at higher polygenetic risk and the genetic risk-HbA1C association was stronger for participants with low childhood cognitive ability.

These results, providing some evidence for gene by cognitive ability interaction in predicting diabetes symptoms, may advance our understanding of the behavioural trait-health associations and help to increase the accuracy of (early) genetic prediction of disease risk.

The Effects of Cognitive Training on Psychometric Intelligence

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Two experiments are reported in which the effects of cognitive training on psychometric intelligence have been investigated. In experiment 1, seventy five schoolchildren were divided into three groups: experimental, control, and clinical (consisting of children with ADHD). All participants completed a battery of psychometric tests (selective attention test, Raven's matrices) three times: before the training, just after the training, and three months afterwards. The experimental and clinical groups were given a program of training, which consisted of four attention tasks. These tasks pertained to the basic functions of attention, such as vigilance, switching, resistance to distraction, and selectivity. The training program consisted of 10 sessions, arranged in the adaptive manner (i.e., the difficulty level was adjusted to a currently observed level of performance of the given participant). Children from the control group were given a computer game that required speed of responding and simple psychomotor skills. We found that cognitive training improved the attention test's results but did not affect psychometric intelligence, measured with Raven's matrices. In the second experiment, children from the control group used the same computer game, whereas children from the experimental group were trying to improve working memory with the battery of four cognitive tasks; there was no clinical group this time. The tasks were based on such paradigms as n-back, keep track, and mental counters, although they were constructed game-like and adjusted to children's level of cognitive development. The training consisted of 20 sessions, and it significantly improved psychometric intelligence, measured with WISC. We conclude that working memory rather than attention should be treated as a cognitive substrate of intelligence. We also suggest practical ways to improve higher-order cognitive skills through basic cognitive interventions.

Generalist Genes and Intelligence

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Quantitative genetic research (twin and adoption studies) has shown that cognitive abilities are highly heritable but that the effects of genetic differences are not specific to particular abilities. To the contrary, most genetic effects are general across cognitive abilities as diverse as reasoning, spatial, verbal, memory, language, reading, and mathematics. About two-thirds of the genetic variance of these cognitive abilities covaries, which is the primary evidence supporting the Generalist Genes Hypothesis. Intelligence ('*g*', general cognitive ability) is an index of generalist genes for cognitive abilities.

I will review these findings from quantitative genetic research and I will describe new DNA research (Genome-wide Complex Trait Analysis) that confirms these findings. I will also describe another way in which genes are generalists: Genetic effects are general across the distribution of cognitive ability in that the same genes are responsible for genetic influence throughout the distribution, including the high end of the distribution. I am capitalising on this aspect of generalist genes to sequence the entire genomes of 2000 individuals of extremely high 'g' (IQs > 150) in order to increase power to identify genes associated with 'g'.

Genome-wide association studies have shown that cognitive abilities and disabilities are highly polygenic, similar to other complex traits and common disorders in the life sciences. That is, many genes of very small effect size are responsible for the heritability of cognitive abilities, which has made it difficult to identify specific genes responsible for genetic influence. Further complicating this story, the Generalist Genes Hypothesis implies that these genetic effects are also highly pleiotropic – each gene affects most cognitive abilities. I will discuss implications of polygenicity and pleiotropy for understanding intelligence.

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Breastfeeding Causes Long-Term Increases in Intelligence: p-Score Analysis and Breastfeeding as an Explanation of the SES Intelligence Gap

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Children from poor homes are not as intelligent as those from wealthy homes; answering *why*? has proven difficult due to a lack of causal evidence. Children who were breastfed for longer are more intelligent than children who were not breastfed. Wealthy mothers breastfeed their children for longer than poorer ones. These three arguments suggest breastfeeding may help explain part of the socioeconomic status (SES) intelligence gap; though there is no evidence that breastfeeding causes long-term changes in intelligence. I wished to take advantage of the covariation of wealth and breastfeeding and separate it using propensity score matching—a statistical form of causal modeling. Employing a nationally representative sample, I show breastfeeding causes increases in intelligence that last until adolescence, using the most conservative methods possible. I propose differences in breastfeeding behavior as an explanation of part of the SES intelligence gap.

Some Videogames and Intelligence Tests Measure the General Factor of Intelligence (*g*): Further Proof for Spearman's Principle of the Indifference of the Indicator

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Researchers have speculated with respect to renewed and modern ways for assessing the intelligence construct in the XXI century (Horn, 1979; Hunt and Pellegrino, 1985; Resnick, 1979; Snow, 1986). Suggestions have included the use of computers and adaptive testing along with simulations of everyday problem solving situations. Computerized assessment is now widely available but printed tests still dominate. Jensen (2006), among others, asked researchers for finding new assessing approaches. The present study tests if videogames can be used for measuring the general factor of intelligence (g). 113 undergraduate students (46 males and 67 females; Mean age was 22.6, *SD* = 2.92) played 12 videogames during three hours under supervision in the Laboratory. They also completed a set of intelligence tests (in two different sessions and small groups -no more than 10 participants each) including the Advanced Progressive Matrices Test, Spatial Relations, Abstract Reasoning, Verbal Reasoning and Perceptual Speed from the DAT Battery, Verbal and Numerical subtests from the Primary Mental Abilities Battery, the Rotation of Solid Figures Test, The Perceptual Speed Test of Faces from Thurstone, and the Memory subtest from "*Evaluacion Factorial de Aptitudes Intelectuales*" (Factorial Assessment of Intellectual Abilities, TEA, 2005). Obtained data were submitted to a Confirmatory Factor Analysis to test the main prediction. Results clearly show that the 12 videogames tap a common latent factor. Furthermore, this factor is highly correlated (values greater than .90) with the g obtained from the intelligence battery.

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Education Is Associated With Higher Later-Life IQ Scores, But Not With Faster Cognitive Processing Speed

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Recent reports suggest a causal relationship between education and IQ, which has implications for cognitive development and ageing: Education may improve cognitive reserve. In two longitudinal cohorts, we tested whether the effect of education on IQ endures into old age. We then tested whether education is linked to improved scores on processing speed variables such as Reaction Time, which are associated with both IQ and longevity. Controlling for childhood IQ score, we found that education was positively associated with IQ at ages 79 (Sample 1, the Lothian Birth Cohort 1921) and 70 (Sample 2, the Lothian Birth Cohort 1936), and that this relationship was stronger for participants with lower initial IQ scores. However, education showed no significant association with processing speed, measured at ages 83 and 70. Increased education may enhance important later-life cognitive capacities, but does not appear to improve more fundamental aspects of cognitive processing.

Brain Changes Induced by a Challenging Cognitive Training: Can Science Evoke Phenocopies of Superior Intelligence?

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A group of 28 women was scanned twice, before and after extensive cognitive training (24 sessions lasting approx 30 minutes each across 12 weeks). A second (control) group of 28 women (matched by intelligence and several socio-demographic variables) was also scanned twice, but they were not submitted to the training program. This cognitive training program was based on the adaptive n back task designed by S. Jaeggi. Behavioral data demonstrated the expected improvements across sessions, reaching an average level of 5.13 (SD = 1.7) at the end of the training period. Gray matter segmentations obtained from the brain 3D T1 images for both groups of women before and after the training period were systematically compared. This was the main prediction: if training impacts brain networks relevant for intelligence, then key parieto-frontal areas (nominated by the P-FIT model, Jung & Haier, 2007) must reveal significant changes in the training group when compared with the control group. VBM findings revealed differential changes mainly in fronto-temporal clusters, but none survived correction for multiple comparisons. When both groups were analyzed separately, only the control group showed significant changes surviving FWE correction ($p < .05$) mainly in fronto-temporal clusters also. The implication is that the training group appears to be immune to expected spontaneous changes in these still developing participants. These results are consistent with longitudinal studies showing no changes in the brain (cortical preservation) for more intelligent subjects (Burgaleta et al., submitted). If this is indeed the case, it would be tentatively concluded that the administered training program mimics the effect of superior intelligence.

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Gender Differences in Variability in Ability Factors over Time

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A substantial literature has demonstrated mean gender differences in a number of cognitive abilities such as spatial ability and verbal fluency (Halpern, 2000). In recent years, investigators have examined gender differences in variability, although there is not full consensus on the size and generality of these effects (Ceci & Williams, 2010; Johnson et al., 2008). In this presentation, differences in variability and right-tail ratios are examined for a data set collected in 2008-10, and the results are compared with corresponding data sets for 1998-2000 and 1988-90.

The data for this presentation consist of test scores for clients of the Johnson O'Connor Research Foundation's aptitude-testing program, who take a battery of tests for a fee, generally for career and educational planning. For the 2008-10 data set, there are 8,185 females and 9,619 males, with ages ranging from 14 to 65 (M = 25.1), and the 1998-2000 and 1988-90 samples are similar.

The JOCRF battery yields four group factors (Spatial, Speed of Reasoning, Numerical, and Memory) and a general (g) factor. All scores here are partialled for the effects of age.

In terms of results, the 2008-10 sample shows mean gender differences in line with the previous literature (Halpern, 2000). For variability, the Spatial factor shows a male-female ratio of 1.25, while the other factors show ratios near one. Regarding right-tail ratios, for examinees scoring above the 95th percentile, the male-female ratio is 2.6 for the Spatial factor, 0.6 for the Memory factor, and near one for the other factors. When mean gender differences are statistically controlled, however, there are only small differences in the right-tail proportions, with ratios of 0.94 to 1.24.

The results for the other two time periods are generally similar to those for 2008-10: (a) fairly small differences in variability, (b) right-tail differences for factors with well-established mean differences, and (c) relatively equal right-tail proportions when mean differences are accounted for—in other words, the right-tail differences do not appear to be due to differences in variability, for the most part.

The Flynn Effect in the Right Tail of the U.S. as a Function of Sex, Race/Ethnicity, and SES

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Are the smart getting smarter? The Flynn effect has been documented around the world in the left tail and at the mean. However, whether the effect holds for the right tail—the top 5%—until recent years remained unknown. Using a sample of over 1.7 million 5th, 6th, and 7th grade student test scores of intellectually talented students from the top 5% on the SAT, ACT, and EXPLORE—partof the Duke University Talent Identification Program Talent Search—wefirst investigatedwhether the effect waspresent in the right tail overall andwhether it variedas a function of sex. Next, we exploredwhether the effect waspresent for various racial/ethnicsubgroups overall andthen whether results differed by sex and SES within these subgroups.According to preliminary results, the effect was found overall in the top 5% and was primarily concentrated on the math subtests. Gains appeared to be slightly larger for females than males, but this effect was not uniform across the measures. The effect was also found within various racial/ethnic subgroupsin the top 5%, again primarily concentrated on the math subtests. Withinsubgroup gains wereagain mostly similar for males and females, but the gains were not uniform across the measures or across the racial/ethnic subgroups examined. For example within the low SES Caucasian subgroup females appeared to show much larger gains than males on several measures. Although the Flynn effect appears to be present within a wide range of subgroups in the right tail of the U.S. ability distribution, it remains unclear whether the gains are real intelligence gains or due to other factors.

Modeling the Effects of Brain Volumes on Cognition Using Parcelated Whole Brain MRI

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Brain volumes reflect consequences of both aging and disease. Consequently, structural MRI has emerged as an important tool for predicting cognitive function in the aged. Automated parcelation programs, such as FreeSurfer, make anatomically detailed measures of brain volume feasible in large study cohorts, but at the same time create the analytical challenge of how to model appropriately effects of a large number of correlated predictor variables. This study examines two questions: First, is a latent-variable modeling (LVM) approach to the regional brain measures feasible in the sense of yielding models that fit well and that correspond well to the brain's anatomy? Second, does application of this approach improve models of how brain volumes correlate with cognition in the aged?

Using data from the Alzheimer's Disease Neuroimaging Initiative, or ADNI, from 819 older adults with syndromatic diagnoses of dementia, mild cognitive impairment (MCI), and normal cognition, we used factor analytic methods to create a latent variable measurement model of the FreeSurfer brain volumes. The final model, which fit the data extremely well, has 12 region of interest (ROI) factors (e.g. Left Frontal, Cingulate, etc.), a second-order Medial Temporal Lobe Factor, and 4 factors that captured lateralization patterns. We then used these factors to explain cognitive performance. Compared to simple approaches for modeling brain atrophy, such as measuring hippocampal volume and total cortical gray matter, the LVM approach improved increased the percent of variance accounted for by 2-3 fold. We conclude that LVM of brain volumes is both a feasible and useful approach to incorporating high-resolution volumetric MRI information in models of cognitive function in aging.

SYMPOSIA

Symposia are organized in order of presentation time

Names of students eligible for the John B. Caroll Award for Research Methodology are marked with an asterisk

SYMPOSIUM 1

Applying Behavioural Genetic Methodology to Educationally Relevant Questions

Symposium Chair: Yulia Kovas[1,2]
Discussant: Sergey Malykh[1]

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The current symposium brings together four studies that use behavioural genetic methodology in different ways to address important questions concerning educationally relevant traits. The first study (**Petrill et al.)** applied twin methodology to the issue of genetic and environmental overlap between estimation, mathematical and reading variation in a sample of US twins. The second study (**Rodic et al.**) used behavioural genomic analyses to examine whether variation in the regions of the genome associated with known genetic syndromes also explains normal variation in cognitive traits. The third study (**Voronin et al.**) used multivariate analyses to compare the relative contribution of genetic and environmental factors to numeracy, literacy, and g across the early school years. Finally, the fourth study (**Tosto et al.**) used multivariate twin methodology to examine the sources of the relationship between 'number sense', mathematical ability, and g in UK twins. Interestingly, the results of this study are partly inconsistent with the results of the first study, calling for further investigation, but also careful examination of the differences between the two samples. Together these four studies demonstrate the potential of behavioural genetic research to provide important insights into the origins and mechanisms through which individual differences in human intelligence and achievement emerge.

Multivariate Genetic Analysis of Math Cognition in the Context of Psychometric Math and Reading Skills

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Behavioral genetic studies suggest that 2/3 to 3/4 of the genetic variance, and nearly all of the common environmental variance, is shared between reading/reading disability (RD) and math/math disability (MD). At the same time, roughly 1/4 to 1/3 of the genetic variance is independent, suggesting some level of etiological independence. Using the Western Reserve Reading and Math Projects Sample (WRRMP: N = 436 identical and same-sex fraternal twin pairs), we examined whether numeric estimation explained a portion of the genetic variance contributing to the independence between psychometric math and reading skills. Univariate analyses suggested that variance in numeric estimation was explained by both genetic and environmental variation (h2 = .58, c2 = .15, e2 = .25). Multivariate genetic analyses using latent factors suggested that 7% of the total variance in numeric estimation could be explained by general genetic factors between psychometric math and reading. An additional 6% of the total variation in numeric estimation was explained by genetic factors related to psychometric math, but separate from psychometric reading. A further 45% of the genetic variation in numeric estimation was independent from both psychometric reading and math skills. In contrast, shared environmental influences were associated with a general factor across psychometric reading and psychometric math. These results suggest that processes related to numeric estimation, although tied to psychometric reading through some genetic and environmental sources of variation, may explain a portion of the genetic independence between reading and math skills. We are currently conducting imaging studies examining the relationship between numeric estimation, reading and math to examine whether these independent genetic effects can be isolated to distinct brain areas (e.g. interparietal sulcus).

From Genetic Disorder to Normal Variation: Do Genetic Markers Associated with Numerical and Spatial Cognition in Known Genetic Disorders Play a Role in Normal Variation in Mathematical Ability?

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Introduction: Evidence from the multivariate genetic research suggests that most cognitive abilities and disabilities are largely affected by a single set of genes (Butcher et al., 2006). To identify common genetic variants that might be associated with mathematical, numerical and spatial cognition we have conducted a genetic association study analysing single nucleotide polymorphisms (SNPs) from the genetic regions affected in four genetic syndromes (i.e. Down's, Williams, Prader-Willi, and DiGeorge). These syndromes were chosen as they have specific mathematical, numerical and spatial cognition profiles. The hypothesis that genetic regions affected in genetic disorders contain variants that might contribute to normal variation in mathematical traits has never been systematically tested before.

Method: The sample included 3154, 7-16-year-olds from the Twin Early Development Study (TEDS) with data available for 33 phenotypes relating to mathematical ability, numerical and spatial cognition, general intelligence, as well as the genome-wide DNA markers (over 1mln SNPs). Phenotypic data was collected when participants were age 7,9,10, 12 and 16 using different approaches (i.e. teacher reports, telephone interviews and on-line administration). All available SNPs in the following regions (associated with specific genetic syndromes) were used for the analyses: 7q11.22 (Williams syndrome); 15q11-13 (Prader-Willi syndrome); 22q11.2 (DiGeorge syndrome); and 23,091 SNP on chromosome 21 (Down's syndrome).

Results: In the area 7q11.23, two SNPs were found to be significantly associated with two mathematically related phenotypes after passing demanding criterion of $p < 1.57E-4$ corrected for multiple testing: rs6964590, p=4.92E-05 associated with the teacher assed maths achievement at age 7; and rs4728289, associated with the teacher assed children's maths achievement at age 10.

In area 15q11-13, a criterion of $p < 2.62E-05$ corrected for multiple testing was met by two SNPs: rs3826092 and rs744776. Both SNPs fall in the RYR3 gene area and both were associated with g (composite of 4 tests: conceptual grouping, similarities, vocabulary and picture completion). Further, 4 SNPs (rs5006363, rs8030140 and rs8029691 falling at the TUBGCP5 gene area and rs12591064 falling outside any gene area) were significantly associated with mathematics performance on computerised tests at age 16.

In the area 22q11.2, one SNP (rs361988 found in the area of KLHL22 gene) was significantly associated with a score on Raven progressive matrices at age 16. Another 6 SNPs were found to be significantly associated with the scores on an estimation task (rs674478 outside any gene area; rs5751939 overlapping area of the PI4KA and SERPIND1 genes; rs5760343 and rs6004060, both belonging to the area of PI4KA gene; and rs10483104 and rs5752165, both belonging to the area of SNAP29 gene).

In chromosome 21 region, no SNP associations met the demanding criterion of $p<8.16E-06$ corrected for multiple testing.

Conclusions: Although the results need to be replicated, they suggest that, in line with the previous research (Butcher et al., 2006; Docherty et al., 2010), and similar to other quantitative traits, such as height, different cognitive abilities are affected by many genes of small effects. Mutations, associated with known genetic syndromes, explain at least some of the normal variation in cognitive traits. However, as our results show only a few significant associations, it is possible that genetic influences on these cognitive abilities are not well tagged by common SNPs in the areas that we have tested.

Heritability of Literacy and Numeracy Is Higher Than That of G in the Early School Years

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Introduction: The aim of our study was to compare heritability of reading, mathematical and general cognitive ability (g) in the early school years. Previous research suggested differences in the relative contributions of genes and environments to these traits (e.g., Kovas et al., 2007), in that literacy and numeracy were found to be twice more heritable than g.

Method: We applied the Common Pathway model to several measures of each ability (literacy, numeracy, and g). The model allows to estimate genetic, common environmental, and unique environmental influences on phenotypic variance under the assumption that cross-trait covariance is mediated by a common latent factor. Our participants were 11,000 twin pairs, at ages 7, 9 and 12 from The Twins Early Development Study (TEDS, Oliver & Plomin, 2007). Reading and mathematics were measured by teacher ratings (at all ages) and Web-tests (at age 12 only). For reading, telephone measures were also available at ages 7 and 12. General abilities were measured via booklet (at 7 and 9) and Web (at 12) formats. For analysis we used OpenMx package for R environment for statistical computations (Boker et al., 2011, R Development Core Team, 2012). Models were fit using full information maximum likelihood method.

Results and Conclusions: The overall results of the Common Pathway model show that heritability of literacy and numeracy (68% and 65% on average) are twice higher than heritability of g (32% on average) at all examined ages. It is possible that higher heritability of reading and mathematics can be explained by the high homogeneity of conditions of their development. For example, the UK National Curriculum provides high uniformity and therefore may decrease the environmental contribution to the variance in these traits. On the contrary, g is not explicitly taught at schools, and therefore may be under highly variable environmental influences across individuals.

The Myth of Maths: Is There Anything 'Special' about It?

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Introduction: Despite much research, many questions about the origins of individual differences in mathematical abilities remain unanswered. In addition, the aetiology of the relationship between mathematics and other abilities and the causes of gender differences in mathematics are still poorly understood. The ability to discriminate more from less and to estimate numerical magnitudes, have been recently found to be associated with mathematical performance and achievement. These abilities, known as "number sense", have been reported for human infants and across many animal species – suggesting it is an evolutionary preserved trait. However, it is not known whether the variation in number sense skills is also largely driven by genetic factors.

Method: We conducted the first large scale genetically sensitive investigation into the variation in number sense and its co-variation with other traits - assessing number sense, mathematics and general intelligence (g) in 3,589 16-year old twin pairs of the Twin Early Development Study (TEDS).

Results and Conclusions: The heritability of number sense was modest (.32) with no sex differences in the aetiology of individual differences. The low genetic estimate supports a direction selection whereby for traits successfully transmitted through generations, the genetic variance is reduced. Non shared environmental influences largely explained the observed variation in number sense. The absence of mean or aetiological gender differences in number sense suggests that the observed sex differences in mathematics may be driven by factors not related to number sense. We further investigated the aetiology of the relationship between number sense, mathematics and g. The genetic correlation between mathematics and number sense was high (.57). The phenotypic correlation between number sense and mathematics was modest (.28), but largely mediated by common genetic factors (~75%). The genetic correlation between number sense and g was higher compared to mathematics (.68), and their phenotypic correlation (.24) was entirely mediated by common genetic factors (93%). Further, most of the genetic variance in number sense and mathematics was explained by genetic factors in common with g. These results suggest that the observed association between number sense and mathematics is in fact largely mediated by general intelligence.

SYMPOSIUM 2

Flynn Effect

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Test-Taking Patterns Have Changed over Time

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The Flynn Effect (FE) is the result of different influences on the person's capacity to take IQ tests. The answers to the IQ test items are usually coded as right, wrong and missing. We found that the pattern of providing answers has changed over time. Two cohorts (1933/36 and 2006) of Estonian students (N=1803) are compared on the basis of using the Estonian National Intelligence Test. During this 72-year time period, there are some major changes in the test-taking behavior of students. There is rise not only in number of right answers (secular rise .79 SD), but the number of wrong answers has also increased (secular rise .15 SD). There were differences in the numbers of wrong answers between subtests; in some cases, the secular rise in wrong answers is more than 1 SD. The number of missing answers has clearly dropped. In 1933/36, the number of wrong answers did not correlate with the number of right answers, while in 2006, moderate correlation (r = -.34) emerged. In 2006, the number of missing and wrong answers had no correlation, while in 1933/36, small negative correlation (-.28) was found. We explain those findings in terms of test-taking motivation. The ambition to pass the test and the desire to provide correct answers have changed over time. Evidently an aggressive approach to test-taking (noncritical guessing of answers) is more applied by students and this may partly explain the FE. Wrong answers do not diminish the test score, yet random right answers raise the overall score.The FE is partly affected by the changes in using different test-taking patterns over time.

Item-Level Examination of the Flynn Effect

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The purpose of the current study was to examine the Flynn Effect (FE) in Estonia on the National Intelligence Test (NIT) given in 1933 and again in 2006. The NIT is a group-administered measure of cognitive ability designed for students in upper elementary and middle school grades. This study examined the following NIT subtests measuring Comprehension-Knowledge (Gc), Fluidability (Gf), or mental arithmetic (Gq): Analogies, Arithmetic, Computation, Information, LogicalSelections, Sentence Completion, Synonyms-Antonyms, and Vocabulary. We used Item Response Theory (IRT) for this study's analysis. IRT concurrently estimates both person and item parameters, which not only allows for an assessment of trait changes, but instrument changes (i.e., invariance) and the ability to adjust the trait estimates accordingly (i.e. equating).

Method: The first sample comes from students (n = 899) who were part of the original Estonian NIT norming sample, gathered in 1933/36 (mean: 13.4 years, σ: 1.31 years). The second sample was gathered in 2006 (n = 913) (mean: 13.5 years, σ: .93 years), and came from the same region as the first sample. FE estimation was done byusing four steps for each subtest (a) Determine which IRT model best fits a given subtest's data; (b) testing to see what items exhibit non-invariance/differential item functioning (DIF) between the 1934 and 2006 groups; (c) link the items not exhibiting DIF between the two time groups, and use linked items to equate the trait estimates; and (d) examine the meansand variances of the trait scores for both groups.

Results: For all subtests, a 2-parameter model was the best fit. The number of items exhibiting DIF ranged from 13-48%. As shown in Table 1, all subtests exhibited a FE except Computations. Therewere minimal differences in score variability except for the Information, Comparisons, Synonyms-Antonyms, where there was a noticeable decrease in variability.

Table 1. Effect Sizes for Flynn Effect

Subtest	Domain	ES	ES/Year
Analogies	Gf	1.02	0.014
Arithmetic	Gq	0.24	0.000
Computation	Gq	-0.10	-0.001
Information	Gc	0.44	0.006
Logical Selections	Gc	0.82	0.001
Sentence Completion	Gc	0.64	0.001
Synonyms-Antonyms	Gc	1.05	0.002
Vocabulary	Gc	0.79	0.011

Note. ES = Hedges' g; ES/Year = $ES_{2006-1934}$

Are International IQ Gaps Shrinking? Evidence from TIMSS and PISA

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IQ differences between countries most likely increased in the recent past as a result of vigorous Flynn effects in the economically most advanced nations. In some of these advanced nations, Flynn effects in adolescents and young adults have diminished or even reversed in recent years, while Flynn effects in less developed countries are being reported more frequently. However, it is not clear whether there is an overall worldwide trend towards diminishing international IQ differences.

The most important sources for systematic comparative studies of intelligence trends are international assessments of scholastic achievement. In the Trends in International Mathematics and Science (TIMSS) study, the performance of 8th-graders in mathematics and science has been tracked in a 4-year cycle between 1995 and 2007. In the OECD's Program of International Student Assessment (PISA), tests of mathematics, science and reading were administered in a 3-year cycle from 2000 to 2009.

The trend measure was defined as the difference between performance on the last and first assessment, with positive signs indicating improvement and negative signs indicating decline. Hypothesized predictors of the trends included growth in per-capita GDP measured 5 years before the dates of the first and last assessments, the trend in the average length of female education in the maternal generation approximately 0-10 years before the dates of the first and last assessments, and the extent of differential fertility by education in the country, according to data from the World Values Survey. It was hypothesized that countries with low performance on the initial assessment are more likely than those with higher performance to have a rising trend from the first to the last assessment.

In TIMSS, the correlation between the trend measure and performance on the first assessment was -.366, $p = .060$, $N = 27$ countries. In the most parsimonious regression model ($N = 21$ countries), the TIMSS trend was predicted by the TIMSS 1995 score ($\beta = -.721$, $p = 0.01$), rise in female education in the mother's generation ($\beta = .380$, $p = .041$), and differential fertility by education ($\beta = .596$, $p = .007$). In PISA, the correlation between the trend measure and performance on the first assessment was -.687, $p<.001$, $N = 31$ countries. In regression models, the PISA trend was predicted only by the PISA 2000 score.

Despite the short time series, these first results indicate that on a global scale, countries with (initially) low performance do indeed tend to catch up with performance in the higher scoring countries.

Continuing Rise of Cognitive Competence in US NAEP 1971-2008

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The National Assessment of Educational Progress study (NAEP) measures competences of 9, 13 and 17 years old students in US representative samples. The surveys report academic achievement in reading and mathematics. To solve them domain specific knowledge and intelligence are necessary. Both scales together measure a mixture of general intelligence and specific knowledge, covered by the construct *cognitive competence* (interchangeably with cognitive ability).

The NAEP 2008 report (Rampey et al., 2009) presents data from 1971 to 2008 in 0-500 point scales without giving SDs, but with results for percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}). From this given information SDs were calculated and results were transformed into IQs.

Past decades' increases in *mathematics* (1.98 IQ/dc) are larger than in reading (0.54 IQ/dc). Increases are larger for *younger* students than for older students (9y: 2.15 IQ/dc; 13y: 1.29 IQ; 17y: 0.34 IQ). The average increase for Whites is 1.23 IQ/dc, Blacks 2.96 IQ/dc, and Hispanics 2.07 IQ/dc. *White-Black-differences* were reduced from 16 IQ to 10 IQ, the increase in 1971 norms to 2008 were from 103 to 107 (Whites), 87 to 97 (Blacks), and 91 to 99 (Hispanics).

The *total increase* from 1971 to 2008 is 3.97 IQ (from IQ 100 to 104; per decade: 1.07 IQ/dc; weighting data quality: 1.26 IQ/dc). Hypothetically, assuming a non-changing racial-ethnic population (2008 as if 1971: 81% Whites, 14% Blacks, 5% Hispanics), the mean gain would have been 1.75 IQ points higher (IQ 106). Hypothetically, without gap-narrowing between Whites and the two other groups, the mean gain would have been 2.22 IQ points lower (IQ 102).

Taking the cognitive competence level of 17 year old students as a proxy for the workforce of the US economy, their 0.58 IQ gain in the period 1971-2008 suggests that the GDP increase due to the IQ gain (1 IQ point for 738 $ per year and capita) is only 428 US Dollar. So the large economic growth between 1971 and 2008 is hardly due to a cognitive rise in this period. Had the population composition not changed, the mean IQ would be higher (1.81 IQ) representing 1,335 $ per year and capita, but due to gap-narrowing it gained 2.55 IQ standing for 1,882 $.

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Assessing the Impacts of Historical Changes in IQ: Dysgenesis vs. the Flynn Effect

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Reconstructed changes in Western genotypic IQ means which trend in the same direction as the Western historical status-fertility relation (i.e. positively up until the early to mid 1800's and then negatively after) are strong predictors of changes in the per capita rates of innovation in science and technology (Woodley, 2012). A prediction from 'smart fraction' theory is that this effect should be strongly mediated by changes in the numbers of eminent individuals, i.e. those who actually generate innovation. This is tested using a newly calculated Western historical genotypic IQ index, along with data on per capita innovation rates (Huebner, 2005) and per capita eminent individuals (Murray, 2003). In testing the theory we employed a combination of growth curve and hierarchically nested path analysis in which serially autoregressive and Flynn effects over time are considered along with model constraints based on heritability estimates. Consistent with smart fraction theory, eminent individuals mediate the impact of changing genotypic IQ on innovation rates (IQ.g → Eminent individuals = β =.91; Eminent individuals → Innovation rates = β =.45), whereas rising phenotypic IQ has had no effect on either the numbers of eminent individuals, or innovation rates. This is consistent with the finding that dysgenic fertility is a Jensen effect (Woodley &Meisenberg, in press), unlike the Flynn effect (teNijenhuis, in press), indicating that dysgenesis is principally associated with a decline in 'genetic *g*' whereas the Flynn effect is simultaneously associated with secular gains mostly in 'narrow' abilities. These findings are evaluated in the context of a multilevel selection model developed by Figueredo (2012), first suggested by Hamilton (2000), which proposes that innovation represents a group-selected altruistic behavior due to the low individual benefits documented for the innovators and the huge collective benefits documented for the group (Clark, 2007). One prediction of this multilevel selection model connects individual-level selection for a declining within-population mean IQ with group-level selection for a rising between-population mean IQ. The dynamics of these two opposing processes during the last half-millennium are presented as supportive of this model.

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SYMPOSIUM 3

Manifold Inconstancy Effects in Life History and Intelligence

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In this symposium, we explore both the theory and the evidence supporting the existence and the commonalities among several different forms of what we propose to designate as Manifold Inconstancy Effects in both human life history strategy and general intelligence. These studies follow directly as generalizations of the principles and methods presented by members of our group at ISIR 2011 in Limassol, Cyprus.

In the first presentation, **A.J. Figueredo**, Michael Woodley, Sacha Brown, and Kari Ross present evidence from two college student samples and two nationally-representative US samples supporting the Strategic Differentiation-Integration Effort (*SD-IE*) Hypothesis, which is a generalization to Life History Strategy (*K*) of the Cognitive Differentiation-Integration Effort (*CD-IE*) Hypothesis, specifying equivalent effects upon the latent structure of *g* rather than *K*, that was presented and supported empirically at last year's ISIR meeting, and is a direct analogue to Spearman's Law of Diminishing Returns (*SLODR*) for the positive manifold of life history traits underlying much of human and nonhuman reproductive strategy.

In the second presentation, **Rafael Garcia**, Michael Woodley, Sacha Brown, Kari Ross, Tommy Cabeza de Baca, & A.J. Figueredo present evidence supporting a generalization of the phenomenon of Manifold Inconstancy Effects (such as *CD-IE, SD-IE,* and *SLODR*) to both human life history strategy and general intelligence at the level of these higher-order factors. In this case, although statistically significant manifold inconstancy effects were found, some reversals in the directionality of the effects appeared as compared with the results for *SD-IE* reported in the immediately previous presentation. These analyses were performed on a subset of the data used in the previous presentation that also contained some indicators of different constructs to which the same theoretical and analytical models were extended.

In the third presentation, **Tommy Cabeza De Baca**, Michael Woodley, Ashley Jordan, Sacha Brown, Kari Ross, Rafael Garcia & A.J. Figueredo present evidence supporting how such Manifold Inconstancy Effects can contribute to our understanding of the relations among human life history strategy, general intelligence, and the philosophical/ideological orientation of *meliorism* that is reputed to be widespread among social scientists, leading to the construction of affective barriers to the acceptance of the Modern Neo-Darwinian Synthesis that is currently dominant in evolutionary theory. The data on *meliorism* were obtained from a University Faculty sample, but was supplemented with data on socially desirable responding in one of our college student samples.

In the fourth and final presentation, **Michael Woodley**, serving as discussant for the symposium as a whole, will integrate all of these findings under a common theoretical rubric, based on the common biological mechanisms presumably undergirding all of them.

Multiple Successful Tests of the Strategic Differentiation-Integration (SD-IE) Hypothesis: A Life History Strategy Analogue to Spearman's Law of Diminishing Returns

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The Strategic Differentiation-Integration Effort *(SD-IE)* hypothesis predicts regulation by life history speed *(K)* of the magnitudes of the correlations among its components, such that individuals with slower life history strategies exhibit life history traits that are less correlated with each other than individuals with faster life history strategies, analogously to Spearman's Law of Diminishing Returns (*SLODR*) in the latent structure of general intelligence *(g)*. This means that high-*K* individuals should be *conatively differentiated* with respect to their life history traits (*SD-IE*) as well as *cognitively differentiated* with respect to their mental abilities (*CD-IE*). Strategic specialization with respect to various domain-specific resource allocations should permit resource polymorphism under conditions of elevated social competition (Woodley, 2011). *SD-IE* can thus be viewed as a direct consequence of the *Coral Reef Model* of individual differences in personality, wherein centripetal or *disruptive* selective pressures due to social competition produce intraspecific character displacement and competitive release through socio-ecological niche-splitting (Figueredo et al., 2005, 2011), stipulating that high-*K* populations: (1) are subject to greater intraspecific competitive pressures due to higher and more stable population densities; and (2) tend towards *mutualistic* ("prosocial") rather than *antagonistic* ("antisocial") strategies of social interaction, whether cooperative or competitive (Figueredo & Jacobs, 2010). We examined the predictions of *SD-IE* using data from two college student convenience samples, one all-female sample and one mixed-sex sample, as well as two nationally-representative samples of the US population, the *MIDUS (National Survey of Midlife Development in the United States)* and the *NLSY (National Longitudinal Survey of Youth)*.

For both student samples, three lower-order and one higher-order slow life history factors were constructed from component scales of the ALHB (constituting the *K*-Factor), the SF-36 (constituting the Covitality Factor), and the NEO-FFI (constituting the General Factor of Personality or *GFP*). Parallel lower-order and higher-order slow life history factors were constructed from selected scales of the MIDUS Survey in which it previously had been shown that both their genetic and phenotypic covariances yielded an equivalent latent structure (Figueredo et al., 2004, 2007). In these three samples, the same set of indicators of the three lower-order factors as well as the single higher-order factor (*Super-K*) was constructed and tested parametrically for factorial invariance: (1) *K*-Factor indicators were *Insight, Planning, and Control, Mother and Father Relationship Quality, Family Social Contact and Support, Friends Social Contact and Support, Romantic Partner Attachment, General Social Altruism,* and *Religiosity*; (2) Covitality indicators were *Mental Functioning* and *Physical Functioning*; (3) *GFP* indicators were *Openness to Experience, Conscientiousness, Extraversion, Agreeableness,* and *Emotional Stability*. A conceptually related general slow life history factors was constructed from a selection of psychosocial indicators from the *NLSY* data: *Self-Esteem*, *Happiness* or *Subjective Well-Being*, *Delay of Gratification*, *Sociability*, *Trust*, *Self-Concept*, and *Internal Locus of Control*. Applying the Continuous Parameter Estimation Method (*CPEM*), the predicted *SD-IE* effects were found statistically significant and in the expected negative direction among most indicators of the lower-order slow life history factors (11/14 in the combined student sample; 13/14 in the *MIDUS* sample; 7/7 in the *NLSY* sample) and among all indicators of the single higher-order slow life history *Super-K* factor (3/3 in all samples tested).

SYMPOSIA

Evidence for Two New Cognitive and Conative 'Manifold Inconstancy' Effects

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The family of *manifold inconstancy effects* (the tendency for the *strength* of a latent variable to change as a function of the *level* of a variable), which includes Spearman's Law of Diminishing Returns (SLODR, which is a weakening of the strength of *g* as a function of level of *g*) and the differentiation hypothesis (a weakening of *g* as a function of age), have been expanded to include two new effects: the Cognitive Differentiation-Integration Effort effect (CD-IE), which involves a weakening of *g* as a function of the speed of life history (*K*) and the Strategic Differentiation-Integration Effort effect (SD-IE), which is a SLODR-like effect of *K* upon its own indicators. We present evidence for two types of manifold inconstancy effect: (1) Type 1 Manifold Inconstancy Effects are SLODR-like effects of the level of *g* on the strength of the *K* factor, which should manifest such that individuals with lower *g* exhibit less life history polyethism than those with higher *g*, irrespective of their level of *K*; and (2) Type 2 Manifold Inconstancy Effects are general differentiation effect, which should manifest on both cognitive (*g*) and conative (*K*) factors when correlated. This general differentiation integrates CD-IE and SD-IE within a common theoretical framework.

We obtained multiple indicators of life history strategy (*K)*, emotional intelligence (*EI*), executive functioning (*EF*)) and general intelligence (*g)*, on a sample of 104 college students. We observed strong correlations among the three broadly-defined life history traits, from which we constructed a single higher-order unit-weighted factor (*Super-K*), but not between this *Super-K* factor and *g*. We then applied the Continuous Parameter Estimate Model (*CPEM*), which produces individual-level estimates of the strength of the association between variables, to test for both Type 1 Effects (the SLODR-like effect of *g* on *K*) and Type 2 Effects (general strategic differentiation) by examining the systematic variations in: (1) the factor loadings of the higher-order *Super-K* Factor, which included K (indicated by the 8 component scales of the ALHB), EF Factor (indicated by the 4 behavioural Regulation Scales of the BRIEF-A), and EI (indicated by the 15 subscales of the TEIQue); (2) the bivariate inter-factor correlation between *Super-K* and *g* (indicated by the Vocabulary and Abstraction Subtests of the SILS).

The expected effects of the absolute level *g* upon the factor loadings on the *Super-K* indicators were negative Type 1 Manifold Inconstancy Effects. The observed effect of *g* on the factor loading of *Super-K* on EF was statistically significant and negative (r=-.20, p<.05), whereas the observed effect of *g* on the factor loadings of *Super-K* on *K* (r=-.11, p>.05) and *EI* (r=-.19, p>.05) were not statistically significant. The expected effects of the absolute level of the *Super-K* Factor upon its own indicators' factor loadings were negative Type 2 Manifold Inconstancy Effects. The observed effect of *Super-K* Factor on the factor loadings of both *K* (r=.36, p<.05) and *EI* (r=.29, p<.05) were statistically significant and positive, whereas the observed effect of *Super-K* on the factor loading of *Super-K* on EF (r=-.05, p>.05) was not statistically significant. The expected effects of the absolute level of both *g* and *Super-K* on the bivariate inter-factor correlation between *g* and *Super-K* were negative Type 2 Manifold Inconstancy Effects. The observed effect of *Super-K* on the bivariate inter-factor correlation was statistically significant and negative (r=-.23, p<.05), whereas the observed effect of *g* on the bivariate inter-factor correlation was not statistically significant (r=-.07, p>.05). Similar effects were also tested upon other independent college student samples.

Meliorism, General Intelligence, and Life History Strategy: 'Clever Silly' or 'Crazy Like a Fox'?

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Scholars (Conway, 1992; Kimble, 1984) have long theorized that among psychological sub-fields, individuals drawn toward each sub-field vary based on personality and attitudes – influencing their conceptualizations and interpretations of results. Charlesworth (1994) specifically highlighted that meliorism, the belief that humans can wholly ameliorate the suffering of vulnerable populations by inequitably distributing social afflictions toward less-vulnerable groups, would be present among scholars in developmental psychology (and its related sub-fields). Any world-belief perceived as being in opposition to meliorism would be rejected and/or silenced by such individuals. Recently, Woodley (2010) posited an alternative explanation to the melioristic hypothesis proposed by Charlesworth (1992). The modified clever sillies hypothesis (Woodley, 2010) proposed that melioristic attitudes in academia are the result of costly signaling (e.g., altruistic or charitable monetary donations that seek to promote the status and prestige of the individual performing the task) and intelligent social manipulation (e.g., because academia is politically polarized to the left, it would make sense to attune and assimilate to the prevailing social morés in order to garner status). Thus, we would expect to see that individuals in certain psychological sub-fields of academia are disproportionately high on melioristic attitudes, intelligence, and socially desirable responding.

We report preliminary evidence showing that students and faculty members in family studies and human development departments with higher levels of melioristic beliefs were more likely to reject the theory of natural selection based on affective reactions (e.g., political and religious; Cabeza De Baca, 2012; King & Cabeza De Baca, 2011), supporting Charlesworth's (1992) hypothesis. These data also supported the hypothesis that slow life history individuals tended towards melioristic attitudes, and that the effect of slow life history on the presence of affective barriers to accepting the theory of natural selection was partially mediated by these melioristic attitudes. Because previous studies did not include measures of intelligence or socially desirable responding, however, the modified clever sillies hypothesis could not be directly tested.

As a follow-up, we sought to investigate the association between general intelligence (g), slow life history (K), and socially desirable responding (SDR) in general. Results from a multiple regression on an independent sample of 104 college students found that only K significantly and positively influenced SDR ($\beta = .60$, $p < .05$) while g ($\beta = -.74$, $p > .05$) and the g*K interaction ($\beta = -.74$, $p > .05$) were not statistically significant. The Continuous Parameter Estimation Method (CPEM) was also utilized to estimate the associations of SDR with varying levels g and K, revealing that individuals higher in K had significantly higher correlations of SDR with K ($r = .30$, $p < .05$) and significantly lower correlations of SDR with g ($r = -.25$, $p < .05$). Individuals higher on g had significantly lower correlations of SDR with K ($r = .21$, $p < .05$), whereas there was no significant effect of g on the correlation of SDR with g. These results show that slower life history strategists tend to have higher levels of socially desirable responding, but that when g increases, socially desirable responding tends to decrease. The convergent results support our interpretations of the effects of meliorism on affective attitudes towards evolutionary theory.

Discussant:
Manifold Inconstancy Effects in Life History and Intelligence

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The results presented in the SD-IE effect talk strongly compliment the growing corpus of data from both convenience and nationally representative samples, which consistently indicate that conative specialization at high-K is the norm. The results from the talk in which two new cognitive and conative manifold inconstancy effects were elucidated add to the family of effects, and taken as a whole corroborate long standing predictions by a number of researchers (e.g., Woodley, Figueredo, Miller, & Brand). It is proposed that Type 1 Manifold Inconstancy Effects should be rebranded as Mutation-Inhibited Differentiation (MID) effects, as their proposed mechanism of operation stems from the idea that high mutation load increases the number and strength of genetic correlations between brain regions associated with different conative sub-systems, thus increasing their integration and preventing differentiation. This is the same mechanism as that proposed by Miller (2001) for SLODR, and the effect encompasses the reasonably well-replicated Differentiation of Personality by Intelligence (DOPBI) phenomenon, first predicted by Brand (1994). A key difference is that in this study, we are examining the effect of g on the most general conative factor (K), whereas in previous studies of DOPBI, separate personality dimensions were employed.

The existence of MID as an overarching framework for the above effects permits for an integrative, theoretical framework to be developed in which there are two, largely genetically exclusive sources of individual differences (g and K), each of which have separate and also synergistic reciprocal effects on their respective factor structures. Evidence for this 'Two Source' model of trait variance comes from the successful tests of the Type 2 Manifold Inconstancy Effects or 'general differentiation' (GD) hypothesis, which indicate that the effects of both g and Super-K on the bivariate inter-factor correlation between the two were negative as predicted, albeit non-significantly so in the case of using g as the predictor.

The absence of an interaction effect between g and K in socially desirable responding suggests that both factors are associated with different domains of what could broadly be socially desirable responding. K could be more strongly related to the capacity to strategically modulate response style at the intra-personal level, which is consistent with its performance in the study, as it is being used to predict a factor that very much taps intra-personal level conation (i.e. adaptive self-deception). g on the other hand may relate to the articulation of explicit rationales for socially desirable beliefs, which aid in inter-personal interactions (an explicit rationale for a belief doesn't necessarily correspond to a deeply held conviction). This could explain why g correlates with the holding of 'normatively central' political orientations (e.g. Deary, Batty & Gale, 2008; Rindermann, Florez-Mendoza & Woodley, 2011), but life history indicators (i.e. the GFP) do not (Bell, Woodley, Aitken-Schermer & Vernon, 2012). Political orientations constitute a form of inter-personal token of desirable personality, hence the appeal of certain popular and contextually socially desirable ideologies to those with high-g constitutes evidence for a 'domain specific' variant of the modified clever sillies hypothesis – one in which the belief clusters may actually serve the ulterior motives of socially desirable self-presentation (for example, pretending to be either a socialist, feminist, or environmentalist in college, when one is actually not, so as to enhance one's access to social and sexual resources).

SYMPOSIUM 4

Improving Intelligence

Organizers: Susanne Jaeggi[1] & Roberto Colom[2]

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Studies attempting to improve intelligence by means of short-term interventions targeting working memory skills have captured some attention from scientists and the media. This symposium presents recent data from several research groups and discusses potential implications for the intelligence construct. **Earl Hunt** (Prof. Emeritus, U. of Washington) will provide an overview and introduce the current discussion in this specific field. **Roberto Colom** (Professor of Psychology, Universidad Autónoma de Madrid) will show behavioral data from a working memory training study and illustrate some accompanying neural correlates. **Clayton Stephenson** (Lecturer, U. of Southern California) will present his working memory training data and discuss those findings in relation to other work that aims to improve intelligence. **Louis Matzel** (Prof. of Psychology, Rutgers University) will offer his perspectives from animal research providing insights into potential causal mechanisms of working memory improvements and their impact on intelligence. **Susanne Jaeggi** (Asst. Prof. of Psychology, University of Maryland) will review the current cognitive intervention research, discuss main challenges and offer ideas regarding how to tackle unresolved issues in order to get at the underlying mechanisms of training and transfer. Finally, **Richard Haier** (Prof. Emeritus, U. California, Irvine) will discuss the presented studies and perspectives within the frame of brain research and he will also lead the discussion among participants.

When Is Intelligence Improved?

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Improving intelligence is not a cottage industry! Books, websites, training programs, and even commercial pharmaceuticals claim to do this. Many claims make mystical use of the word "neuroscience," implying that there has been some great new discovery about brain processes. I argue that the word intelligence may refer to knowledge, absolute cognitive power, and relative cognitive power. Intelligence in the first two senses is easy to improve, intelligence in the third sense is not. I also consider the relation between advances in the neurosciences and the improvement of intelligence. I propose criteria to be met by claims to improve intelligence.

Can Intelligence Be Improved By Adaptive Working Memory (n Back) Training?

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Scientists have raised concerns regarding reports of putative improvements in intelligence following adaptive working memory training based on the n back task. The main reservation concerns how intelligence changes are evaluated using a single measure rather than the preferred method based on a test battery. Here we measure fluid/abstract intelligence (Gf), crystallized/verbal intelligence (Gc), working memory capacity (WMC), and attention (ATT) using a battery of several diverse measures, with equivalent test versions, for estimating any changes after training. Two groups of 28 women each were selected and matched for their general mental ability scores and demographic variables. Under strict supervision in the laboratory, the training group completed an intensive adaptive training program based on the n-back task (visual, auditory, and dual) across 24 sessions distributed in 12 weeks. Results showed this group had the expected systematic improvements in the task overtime (achieved average n back level = 5.13, SD = 1.7) and n-back performance systematically correlated with Gf, Gc, and WMC but not with ATT across sessions. However, (a) improvements in n back performance were not correlated with Gf, Gc, and WMC, and (b) average intelligence score differences between the training and control groups (posttest minus pretest) did not show systematic differences. Thus, for instance, even when the difference in Gf favoring the training group is marginally significant ($p = .052$) it is mainly due to one of three measures comprising the Gf construct. Also, although the average difference in WMC is not significant, two out of the three specific WMC measures show a significant advantage of the training group, suggesting the training did improve working memory. In summary, this study, based on multiple measures, finds no compelling evidence that fluid intelligence is improved by adaptive cognitive training on the n back task. Nevertheless, difficulties for replicating previous findings might be attributed to small but significant discrepancies in the administered training program (intensive vs extensive), the consideration of females only, the combination of speeded and power intelligence tests, and so forth. In any case, it is clear that studies with multiple measures are necessary to understand whether, and under what conditions, any cognitive training effects generalize to constructs like intelligence.

Improving Intelligence (or Any Cognitive Ability) May Require a Visuospatial Component

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So far, the majority of research and popular training to improve fluid intelligence has a strong visuospatial component. Is the visuospatial component a requirement for people to experience improvements? Our research suggests that a visuospatial component is necessary, but that the training does not have to be a working memory task such as the n-back task. In theory, higher scores on tests of fluid intelligence predicts higher performance on other tests of cognitive abilities, but does improvement in scores transfer to other complex cognitive functions such as critical thinking? We will address the issue of potential far transfer as a result of cognitive training.

Variations in Intelligence: Working Memory and Dopaminergic Modulation

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Here we describe the psychological processes and molecular mechanisms that regulate the expression of a trait analogous to intelligence in genetically heterogeneous laboratory mice. We have found a robust general factor that accounts for 30-50% of the variance of individual animals across as many as 10 different tests of learning, reasoning, and attention, and this factor underlies a core trait that we refer to as "general cognitive ability". As in humans, variations between individuals in the expression of general cognitive abilities are strongly predicted by the capacity of working memory, and working memory training with a high demand on selective attention promotes improvements in these abilities. We have found that a large percentage of the variance in innate general cognitive performance is accounted for by a small number of dopaminergic (D1 related) genes in the medial and dorsolateral prefrontal cortex. Furthermore, the efficacy of dopamine D1 signalling in these areas is positively related to the expression of general cognitive abilities (and working memory performance). Importantly, these same signalling properties are up-regulated by working memory training. We conclude that working memory capacity is a critical determinant of general cognitive abilities, that working memory performance is regulated (in part) by dopamine signalling in the prefrontal cortex, and that working memory training potentiates the same signalling pathways that regulate innate general cognitive abilities.

Improving Intelligence: Recent Past, Present, and Imminent Future

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Brain training and the study of transfer and plasticity are a current hot topic in cognitive science, especially when it comes to interventions that target fluid intelligence and general mental capacity. While some have argued that there is no evidence for improved intelligence as a function of cognitive training, others have pointed out accumulating evidence that training on working memory and executive control can be, indeed, effective. In this talk, I will provide evidence for the efficacy of several working memory interventions developed in our labs and review the current literature coming from other labs. I will show data that demonstrate transfer to measures of fluid intelligence throughout the lifespan, that is, in young adults, in old adults, in typically developing children, as well as children with ADHD. However, I will also discuss data indicating that such transfer effects can be elusive, and that not all the effects seem replicable. I will argue that instead of taking inconsistencies as a proof for a lack of efficacy, researchers need to develop innovative approaches to move the cognitive training literature beyond the simple question of whether or not training is effective, and to address questions of underlying mechanisms, individual differences, and training features and parameters that might mediate and moderate the efficacy of training.

Intelligence and Cold Fusion

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A recent series of high profile reports claim that intelligence can be increased by adaptive training based on some unspecified combination of memory span and attentional control. In my view, like the Cold Fusion claims from 1989, there is less here than meets the eye. The Cold Fusion claims had enormous publicity but researchers experienced with heat measurement at low levels knew immediately that they were extremely unlikely to be correct. Eminent scientists whose expertise was not in heat measurement carried out the Cold Fusion experiment. They made a mistake in measurement and no replication by researchers with the needed expertise was ever successful. Similarly, researchers with limited experience in intelligence research conducted most of the recent studies claiming increased intelligence after cognitive training. The early studies relied on single measure test score changes, always tricky to interpret, rather than on extracting a g (or Gf) score from a battery of tests (with equivalent forms). The reports generally assumed that scores on intelligence tests were measurements like temperature, rather than estimates of an underlying construct. All in all, we need to remember Carl Sagan's advice: Extraordinary claims require extraordinary evidence. So far we don't have it for increasing general intelligence with cognitive training and, studies with better research designs, like the one from Spain in this symposium, are mainly negative. Training may work for improving some cognitive skills, but this is not the same as increasing g, as noted in Hunt's presentation. As Jaeggi and Stephenson point out in their presentations, however, there is ample opportunity for additional research with many other training parameters. In the future, there may be ways of changing the brain directly (e.g. increasing neurotransmitter activity as per Matzel's presentation or the amount of regional gray matter or the efficiency of white matter transmissions) that will result in faster learning, greater memory, and better reasoning that may transfer to g. Publication of any such claims, however, will require sophisticated research designs including replication in independent samples.

PRESIDENT'S SYMPOSIUM

Brain Imaging and Intelligence: Better Psychometrics and Advanced Image Analyses

Organizer: Richard Haier
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Where in the brain is intelligence? Brain imaging studies of intelligence have come a long way. This symposium presents the newest data from a new generation of studies that use a variety of imaging technologies combined with more sophisticated psychometrics to investigate g and other factors. There are regional brain imaging analyses and whole brain network analyses of gray and white matter and of information flow among networks. Most studies are now hypothesis driven and some have substantial sample sizes. Findings are increasingly more consistent among studies and, as is always the case, better research leads to more questions. Understanding the neuro-basis for individual differences in intelligence is more exciting than ever as new data drive new hypotheses.

Brain-Wide White Matter Tract Integrity Is Associated With Information Processing Speed and General Intelligence

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The available literature on neuronal correlates of general intelligence (g), as for example summarized in the Parieto-Frontal Integration Theory (P-FIT), suggest that widespread networks of distal brain areas are involved in g. This would require well-functioning white matter pathways to allow for fast and orchestrated information transfer between brain areas. Brain magnetic resonance imaging scans of 420 healthy older adults from the Lothian Birth Cohort of 1936 were analysed. Three indicators of white matter integrity, fractional anisotropy (FA), T1 longitudinal relaxation time, and magnetisation transfer ratio (MTR) were measured in twelve major white matter tracts using probabilistic neighbourhood tractography. For all three indicators, people who had good white matter integrity in any one tract tended to have good integrity in all others. Therefore, structural equation modelling was used to model three latent biomarkers of brain–wide white matter tract integrity. These three biomarkers independently predicted g, a latent trait formed from six subtests of the WAIS-III. Together they explained 10% of the variance in g, more so than total brain volume, probably the best-replicated neurostructural correlate of g, in the most recent meta-analysis (6%). The effect of white matter integrity biomarkers on g was fully mediated by a latent information processing speed variable formed from three chronometric tests (simple and 4-choice reaction time, inspection time). The results suggest a mechanistically-plausible neurostructural model of human intelligence differences. However, a first genome-wide association study of the FA biomarker did not indicate any common genetic variants with major effects, suggesting that white matter integrity might not be an endophenotype for g with much simpler genetic architecture.

A Role for the Brain Network Mechanisms of Flexible Cognitive Control in Human Intelligence

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Evidence suggests working memory capacity contributes substantially to the more complex construct of general fluid intelligence (gF) (Engle, Tuholski, Laughlin, & Conway, 1999). Recently, a more basic cognitive control factor – rapid instructed task learning (RITL) (Cole, Bagic, Kass, & Schneider, 2010) – has been shown to contribute to gF (Duncan, Schramm, Thompson, & Dumontheil, 2012). RITL is the ability to rapidly (i.e., on the first trial) learn novel tasks from instruction, reflecting flexible control of cognition. Importantly, working memory and RITL have recently been tied to specific neural mechanisms. Thus, a new multi-level explanation of human intelligence is emerging, in which basic cognitive control capacities mediate the relationship between gF and neural mechanisms.

Given the likely computational complexity of gF, however, there are likely many neural mechanisms underlying cognitive control and gF. Indeed, evidence is emerging that one of the largest networks in the brain – the fronto-parietal control network – is central to cognitive control and gF (Cole & Schneider, 2007; Jung & Haier, 2007). This network includes approximately a dozen brain regions, each with complex connectivity and activity dynamics.

Critically, progress is being made in understanding how these regions' connectivity and activation contribute to cognitive control and gF. For instance, recent work showed how activity in this network during the N-back working memory task correlates strongly with gF (Burgess, Gray, Conway, & Braver, 2011). More recently, we found that the functional connectivity of one control network region – a portion of lateral prefrontal cortex – with the entire brain correlates strongly with gF (Cole, Yarkoni, Repovs, Anticevic, & Braver, 2012). This accounted for 10% of gF variance ($R2 = .10$, $p = .004$), which was greater than and statistically independent from brain volume and LPFC activity in the same dataset ($R2 = .07$ and $R2 = .05$, respectively). These results suggest gF is partially the result of the ability of lateral prefrontal cortex to communicate with a variety of brain regions, possibly due to its role in regulating activity and connectivity in a goal-directed manner (Miller & Cohen, 2001).

One concern regarding this connectivity result, however, is the possibility that the metric used to estimate brain-wide connectivity – global brain connectivity (GBC) – can reflect within-network connectivity in addition to between-network connectivity. We used two additional graph theoretical measures – participation coefficient and betweenness centrality – to isolate between-network connectivity. We found that lateral prefrontal cortex has among the highest between-network connectivity in the brain, and that gF was predicted by lateral prefrontal cortex's between-network connectivity above and beyond GBC. This supports the conclusion that lateral prefrontal cortex's extensive brain-wide connectivity (as opposed to simply connectivity within the fronto-parietal control network) supports gF. We plan to extend these findings in the future by using intermediate cognitive constructs such as RITL, as they will be essential for understanding the functional role of this and other neural mechanisms in implementing gF.

VBM–DTI Correlates of Verbal Intelligence: A Potential Link to Broca's Area

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Human brain lesion studies first investigated the biological roots of cognitive functions including language in the late 1800s. Neuroimaging studies have reported correlation findings with general intelligence predominantly in frontoparietal cortical areas. However, there is still little evidence about the relationship between verbal intelligence and structural properties of the brain. In our structural magnetic resonance imaging (MRI) study of the brain, we predicted that verbal performance is related to language regions of Broca's and Wernicke's areas.

Verbal IQ (vIQ) was assessed in 30 healthy young subjects. T1-weighted MRI and diffusion tensor imaging (DTI) data sets were acquired. Voxel-wise regression analyses were used to correlate fractional anisotropy (FA) and mean diffusivity (MD) values with vIQ. Moreover, regression analyses of regional brain volume with vIQ were performed adopting voxel based morphometry (VBM) and region-of-interest (ROI) methodology.

Our analyses revealed a significant negative correlation between vIQ and FA and a significant positive correlation between vIQ and MD in left-hemispheric Broca's area. VBM regression analyses did not show significant results, while a subsequent ROI analysis of Broca's area FA peak cluster demonstrated a positive correlation of gray matter volume and vIQ.

These findings suggest that cortical thickness in Broca's area contributes to verbal intelligence. FA and MD are common parameters for white matter integrity, while the neuroanatomical correlates of FA and MD in gray matter are less well described. Both diffusion parameters predicted gray matter ratio in Broca's area more sensitive than VBM methodology.

Functional Brain Network Efficiency Predicts Intelligence

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Our perceptions, thoughts and experiences are the product of dynamic interactions occurring between functionally specialized regions of the brain. Thus, a complete understanding of such phenomena will by only possible once we understand how these interactions are organized and coordinated. The present work focuses on functional brain connectivity in the context of graph-theoretical network analysis to investigate so-called small-world networks. Recent studies have shown that functional and anatomical connections of the brain network are organized in a highly efficient small-world manner. A small-world organization of the brain network implies a high level of local neighborhood clustering combined with global efficiency or information transfer. Thus small-world networks explain how the brain minimizes wiring costs while simultaneously maximizing the efficiency information propagation. In the last ten years, there is an increasing interest in modeling the human brain network, because they provide a simplified view on a complex system as the brain is. The main purpose of the presented work was to identify whether individual differences in cognitive functions, such as intelligence, are associated with differences in small-world characteristics of functional networks based on resting-state electroencephalography (EEG) data. High-density resting state EEG was recorded in 74 healthy subjects to analyze graph-theoretical functional networks at an intracortical level. The results showed the more intelligent the subjects are the more the functional network in the alpha2 frequency spectrum resembles a small-world network. Closer inspection of the hubs and nodes of the identified network revealed a parieto-frontal network that is associated with higher intelligence. This is the first study that substantiates the neural efficiency hypothesis as well as the parieto-frontal integration theory of intelligence in the context of functional brain network characteristics. Furthermore, the preliminary results of a follow-up study will be presented, in whichwe aimed to increase the intelligence and working memory performance by an intensive working memory training and shifting the underlying functional brain networks towards more small-world topology.

The Salience Network Contributes to Individual Capacity of Fluid Reasoning

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Fluid reasoning is the ability to think logically, analyze novel problems and identify the relationships that underpin these problems independent of acquired knowledge flexibly. Although many functional imaging studies have investigated brain activations during fluid reasoning tasks, the neural correlates of this capacity remain elusive. In the present study, we aimed to investigate the question by analyzing correlations between Raven's Standard Progressive Matrices (RSPM) (an effective measure of fluid reasoning) and regional gray matter volume (GMV) and regional homogeneity (ReHo) in a voxel-wise manner throughout the whole brain in a large sample of 297 healthy young adults. The most important finding was that the RSPM scores were positively correlated with both GMV and ReHo values in brain areas belonging to the salience network, including the dorsal anterior cingulate cortex and fronto-insular cortex. Additionally, we also found positive or negative correlations between the RSPM scores and GMV or ReHo values in brain areas of the central executive, default-mode, sensorimotor and visual networks. Our findings suggest that the fluid reasoning ability is related to a variety of brain areas, and emphasize the important contribution of the salience network to this capacity.

Common and Unique Neuro-Functional Basis of Psychometrically Validated Cognitive Components of Fluid Intelligence

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Neuroimaging research of fluid intelligence (Gf) has mainly focused on the neural basis of abilities explaining performance on cognitive tasks. However, the neuro-functional basis of clearly defined theoretical cognitive components underlying Gf remains unclear. Induction, Visualization, and Spatial Relationships have the highest relevance for Gf (Carroll, 1993). By means of functional magnetic resonance imaging (fMRI) we explored the neural correlates of these abilities characterized by their unidimensionality and matched for task-difficulty, as evidenced by a psychometric calibration study.

Furthermore, a vast amount of studies shows that the brain is organized in functional networks that are composed of multiple interacting brain regions. It is poorly understood whether such functional networks are dynamically organized according to specific task-states. The anterior insular cortex (aIC) – dorsal anterior cingulate cortex (dACC) / medial frontal cortex (mFC) network has been proposed to play a central role in human cognitive abilities, explaining performance efficiency in a large variety of cognitive activities. Therefore, in addition to task-evoked neural activation patterns, functional connectivity analysis aimed at testing whether aIC-dACC/mFC network organization in terms of background connectivity patterns is dynamically modulated by transitory, ongoing task demands.

For this purpose, 22 healthy young adult females with either below- or above-average Gf abilities underwent fMRI scanning during Gf tasks performance. Analysis of task-evoked BOLD responses showed that distinct tasks with high loadings on Gf, but characterized by psychometric unidimensionality and matched for task difficulty, are associated with neural activation patterns common for different tasks in a shared frontoparietal network. Task-unique activation patterns were also detected. These results are consistent with Carroll's three strata theory (Carroll, 1993), suggesting that specific cognitive abilities with high loadings on Gf, in particular Induction and Visualization, are distinguishable. Nevertheless, in accordance with the unidimensionality of the tasks, there is a substantial common variance reflecting the general Gf factor.

Functional connectivity analysis showed a modulation of background connectivity by cognitively distinct task-states that likely reflect ability-related neural processing. Furthermore, functional connectivity strength within the aIC-dACC/mFC network reliably predicted general task performance. This suggest that the analysis of functional connectivity patterns may provide complementary information about the brain-behavior relationship. We propose that the aIC-dACC/mFC network contributes to the integration of task-common and task-specific information based on its intrinsic within-network functional interactions as well as its dynamic between-network functional interactions.

In conclusion, the key findings suggest that Gf comprises distinguishable cognitive abilities, but the Gf construct is associated with a common network.

Functional Connectivity between Parietal and Frontal Brain Regions and Intelligence in Young Children: The Generation R Study

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It has been shown in adults that individual differences in intelligence are related to the integrity of the interaction between parietal and frontal brain regions. Since connectivity between distant brain regions strengthens during childhood, it is unclear when in the course of development this relationship emerges. Thus, the goal of this study was to determine whether parietal-frontal functional connectivity is associated with intelligence in young children. We performed independent component analyses on resting-state fMRI data of 115 children (6-8 years old) to select seed and target regions for a seed/target region correlation analysis. We found that higher non-verbal intelligence was associated with increased functional connectivity between right parietal and right frontal regions, and between right parietal and dorsal anterior cingulate regions. The association between intelligence and functional connectivity between certain brain regions was stronger in girls than boys. In conclusion, we found that connectivity between the parietal and frontal lobes is critically involved in intelligence in young children.

Sequence and speed of information flow among brain areas during problem solving in high and average intelligence individuals

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The PFIT model describes a network of brain areas related to intelligence test scores and proposes that the sequence and speed of information flow among these areas will be related to individual differences in general intelligence and to specific factors. Here we used MEG imaging to measure information flow millisecond by millisecond throughout the brain while subjects preformed three different tasks based on tests developed by the Johnson O'Connor Foundation. The tasks were vocabulary, inductive reasoning, and paper folding. The subjects were 32 college students. Analyses include comparisons of high and average intelligence subjects and between males and females to test hypotheses about efficient information flow differences for the three tasks. Both the sequence of information flow among brain areas and the speed of flow are assessed. This is one of the first studies to test individual differences in information processing among specific brain areas related to intelligence.

KEYNOTE ADDRESS

Craig T. Ramey

Improving Intelligence, Academic Achievement, and the Life Course for Children from Low-Resource Families: The Abecedarian Approach

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This presentation will review four decades of basic and applied developmental research concerning the life course of intellectual, cognitive, and social functioning of children from vulnerable backgrounds. We will make the case that the potential for substantial improvement in outcomes has been seriously underestimated by non-experimental research. Recommendations for a new era of investigation will be presented. Suggestions include a major overhaul of current social policy with a strong emphasis on implementation science, developmental epigenetics, and cognitive neuroscience. Some of these recommendations will be illustrated with ongoing research within the Roanoke Brain Study.

HOLDEN MEMORIAL ADDRESS ON SCIENCE WRITING

Dan Hurley

Reporting on the Science of Intelligence When Intelligent Scientists Disagree

Dan Hurley

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The nice thing about cognitive tests, whether the N-back test of working memory, or the Raven's test of fluid intelligence, is that all the answers can usually be neatly graded as right or wrong. But in matters requiring the very intelligence those tests measure, the problem is that the answers are often a matter of dispute. Such is the case with the question of whether training of working memory can increase fluid intelligence. As a journalist who writes regularly for The New York Times, my job is to report "just the facts." But in science, the facts themselves are in question. What's a good journalist to do? I propose that the answer is: pretty much the same thing good scientists do.

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