intelligence

International Society for Intelligence Research (ISIR)

2021

21st Annual Conference

September 3–4, held virtually (Zoom)

www.isironline.org

Cover design:

ISIR programs typically display a photograph of the city hosting the conference. Since this is our first virtual conference, our host is the internet itself! This image shows a partial map of the Internet based on the January 15, 2005 data found on opte.org. Each line is drawn between two nodes, representing two IP addresses. The length of the lines are indicative of the delay between those two nodes. This graph represents less than 30% of the Class C networks reachable by the data collection program in early 2005. Lines are color-coded according to their corresponding RFC 1918 allocation.

This program was created by Emily Willoughby (willo074@umn.edu) from template based on the original version at Github.

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About

Founded in 2000, ISIR is the focal scientific society for the world's researchers on human intelligence. The focus of the society is on human intelligence, but we are also interested in cognitive abilities in other species. Artificial intelligence is not a current focus of the society. *Intelligence* is the affiliated journal of the society. It welcomes well-conducted studies, as well as theoretical articles from a variety of perspectives including psychometrics, genetics, individual differences, evolutionary theory and neuroscience. Intelligence is a 'hot topic'. We share a commitment to civility, open dialogue, and respect. Intelligence is a trait. It is an important one with links to many significant outcomes through multiple pathways. Although scores on many measures, including intelligence-type tests, can be ranked from low to high, these ranks do not apply to people, nor to their value. In the absence of global pandemics, we hold an annual conference, usually in July. The venue alternates each year between the USA and Europe. Scholars attend from all over the world to present their latest research, listen to new findings, and explore older ones.

Conference information

The 21st ISIR Annual Conference 2021 will be held virtually for the first time in its history. The virtual conference will take place on Zoom on Friday and Saturday, 3-4 September 2021. We will have a strong and exciting showing of early career researchers in neuroscience and the biological basis of intelligence, including invited speakers Abdel Abdellaoui, Erhan Genç, Kirsten Hilger, Matt Euler and Roger Beaty, **Lifetime Achievement Awardee Rich Haier**, and **Holden Memorial Awardee Adrian Wooldridge**. Further information and updates will be announced on the ISIR website as they arise.

The conference Zoom link will be sent to registered participants before the conference.

ISIR President and Board 2021

President:	Rex Jung
President Elect:	Rosalind Arden
Past President:	William Revelle
Secretary/Treasurer:	James Lee
Board:	Thomas Coyle, Jakob Pietschnig, Kirsten Hilger, and Emily Willoughby

Organizing Committee

Local Hosts:	John Protzko and Rosalind Arden
Program Chair:	Emily Willoughby
Program Design:	Emily Willoughby and Cesca Eaton

Timetable

*All times listed in schedule are in **Universal time** (GMT).*

Universal	**UTC**	**15:00–20:00**
Los Angeles	PDT	8:00–13:00
Denver	MDT	9:00–14:00
Minneapolis	CDT	10:00–15:00
New York	EDT	11:00–16:00
London	BST	16:00–21:00
Amsterdam	CEST	17:00–22:00
Moscow	MSK	18:00–23:00

Schedule key:

HM: Holden Memorial Speaker

HA: Haier Awardee Talk

IS: Invited Speaker

KL: Keynote Lecture

CT: Contributed Talk

LA: Lifetime Achievement Awardee

Friday, 3rd of September

15:00–15:10	**Welcome remarks**		
15:10–15:45	KL	**Abdel Abdellaoui** University of Amsterdam	Socio-economic status: A social construct with genetic consequences
15:45–16:00	IS	**Roger Beaty** Pennsylvania State University	Intelligence, creativity, and the brain
16:00–16:15	HA	**Kirsten Hilger** Julius-Maximilians University	Network neuroscience to understand variations in cognitive ability
16:15–16:30	CT	**Florian Dürlinger** University of Vienna	Cognitive abilities and beliefs: A meta-analysis of intelligence and religiosity associations
16:30–16:45	CT	**Elizabeth Dworak** Northwestern University	Validating aggregated International Cognitive Ability Resource scores against nationally collected educational data
16:45–17:15	HA	**Matthew Euler** University of Utah	Intelligence, EEG, and uncertainty: A framework for linking cognitive ability to momentary neural activity
17:15–17:30	CT	**Jonathan Fries** University of Vienna	Intelligence predicts physical and mental health: Evidence for the Study of Health and Retirement in Europe (SHARE)
17:30–17:45	**Coffee Break (BYO)**		
17:45–18:00	CT	**Jakob Pietschnig** University of Vienna	Introducing ISIR 2022: Vienna, Austria

Friday, 3rd of September *(continued)*

18:00–18:15	CT	**Evgeniya Gavrilova** Moscow State University	Cognitive predictors of foreign language aptitude
18:15–18:30	HA	**James Lee** University of Minnesota	Polygenic prediction within and between families from a 3-million-person GWAS of educational attainment
18:30–19:05	LA	**Rich Haier** University of California	Thrills and chills: My 50 years researching intelligence and what they might mean for you
19:05–20:00	**Poster session with Wine & Cheese (BYO)**		

Saturday, 4^{th} of September

*All times listed in schedule are in **Universal time** (GMT).*

15:00–15:35	HM	**Adrian Wooldridge** London, England	"Bell curve liberalism" as the most humane approach for addressing individual differences in modern society
15:35–15:50	IS	**W. David Hill** University of Edinburgh	The impact of ultra-rare genetic variation on intelligence
15:50–16:05	IS	**Hilleke Hulshoff Pol** University Medical Center Utrecht	Brain changes throughout life and intelligence
16:05–16:20	CT	**Michael Woodley of Menie** Vrije Unversiteit Brussel	Estimating the additive heritability of historiometric eminence in a super-pedigree comprised of four prominent families
16:20–16:35	HA	**Erhan Genç** Leibniz Research Centre	Utilizing "layer fMRI" in the human brain to understand feedforward and feedback interactions during reasoning
16:35–16:50	CT	**Maxim Likhanov** ITMO University	Factor and network perspectives on spatial ability interventions
16:50–17:05	CT	**Damien Morris** King's College London	Developmental changes in genetic and environmental influence on intelligence from age 2 to age 16: A large, longitudinal twin study
17:05–17:20	CT	**Jakob Pietschnig** University of Vienna	Intelligence heritability and (in-)equality: A meta-analysis of twin data
17:20–17:35	CT	**Heiner Rindermann** Chemnitz University of Technology	Why are there differences across German states in student achievement and cognitive ability?
17:35–18:50	**Coffee Break (BYO)**		
17:50–18:05	HA	**Anna-Lena Schubert** University of Mainz	Faster information-transmission improves reasoning ability by facilitating the access to and transformation of information in working-memory

Saturday, 4^{th} of September *(continued)*

18:05–18:20	CT	**Andrea Stoevenbelt** Tilburg University	The uniformity of stereotype threat: Analyzing the moderating effects of premeasured performance
18:20–18:35	CT	**Paul Westrick** The College Board	Challenges in the interpretation of admission test validity research
18:35–18:50	HA	**Natalia Goriounova** Vrije Universiteit Amsterdam	Human intelligence from a cellular perspective
18:50–19:05	CT	**Emily Willoughby** University of Minnesota	Reaction time and g in the number-comparison task: Perceptual effects of decade discontinuity
19:05–19:20	CT	**Konrad Kulikowski** University of Social Sciences	Cognitive abilities: A new direction in burnout research
19:20–19:45	CT	**Gregory Clark** University of California	Social status through genetic transmission? England 1670–2021
19:45–19:55	**Closing remarks**		

List of Abstracts: Talks

Abstracts are listed in alphabetical order by presenting author's last name. If a given talk has more than one author, presenting author's name is underlined.

HM : Holden Memorial Speaker

HA : Haier Awardee Talk

IS : Invited Speaker

KL : Keynote Lecture

CT : Contributed Talk

LA : Lifetime Achievement Awardee

Socio-economic status: A social construct with genetic consequences

Dr. Abdel Abdellaoui IS

University of Amsterdam, Amsterdam, Netherlands

Social stratification is the way in which human civilizations sort individuals into different strata of socio-economic status (SES). SES is known to cluster in families and geographically, which has been associated with genetic effects. I will first review the history of scientific research on the relationship between social stratification and heredity. I then discuss recent findings in genomics research in light of the hypothesis that SES is a dynamic social construct that can exert selection pressures on genes associated with talents that help in attaining or retaining a position in a certain socio-economic system. Through social stratification, these talents sort into different layers of environmental exposures, which could result in natural selection through differential mortality and reproduction rates and non-random mating. This correlation between environmental exposures and genetic effects can confound genetic effect estimates in genetic association studies. Recent societal developments may have influenced these selection pressures in ways that stimulate a growth in social inequalities. Novel tools in genomics research are revealing previously concealed genetic consequences of the way we organize our societies, which should be handled with caution in our search for a fair and functional society.

Intelligence, creativity, and the brain

Dr. Roger E. Beaty IS

Pennsylvania State University, University Park, Pennsylvania, United States

The relationship between intelligence and creativity has been historically controversial, partly due to prior limitations in the measurement and modeling of these cognitive abilities. Recently, however, increasing evidence from latent variable studies is providing a more consistent view on the association between intelligence and creativity, pointing to a considerable overlap between the two. In this talk, I will take a CHC perspective to conceptualizing the roles of lower-order intelligence facets and higher-order *g* to creative thinking ability. I will also present data from recent work examining how intelligence and creativity may overlap in the brain, focusing on network neuroscience and machine learning approaches to modeling patterns of functional brain connectivity that predict both cognitive abilities. I will conclude with future directions to further understand the mechanisms underlying the intelligence-creativity relationship.

Social status through genetic transmission? England 1670–2021

Prof. Gregory Clark CT

University of California, Davis, Davis, California, USA

Using a genealogy of 407,000 English people (1670–2021), with extensive information on familial connections, the paper explores the pattern of inheritance of social outcomes such as occupational status, education, house value, and neighborhood social attributes. Four things stand out. One is the very strong persistence of social status correlations across distant relatives. Even fourth cousins have significantly correlated social outcomes. The underlying persistence of the correlation across generations is 0.8.

The second is that underlying rates of persistence are similarly high at around 0.8 all the way from 1670 to 2021. House values measured 1999–2021 show the same implied underlying persistence for people whose common ancestor was born 30 years earlier as for people with a common ancestor born in 1800. Despite significant social changes over these years, and in particular the introduction of mass public education and other social supports for poorer families, there has been no increase in social mobility rates.

The third is that the pattern of correlations is strongly consistent with additive genetic determination, as long as there was a consistent correlation in parents in the relevant genetics of 0.6 throughout the period 1670–2021. The observed patterns seem thus to be the product of both a biological fact, additive genetic determination of social abilities, and a social fact, the strong assortment of men and women in marriage by the genetics that produce social outcomes throughout these years. Recent GWAS studies of educational assortment find such a correlation in the genetics determining years of schooling of around 0.6.

The fourth feature is that consistent with the genetic interpretation outcome correlation patterns on the matriline are precisely equal to those on the patriline, except for wealth where the patriline dominates, but where there is significant non-genetic transmission.

Cognitive abilities and beliefs: A meta-analysis of intelligence and religiosity associations

Mr. Florian Dürlinger*, *Dr. Jakob Pietschnig CT

University of Vienna, Vienna, Austria

A quite remarkable body of research concerning the association of intelligence and religiosity has accumulated since the early 20th century. So far, the majority of the available studies showed a negative correlation, indicating lower cognitive abilities of individuals reporting stronger religious beliefs.

Despite the largely consistent signs of reported effect sizes, effect strengths vary substantially between studies, suggesting moderating influences of further variables. As likely candidates for explaining systematic differences in effect strengths, subject-level characteristics like participant sex or educational status of samples as well as different methods to assess the concepts of intelligence and religiosity have been proposed. However, their effects on intelligence and religiosity associations remain to be clarified.

In the current meta-analysis of n = 78 studies (k = 93 independent effects; N = 101,063), we investigate effects of these moderators on the religiosity and intelligence link and show evidence for the effect robustness by providing effect estimates in a large number of (reasonable) conceptual and analytical specifications. Random-effects analyses yielded a small negative association between religiosity and intelligence r = –.14 ($p < .001$; 95% CI [–.17, –.11]). Effects were stronger for (i) psychometric intelligence tests than for proxy measures, (ii) general population samples than college and pre-college samples, and (iii) women than men. In a multiverse analysis 276 (47.9%) out of 576 reasonable specifications showed significant negative summary effects, but no meaningful positive ones. Application of several standard and more modern bias analyses did not yield evidence for confounding dissemination bias, thus further corroborating our findings of small but meaningful negative religiosity and intelligence associations.

In all, we show a small but clear and almost ubiquitous association between religiosity and intelligence that appears to be more salient for genuine intelligence measures, general population samples, and women.

Validating aggregated International Cognitive Ability Resource scores against nationally collected educational data

Mrs. Elizabeth M. Dworak*, *Dr. William Revelle CT

Northwestern University, Evanston, Illinois, United States

Using items from the Stanford Education Data Archive Version 4.1 (SEDA; Reardon et al., 2021), Child Opportunity Index 2.0 database (COI; diversitydatakids.org, 2021), and the SAPA Project, this study will validate the use of the International Cognitive Ability Resource scales aggregated at the county level. For the participants (n = 57,634) between the ages of 14 to 18 years within the United States, the SAPA Project contains data for 2,115 unique counties. By joining the 5 scales of the ICAR60 (verbal reasoning, letter and number series, matrix reasoning, three-dimensional rotation, and total score) with county level average math and reading achievement scores from the SEDA and educational opportunities data from the COI, we examine how well county level ability estimates based on national surveys correspond with pooled individual data from the open-source ability measures of the ICAR. Correlations and regressions will be weighted by sample density to help control for noise created by low sample size within cluster. Additional analyses include examining gender gap estimates provided by the SEDA to observed pooled county level differences in the ICAR60. Implications of this study suggest understanding how representative ICAR60 data collected by the SAPA Project are compared to national norms as data from the SAPA Project are made publicly available.

Subsequent use of the ICAR at the ZIP code level will examine how nationally collected measures of environmental, health, and economic opportunities relate to individual differences in cognitive ability.

Intelligence, EEG, and uncertainty: A framework for linking cognitive ability to momentary neural activity

Dr. Matthew Euler HA

University of Utah, Salt Lake City, Utah, United States

Neurophysiological studies face several challenges in relating intelligence to momentary brain activity. Key among these is the tension between intelligence as a higher-order capacity, typically operationalized via complex tasks involving many different cognitive processes, and the reductive approach to isolating neural processes that characterizes most of cognitive neuroscience. This challenge is especially acute in electroencephalography (EEG) and event-related potential (ERP) research, where neural processes of interest are commonly elicited under precisely time-locked conditions using simple paradigms. However, rather than undermining EEG studies as a method for uncovering neural correlates of intelligence, this presentation will argue that resolving the tensions inherent to reductionist EEG research on intelligence can clarify important aspects of the construct itself.

It will be argued that, after a long period of incremental progress, EEG studies on intelligence have now clarified a set of key questions around which the field can coalesce. These pertain to:

1. The degree to which relationships between intelligence and brain activity increase across levels of cognitive complexity
2. The degree to which relationships between intelligence and specific neural processes depend on their eliciting conditions, and
3. The degree to which successfully observing relationships between intelligence and brain activity depends on matching levels of aggregation across behavioral and neural measures.

Relevant studies illustrating these issues will be briefly reviewed. Finally, it will be argued that the concept of “appropriate responding in spite of uncertainty” provides a unifying framework for thinking about activity-ability effects in neurophysiological research on intelligence, and potentially for understanding the construct itself.

Intelligence predicts physical and mental health: Evidence for the Study of Health and Retirement in Europe (SHARE)

Mr. Jonathan Fries*, *Dr. Jakob Pietschnig CT

University of Vienna, Vienna, Austria

Background: Positive associations between intelligence and health have been well-established in the available literature. However, determinants of these associations need to be identified to understand the causes, nature, and meaning of this phenomenon. Particularly, the roles of environmental and behavioral risk factors are yet to be conclusively investigated.

Methods: We examined data of the Study of Health and Retirement in Europe (SHARE), a large-scale longitudinal survey among residents of the European Union above the age of 50 (*N* range = 10,000 – 30,000+). Intelligence was estimated by using variables for cognitive functioning (i.e., mathematical ability, memory, verbal fluency) and linked to physical and mental health indicators (e.g., number of chronic conditions; self-reported depression) as well as behavioral and environmental risk factors (e.g., work environment risk; smoking).

Results: Cognitive abilities in any domain were consistently correlated with better self-perceived and objectively assessed health across all variables (excepting having any type of cancer or not), yielding small-to-moderate associations *rs* = $|.13 - .29|$. As expected, risk factors were on the whole negatively associated with health (not all effect sizes exceeded the non-triviality threshold; *rs* = $|< .01| - |.38|$); although consistent with several prior findings, alcohol intake has positively related with health (*r* = .16). Mixed-model Poisson regression analyses indicated an 11 percent decrease in self-reported physical symptom number with each unit of increase in mathematical ability. There was only little evidence for moderation effects of environmental or behavioral risk factors regarding health and intelligence associations.

Discussion: Here we show that intelligence is consistently positively associated with a large number of physical and mental health indicators in a representative sample of Europeans. Interestingly, environmental or behavioral risk factors are insufficient to explain this association. This means that alternative mechanisms such as a general fitness factor that improves multiple aspects of human life may be responsible for this relationship.

Pitfalls in oversimplifying the measurement of cognitive processes: The example of the anti-saccade task (WITHDRAWN)

Dr. Gidon T. Frischkorn*, *Prof. Klaus Oberauer

University of Zurich, Zurich, Switzerland

Research on the cognitive processes underlying intelligence differences heavily relies on the tasks and measures used to measure individual differences in cognitive processes. For example, research suggesting a relation between attention control and intelligence relied strongly on a manual version of the anti-saccade task as an indicator of attention control. We will show that performance in this task conflates several cognitive processes that might be sources of individual differences:

1. The inhibition of automatic saccades towards the cue preceding the target stimulus
2. Bindings between cue and target-location dependent on the block instruction (pro- vs. anti-saccades), and
3. Sensory discrimination ability to detect the target letter before it is masked.

We present a set of experiments that varied the requirements of inhibition and binding to investigate to what extent these processes are tapped by the manual anti-saccade task. For this, we introduced additional cue conditions, and manipulated the cue-target interval to evaluate the contribution of inhibition and binding ability to anti-saccade performance. Experimental results indicate that participants need to process bindings between the location of the cue and the location of the target and inhibit automatic responses. Nevertheless, individual differences in anti-saccade performance predominantly measured sensory discrimination ability independent from different cue conditions. Thus, the correlation between performance in the manual antisaccade task and intelligence probably has nothing to do with attention control. These experiments highlight that despite their appealing face validity, simplified measures from cognitive tasks often fail to represent the cognitive processes they are assumed to measure.

Cognitive predictors of foreign language aptitude

Ms. Evgeniya Gavrilova CT

Moscow State University of Psychology and Education, Moscow, Russian Federation

The present study aims at revealing the impact of the certain cognitive abilities, namely general and verbal intelligence, working memory capacity, defocused attention, on the efficiency in foreign language aptitude taking participants' language learning experience into account. Four language aptitude tests were specially elaborated for this study. Each test was aimed to measure one distinct language skill, including language reasoning, grammatical sensitivity, semantic rote learning ability, phonetic coding. General intelligence was assessed by Raven's Progressive Matrices whereas verbal intelligence was tested by three verbal scales of Intelligence structure test. As for working memory capacity two measurements with different stimuli (letters and geometric figures) were taken, while defocused attention was tested by peripheral information processing test.

388 L1 Russian (L2 English) students from different language faculties participated in this study (M = 19.51, SD = 1.89). The two-step data analysis was conducted. First, structural equation modeling technique was used to all language tests data and revealed one latent factor structure of foreign language aptitude. Thus, this is one general source responsible for foreign language attainment. Second, we took the same statistical method to properly analyze the interactions between cognitive abilities and diverse language skills. Three different structure models highlighting different patterns of correlations have been detected. It turned out that narrow language abilities like grammatical sensitivity or semantic rote learning ability significantly related to more specific cognitive variables, such as verbal intelligence or semantic memory capacity. Whereas language reasoning (namely, general ability to induce the rules governing a set of language materials and to use these rules in speech) seems to be determined by both general intelligence and some specific cognitive competences including defocused attention. In this case we can conclude that the patterns of the interactions between cognitive abilities and foreign language aptitude should be considered as a complex cognitive phenomenon.

Utilizing “layer fMRI” in the human brain to understand feedforward and feedback interactions during reasoning

Dr. Erhan Genç HA

Leibniz Research Centre for Working Environment and Human Factors (IfADo), Dortmund, Germany

Brain regions underpinning intelligent thinking are organized as an interconnected network that enables information processing to be carried out in multiple steps. Within this network, the dynamic exchange of information is likely to be realized in the form of feedforward and feedback interactions. It is conceivable that interindividual differences in intelligence are to some extent caused by differences in the quality of these interactions. Specific layers within the human cerebral cortex are primarily associated with either feedforward of feedback interactions. Unfortunately, conventional 3 Tesla fMRI does not provide sufficient spatial resolution in order to delineate different cortical layers. However, ultra-high field 7 Tesla fMRI, also called “layer fMRI”, is capable of producing brain images on the submillimeter scale. In my presentation I will talk about the possibilities of utilizing this technique to disentangle layer-specific brain interactions during reasoning.

Human intelligence from a cellular perspective

Dr. Natalia Goriounova HA

Vrije Universiteit Amsterdam, Amsterdam, Netherlands

Our brain works through the activity of its almost 100 billion brain cells that each act as a small chip: they collect, process and pass on information in the form of electrical signals. Especially in brain areas that integrate different types of information, such as frontal and temporal lobes, brain cells have larger dendrites—long branches specialized to collect signals. Theoretical studies predict that larger dendrites help cells to initiate electrical signals faster.

Because of difficult access to human living neurons it is completely unknown whether any of these cellular properties actually relate to human intelligence. Previous studies have revealed that people with higher IQ have a thicker cortex in brain areas such as the frontal and temporal lobes. But does a thicker cortex also contain cells with larger dendrites and do they function differently? In my talk I will show the latest research in our lab that links cellular properties of human neurons to intelligence.

Thrills and chills: My 50 years researching intelligence and what they might mean for you (acceptance of Lifetime Achievement Award)

Dr. Richard Haier LA

University of California, Irvine, California, United States

No one had ever seen regional brain function related to intelligence so it was a thrill of discovery when I saw color PET scans in 1988 that suggested a hypothesis of brain efficiency. The story of those images set the stage for more thrills of discovery that included Tetris, anesthesia, Down Syndrome, neuro-*g*, sex differences, and the PFIT model of brain networks and intelligence. A few chills along the way were inevitable, but none outweighed the thrills. In my view, thrills of discovery await you all as intelligence research moves into a Golden Age of experimental studies that are based on findings from molecular biology, polygenic scores, brain imaging connectivity, and cognitive neuroscience—all informed by new psychometrically sophisticated assessments of intelligence that can be used as either dependent or independent variables to emphasize individual differences. It is also my view that all intelligence research shares a primary goal—to permanently and dramatically increase fluid intelligence (*g*) in individuals. I urge you to embrace this goal and, if you do, dedicate yourself to achieving it.

Network neuroscience to understand variations in cognitive ability

Dr. Kirsten Hilger HA

Julius-Maximilians-University, Würzburg, Germany

The human brain is a complex network consisting of numerous specialized brain regions that interact via functional and structural connections. In recent years, much research has focused on identifying principles of the organization of brain networks and their relation to spontaneous (intrinsic) or task-related activity. This line of research has led to the identification of relationships between variations in brain network features and individual differences in behavior and cognition. In this talk, Dr. Kirsten Hilger will present evidence from a research program applying methods from network neuroscience to further understand the biological basis of differences in general intelligence. At first, findings from resting-state investigations suggesting that variations in intrinsic properties of functional brain networks covary with differences in intelligence are presented. Second, the focus will be broadened to task-related adaptations of functional brain connectivity and to the question whether people with higher intelligence scores may have an intrinsic network architecture that is closer to a network organization as required by various cognitive demands. Third, the idea of combining knowledge from functional and structural connectivity analyses to gain insights into the Neural Efficiency Hypothesis of intelligence is explained, before in the last part of her talk, the differentiation between explanatory and cross-validated predictive analyses is addressed. Specifically, it will be outlined how valuable predictive analysis methods can be in order to provide more realistic estimates of the generalization error, however, the need for large and phenotypically well-characterized samples is still a major problem requiring particular attention.

The impact of ultra-rare genetic variation on intelligence

Dr. W. David Hill IS

University of Edinburgh, Department of Psychology

Intelligence is heritable and predictive of physical health, mental health, and longevity. Genome-wide association studies (GWAS) have identified over 200 loci linking common genetic variants to intelligence. Heritability estimates derived using genetic variants in linkage disequilibrium with common genotyped single nucleotide polymorphisms (SNPs) explain ∼23% of phenotypic variation in intelligence. However, an additional 31% of differences in intelligence is explained by genetic variants poorly tagged by common SNPs and so will not be detected using GWAS. Here we examine the consequences of rare genetic variation on intelligence using whole exome sequencing (WES) in 100,368 participants from UK Biobank. We classify variants as synonymous, damaging, or those that are protein truncating variants. We find that the burden of ultra-rare genetic variants, defined as those with a minor allele count of 1 and not present in external reference panels, in protein truncating variants and damaging variants is significantly associated with intelligence, whereas in synonymous variants this effect was absent. When we confined our analysis to brain expressed genes under evolutionary selective pressure, the deleterious effect of ultra-rare protein truncating variants and damaging variants was greater. These results show that alleles associated with intelligence fall across the frequency spectrum, and help identify the postsynaptic density as molecular mechanism involved in intelligence and being susceptible to perturbation by ultra-rare variation.

Brain changes throughout life and intelligence

Prof. Hilleke Hulshoff Pol CT

University Medical Center Utrecht, Utrecht, Netherlands

The size and surface area of the human brain are considered critical determinants of human intellectual ability. Although in comparison with other species humans do not have the largest brain nor the biggest cortex either in absolute or relative terms, owing to the thickness and relatively high cell density in the cortex, man does have the largest number of cortical neurons of all species. Indeed, intelligence is genetically represented in a specially distributed and densely connected network of gray matter regions providing a high capacity infrastructure.[1] However, brain structure changes throughout life, during development and during ageing.

Interestingly, intelligence has also been related to changes in cortical thickness and surface over time[2] and was increasingly reflected in the structural brain network over time.[3] Indeed, intelligence may be more related to the magnitude and timing of changes in brain structure during development than to brain structure per se, and the brain is never completed but shows continuing intelligence-dependent development. Recently, we have identified genetic variants that alter age-dependent brain growth and atrophy throughout our lives, including pleiotropy for brain change and intelligence.[4]

What this means for dynamic aspects in intelligence, for brain network development, and for health and psychiatric disorders will be discussed.

References

[1] Bohlken, M. M., et al. (2016). Topology of genetic associations between regional gray matter volume and intellectual ability: Evidence for a high capacity network. *NeuroImage*, *124*, 1044–1053. DOI: 10.1016/j.neuroimage.2015.09.046.

[2] Schnack, H. G., et al. (2015). Changes in thickness and surface are of the human cortex and their relationship with intelligence. *Cerebral Cortex*, *25*(6), 1608–1617. DOI: 10.1093/cercor/bht357.

[3] Koenis, M. M., et al. (2018). Association between structural brain network efficiency and intelligence increases during adolescence. *Human Brain Mapping*, *39*(2), 822–836. DOI: 10.1002/hbm.23885.

[4] Brouwer, R. M., et al. (2020). Dynamics of brain structure and its genetic architecture over the lifespan. *bioRxiv*. DOI: 10.1101/2020.04.24.031138v1.

Cognitive abilities: A new direction in burnout research

Dr. Konrad Kulikowski CT

University of Social Sciences, Łódź, Poland

I would like to discuss and submit for criticism a theoretical model of effects of cognitive abilities on burnout, that I have proposed in the European Journal of Work and Organizational Psychology (https://doi.org/10.1080/1359432X.2020.1841284).

The emerging body of evidence suggests that burnout is negatively associated with cognitive functioning and there are evidences of a positive role of cognitive abilities in the world of work, however leading burnout models ignore employee's cognitive abilities in explaining burnout. In this conceptual research, based on the cognitive abilities scholarship and the Job Demands-Resources theory (JD-R) of employee well-being, I attempt to put forward a conceptual model of the role of the general cognitive abilities in burnout formation.

This conceptual model explains how cognitive abilities might influence burnout by fostering job resources and buffering cognitive job demands and how the cognitive abilities might generate specific types of job demands.

The originality of my conceptual model lies in challenging the "traditional" view that burnout impairs cognitive abilities with the proposition that these are cognitive abilities that affect burnout. In other words, reported in the literature negative correlations between burnout and cognitive abilities are not due to burnout impairing cognitive functioning but because employees with lower cognitive abilities are more vulnerable to burnout. The proposed model might be useful for the emerging field of cognitive research in burnout by providing a model of possible reciprocal relationship that might be used to control for spurious correlations when testing structural models and planning longitudinal research.

This model might help to integrate research findings on relationships between cognitive abilities and burnout and be the first step in creating a common theoretical framework to guide emerging research on burnout–cognitive abilities relationships. This model might also encourage researchers to more critical and theory-driven look at burnout–cognitive abilities relationships.

Polygenic prediction within and between families from a 3-million-person GWAS of educational attainment

Aysu Okbay[1], *Yeda Wu*[2], *Nancy Wang*[3], *Hariharan Jayashankar*[3], *Michael Bennett*[3], *Seyed M. Nehzati*[4], *Julia Sidorenko*[2], *Hermon Kweon*[1], *Grant Goldman*[3], *Tamara Gjorgjieva*[3], *Yunxuan Jiang*[5], *Chao Tian*[5], *Rafael Ahlskog*[6], *Patrik K. E. Magnusson*[7], *Sven Oskarsson*[6], *Caroline Hayward*[8], *Archie Campbell*[8], *David Porteous*[8], *Jeremy Freese*[9], *Pamela Herd*[10], *23andMe Research Team*, *Social Science Genetic Association Consortium*, *Chelsea Watson*[4], *Jonathan Jala*[4], *Dalton C. Conley*[12], *Philipp D. Koellinger*[1,13], *Magnus Johannesson*[14], *David I. Laibson*[15], *Michelle N. Meyer*[16], *James J. Lee*[17], *Augustine Kong*[18], *Loic Yengo*[2], *David Cesarini*[3,19], *Patrick Turley*[20], *Peter M. Visscher*[2], *Jonathan P. Beauchamp*[21], *Daniel J. Benamin*[3,4,22], *Alexander I. Young*[4]

HA

[1] Vrije Universiteit Amsterdam, Amsterdam, Netherlands
[2] University of Queensland, Brisbane, Australia
[3] National Bureau of Economic Research, Cambridge, MA, USA
[4] UCLA Anderson School of Management, Los Angeles, CA, USA
[5] 23andMe, Inc., Mountain View, CA, USA
[6] Uppsala University, Uppsala, Sweden
[7] Karolinska Institutet, Stockholm, Sweden
[8] University of Edinburgh, Edinburgh, United Kingdom
[9] Stanford University, Stanford, CA, USA
[10] Georgetown University, Washington, DC, USA
[12] Princeton University, Princeton, NJ, USA
[13] University of Wisconsin Madison, Madison, WI, USA
[14] Stockholm School of Economics, Stockholm, Sweden
[15] Harvard University, Cambridge, MA, USA
[16] Geisinger Health System, Danville, PA, USA
[17] University of Minnesota Twin Cities, Minneapolis, MN, USA
[18] University of Oxford, Oxford, United Kingdom.
[19] New York University, New York, NY, USA
[20] University of Southern California, Los Angeles, CA, USA
[21] George Mason University, Fairfax, VA, USA
[22] UCLA, Los Angeles, CA, USA

We conducted a genome-wide association study (GWAS) of educational attainment (EA) in a sample of ∼3 million individuals and identified 3,952 approximately uncorrelated genome-wide-significant SNPs. A genome-wide polygenic predictor, or polygenic index (PGI), explains 12–16% of EA variance and contributes to risk prediction for ten diseases. The PGI's associations with EA and other phenotypes falls by roughly half when controlling for parental PGIs. In contrast, a PGI to predict IQ shows an attenuation of only ∼20 percent, suggesting that most of the signal in a GWAS of IQ is causal. The correlation between spouses' PGIs for EA is far too large to be consistent with phenotypic assortment alone. In an additional GWAS of dominance deviations from the additive model, we identified no genome-wide-significant SNPs. A separate X-chromosome additive GWAS identified 57.

Factor and network perspectives on spatial ability interventions

Dr. Maxim Likhanov[1,2], ***Mrs. Ekaterina Maslennikova***[3], ***Dr. Giulio Costantini***[4], ***Mrs. Anna Budakova***[2], ***Dr. Elena Esipenko***[2], ***Dr. Victoria Ismatullina***[3], ***Prof. Yulia Kovas***[5,6] **CT**

[1] ITMO University, St. Petersburg, Russian Federation
[2] Tomsk State University, Tomsk, Russian Federation
[3] Psychological institute of Russian Academy of Education, Moscow, Russian Federation
[4] Università degli Studi di Milano-Bicocca, Milan, Italy
[5] Tomsk State University, Tomsk, Russian Federation
[6] Goldsmiths University of London, London, United Kingdom

Spatial ability (SA) was shown to be important for success in different fields, including STEM. Multiple interventions for SA improvement are suggested in the literature, but it is unclear which SA facet should be targeted for more effective interventions. This is partly because it is still unclear whether SA is a unitary construct or a set of related skills and how it relates to general cognitive ability. The aim of the present study was threefold: 1) to replicate previous findings of unifactorial structure of SA; 2) to check whether spatial ability is distinct from general cognitive ability; and 3) to identify SA facets for interventions by means of network analysis. The data was collected from 537 students from Russia using 16 SA tests. Results supported previous research, suggesting moderate overlap between all SA facets. Factor analysis suggested several potential structures, including split into small- and large-scale; manipulation, visualization, and navigation, with similar fit indices for five different theoretically-driven models. Confirmatory factor analysis, mediation and network analyses showed spatial ability being largely independent from verbal ability. In addition, network analysis showed that navigation according to directions is in the centre of network, potentially linking all SA facets. The results call for experimental studies that evaluate the effectiveness of interventions targeting navigation in comparison to other facets of SA.

Developmental changes in genetic and environmental influence on intelligence from age 2 to age 16: A large, longitudinal twin study

Mr. Damien Morris*, *Dr. Stuart J. Ritchie*, *Prof. Robert Plomin CT

King's College London, London, United Kingdom

We attempted to replicate previous findings of rising heritability and declining shared environmental influence on intelligence across development using TEDS, a longitudinal sample of British twins. Cholesky and Simplex models were fitted to 9 waves of cognitive test data for 10,535 twin pairs. Heritability rose significantly from 24% at age 2 to 48–52% at age 16. Concurrently, shared environmental influence declined significantly from 65% to 9–13%. Non-shared environmental influence also rose significantly from 11% to 39%. The rise in heritability was mainly explained by the accumulation of new genetic influences that tended to initially decay before partially recovering. This provides ambiguous support for the theory that active gene-environment correlations are a major mechanism driving developmental increases in heritability for intelligence.

Intelligence heritability and (in-)equality: A meta-analysis of twin data

Dr. Jakob Pietschnig*, *Mr. Jonas Traub*, *Ms. Magdalena Siegel*, *Ms. Marie Pellegrini CT

University of Vienna, Vienna, Austria

Background: Since decades, intelligence heritability estimates have interested the scientific community around the globe. Despite a solid consensus amongst researchers that intelligence is heritable to a certain extent, reported heritability estimates have been observed to show considerable variability between different studies, thus leaving the strength of intelligence heritability yet to be clarified. Moreover, effects of environmental influences (i.e., between-individual variations of environmental influences) remain to be empirically investigated.

Methods: We performed a keyword search for "(IQ OR Intelligence) AND heritability" up to October 2020 in the literature database *ISI Web of Knowledge*. We identified data from *n* = 30,880 monozygotic and 39,403 dizygotic independent twin pairs yielding *k* = 328 effect sizes (88 unique) that had been reported in 77 studies. We obtained twin correlations as well as ACE-estimates that had been reported in primary studies to estimate heritabilities. We used three different heritability estimation types (analysis of reported h^2-levels vs. ACE-calculation preceding effect synthesis vs. ACE-calculation after effect synthesis) and two different approaches (traditional vs. multi-level modeling) to synthesize effect sizes.

Results: Summary effects were remarkably consistent across estimation type and meta-analytical approach, yielding heritability estimates ranging from h^2 = .52 to .61. Effect sizes for shared and unique environmental influences were less consistent, ranging from .15 to .29 (C) and .22 to .30 (E). National indicators of income equality (GINI) were negatively and social mobility indicators (GSMI) were positively related to intelligence heritability. Application of eight standard and modern bias detection methods showed only little evidence for confounding dissemination bias.

Discussion: Here, we demonstrate a strong effect of intelligence heritability in a large number of twin pairs, whilst environmental effects appear to play only a comparatively minor role. Estimates were systematically associated with economic and social equality indicators, showing larger intelligence heritabilities in more egalitarian countries.

Why are there differences across German states in student achievement and cognitive ability?

Prof. Heiner Rindermann CT

Chemnitz University of Technology, Chemnitz, Sachsen, Germany

For more than twenty years, large and generally stable differences within Germany in ability and student achievement have been reported. The South in the West and East are ahead, while the North and the city-states are behind. Bavaria is 14 months ahead of Bremen in school learning. It is striking that there are no (or only marginally received studies on causes and consequences; e.g. Roivainen, 2012). The south-north effect is purely descriptive: geography is not a causal theory. In contrast to research on (inter)national differences, there are no (stable) correlations and effects for evolution (genes), educational level of society (number of years of schooling for adults) and wealth (GDP per capita). However, there are high correlations, robust across indicators, with "burgher-conservative" education policies (e.g. central exams, tracking in young age, grades at a young age, lower proportion of comprehensive schools); with measures of students' quantity of education (hours of instruction, no shortage of teachers); with measures of tertiary educational quality and appreciation of education (university quality, short duration of studies, professors' salaries); with the native/immigrant ratio among students; with burgher-bourgeois (middle-class) lifestyle (less private debt, less Hartz IV/welfare dependency and less crime); and with burgher-conservative-right politics (share of votes for CDU/CSU and non-left parties, non-left state governments). Longitudinal analyses over two to four decades show interaction effects, i.e., more burgher-conservative policies statistically lead to more cognitively competent students and (somewhat less strongly) more cognitively competent populations vote for burgher-conservative parties. This result is delicate both to the practice of student achievement research and to the political milieu that dominates the social sciences and humanities. These policy problems, rather than problems in methodology, are estimated to be the cause of a lack of research in this area.

Faster information-transmission improves reasoning ability by facilitating the access to and transformation of information in working-memory

Prof. Anna-Lena Schubert[1], ***Prof. Dirk Hagemann***[2], ***Mr. Christoph L'offler***[2], ***Dr. Gidon T. Frischkorn***[3]

HA

[1] University of Mainz, Mainz, RLP, Germany
[2] Heidelberg University, Heidelberg, BW, Germany
[3] University of Zurich, Zurich, Switzerland

Individual differences in the speed of information processing have been shown to be consistently related to individual differences in general intelligence. It is an open debate whether these associations can be explained in terms of individual differences in some brain-wide property affecting a large number of cognitive processes, or whether these advantages in processing speed reflect advantages in specific cognitive processes such as executive functions or evidence accumulation. We will demonstrate how mathematical models and psychophysiological approaches can be used to shed some light onto these questions by decomposing the time-course of information processing and relating process parameters to cognitive abilities. In particular, we demonstrate that more intelligent individuals show specific advantages in the speed of higher-order cognitive processes related to the transmission and updating of information in working memory. Moreover, we will present results from recent studies suggesting that the association between processing speed and general intelligence may reflect individual differences in the structural and functional connectivity of brain regions involved in goal-directed information-processing and cognitive control processes. Finally, we will outline a research agenda that combines mathematical modeling and neuroscientific approaches to identify the neuro-cognitive processes giving rise to individual differences in general intelligence.

The uniformity of stereotype threat: Analyzing the moderating effects of premeasured performance

Ms. Andrea H. Stoevenbelt[1], ***Dr. Paulette C. Flore***[2], ***Dr. Inga Schwabe***[1], ***Prof. Jelte M. Wicherts***[1] **CT**

[1] Tilburg University, Tilburg, Noord-Brabant, Netherlands
[2] The Netherlands Institute for Social Research, The Hague, Zuid-Holland, Netherlands

Stereotype threat theory states that underperformance by female or ethnic minority students can be explained by the pressure they may experience by negative stereotypes about their group's performance. Stereotype threat has been widely studied by experimentally introducing stereotype threat, e.g., by stating that women underperform on a certain mathematics test. Moreover, some of these studies investigated whether stereotype threat effects are moderated by individual differences reflected by previous academic performance (e.g., SAT scores or GPA), where larger effects are found for test-takers who strongly identify with an academic domain, and for whom the test is more difficult. Previous academic performance is commonly included as a covariate in stereotype threat research. Including, for example, SAT scores may lead to a treatment-by-covariate interaction. The score on the SAT may affect the strength of the manipulation for a certain participant in such a way that, for example, the manipulation is stronger for participants who score higher on the SAT. Thereby, the results and conclusion may be biased.

We applied a preregistered novel Bayesian approach to meta-analytically study this treatment-by-covariate interaction and whether stereotype threat effects are, indeed, moderated by prior performance. We used raw data from 31 stereotype threat studies involving 3,357 participants. We found that correlations between premeasured performance and tests scores were similar across conditions. In other words: We did not find any evidence for a moderation by premeasured performance. In fact, the effect of a stereotype threat appears to be uniform, where the strength of stereotype threat manipulation would be similar for all participants. This suggests that earlier findings of a moderation of stereotype threat effects by domain identification and test difficulty are most likely chance findings.

Challenges in the interpretation of admission test validity research

Dr. Paul A. Westrick CT

The College Board, New York, New York, United States

This talk addresses three common issues that validity researchers encounter when test users seek assistance with interpreting admission test validity evidence: Simpson's Paradox; differential validity and differential prediction; and using criteria as a single criterion.

The first issue concerns Simpson's Paradox, a statistical phenomenon in which a trend seen across subgroup analyses reverses when data from the subgroups are combined in an overall analysis. This can occur when a higher education system examines the utility of admission tests by combining data across multiple institutions for a single analysis versus conducting institution-level analyses and meta-analyzing the institution-level results.

The second, related issue is differential validity and differential prediction for subgroups. Overall analyses provide valuable information, but when discussions turn to the effects of admission testing on specific subgroups of students, evidence for or against the use of admission tests should include results of analyses conducted at the subgroup level. Recent research showed that high school grade point average (HSGPA) was a slightly stronger than admission test scores as a predictor of first-year GPA (FYGPA) in the overall analyses, but subgroup analyses indicated that only for White students was HSGPA the best predictor of FYGPA, and that admission test scores were equal to or stronger than HSGPA as a predictor of FYGPA for other subgroups. Regarding differential prediction, using test scores and HSGPA together reduced the amount of over- or under-prediction for all but one subgroup.

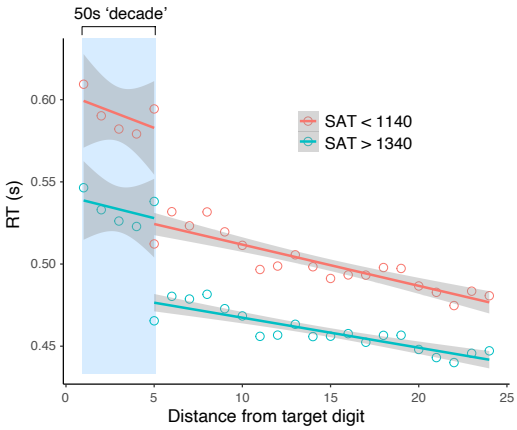
The third example highlights the difficulty of presenting validity evidence for a predictor when criteria are labeled as a criterion. GPA is a common name for a multitude of composite measures that are unique to nearly every student due to differential course selection and differential grading standards. Examples of validity results conducted at the course level and within academic majors reveal these differences.

Reaction time and *g* in the number-comparison task: Perceptual effects of decade discontinuity

Dr. Emily A. Willoughby*, *Dr. James J. Lee CT

University of Minnesota Twin Cities, Minneapolis, Minnesota, United States

Investigation of mechanisms that drive the association between reaction times (RT) and general intelligence (*g*) has revealed several consistent observations. In recent work, models that partition RT into discrete stages of central and perceptual processing have shown that higher-*g* subjects tend to be faster primarily due to an advantage that resides in a strictly serial, central processing stage, rather than a relatively fixed and parallelizable non-decision stage (e.g., Lee & Chabris, 2013; Willoughby & Lee, 2021). To further test the assumptions of this interpretation, our current project employs a double-digit variant of a number-comparison task across a wider range of numerical stimuli (31–79, with a target digit of 55), thus enabling the investigation of whether the tens digit of the numerical stimuli has a perceptual effect on reaction times unmoderated by *g*.



In a sample of 126 high- and 91 moderate-*g* participants, we replicated previous findings that greater numerical distance from the target digit is associated with faster RT, and that the effect of distance interacts with *g* ($p < .001$). However, we additionally found that both moderate- and high-*g* groups showed discontinuities in mean RT when the stimulus crossed the edges of the decade including the reference (55). That is, when the stimulus is 50 rather than 49, or 59 rather than 60, RT shows an average discontinuous increase of about 52 ms, which does not differ significantly between high- and moderate-*g* groups ($p = .27$; 95% CI: [−22.3, 6.4]). Along with supporting evidence from diffusion modeling, this finding suggests that the perceptual stage can be prolonged by visual similarity between the stimulus and the memorized reference, but that the speed of this prolonged stage is not at all correlated with *g*. It is only the central stage, concerned with numerical magnitude, that is so correlated.

References

Lee, J. J. & Chabris, C. F. (2013). General cognitive ability and the psychological refractory period: Individual differences in the mind's bottleneck. *Psychological Science*, *24*(7), 1226–1233. DOI: 10.1177/0956797612471540.

Willoughby, E. A. & Lee, J. J. (2021). Parsing information flow in speeded cognitive tasks: The role of *g* in perception and decision time. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *advance online publication*. DOI: 10.1037/xlm0001026.

Estimating the additive heritability of historiometric eminence in a super-pedigree comprised of four prominent families

Dr. Michael A. Woodley of Menie[1], ***Dr. Mateo Peñaherrera-Aguirre***[2], ***Mr. Matthew A. Sarraf***[3]

CT

[1] Vrije Universiteit Brussel, Brussels, Belgium
[2] University of Arizona, Tucson, Arizona, United States
[3] Independent researcher, Boston, Massachusetts, United States

By merging analytical approaches from the fields of historiometrics and behavior genetics, a social pedigree-based estimate of the heritability of eminence is generated. Eminent individuals are identified using the *Pantheon* dataset. A single super-pedigree, comprised of four prominent and interrelated families (including the Wedgwood-Darwin, Arnold-Huxley, Keynes-Baha'u'lláh, and Benn-Rutherford pedigrees) is assembled, containing 30 eminent individuals out of 301 in total. Each eminent individual in the super-pedigree is assigned a relative measure of historical eminence (scaled from 1 to 100) with non-eminent individuals assigned a score of 0. Utilising a Bayesian pedigree-based heritability estimation procedure employing an informed prior, an additive heritability of eminence of .507 (95% CI [.434 .578]) was found. The finding that eminence is additively heritable is consistent with expectations from behavior-genetic studies of factors that are thought to underlie extraordinary accomplishment, which indicate that they are substantially additively heritable. Owing to the limited types of intermarriage present in the data it was not possible to estimate the impact of non-additive genetic contributions to heritability. Gene-by-environment interactions could not be estimated in the present analysis either, therefore the finding that eminence is simply a function of additive genetic and non-shared environmental variance should be interpreted cautiously.

"Bell curve liberalism" as the most humane approach for addressing individual differences in modern society

Dr. Adrian Wooldridge KL

Political editor and Bagehot columnist for *The Economist*, London, United Kingdom

Modern societies have adopted two strikingly opposed approaches to the problem of individual differences in mental abilities:

1) Deny their existence entirely. Today's humanities disciplines are based on the blank-slate assumption that environment is an all-powerful explanation of individual differences in ability/achievement. This assumption also colours political argument: anybody who suggests that "nature" might explain why some people struggle at school and others succeed is likely vilified as racist or eugenicist.

2) Celebrate their existence and make the most of them. Many people believe that their success is the result of natural talents, and libertarians often resist the idea of expanding opportunities for the disadvantaged because they believe that nothing can be done about natural inequalities. This argument is seldom made in public—environmentalists have decisively won the debate about what is forbidden in public discourse—but it informs much of conservative thinking.

Both positions are misguided. Geneticists and biologists have produced irrefutable evidence that "nature" matters in shaping individual differences, but this doesn't mean that the social order is written into our DNA. Instead, we can accept the reality of individual differences but try to use that reality to address underlying social problems. This "bell curve liberalism" approach would produce interventionist policies designed to take advantage of the upside of individual differences but also deal with the downsides:

- Actively search the population for hidden Einsteins to increase social mobility: there are many more geniuses in the 99% than in the privileged 1% at elite universities.
- Stop the academic creep whereby jobs such as nursing require university degrees.
- Provide more funding for non-academic education, particularly in the form of technical schools and apprenticeships.
- Reduce the unnecessary complexity added by the cognitive elite to try and game the system. Policy makers should constantly push back against such practices.

List of Abstracts: Posters

Abstracts are listed in alphabetical order by presenting author's last name. If a given poster has more than one author, presenting author's name is underlined.

An exploration of the genetic contribution to reading ability from childhood to adulthood in a longitudinal birth cohort

Ms. Elinor C. Bridges[1], ***Dr. William Rayner***[2], ***Dr. Timothy Bates***[1], ***Dr. Michelle Luciano***[1]

[1] University of Edinburgh, Edinburgh, United Kingdom
[2] University of Oxford, Oxford, United Kingdom

Genome Wide Association Studies (GWAS) can be used to investigate the genetic contribution to polygenic phenotypes. Use of GWAS for cognitive traits has become more common in recent years. However, GWAS on the trait of reading ability are relatively scarce, and often limited by sample size, despite evidence that this trait has a genetic component. This study uses a UK longitudinal birth cohort, the National Child Development Study (NCDS), to explore the genetic contribution of reading ability between ages 7 and 33 years.

Data collection for the NCDS commenced in 1958, with the birth of the participants, and is ongoing. A subsample of participants provided a DNA sample, and after quality control these participants comprise the sample for the current study ($N \sim 9800$). The NCDS has a variety of reading ability variables at different age points, including a formal reading test and teacher ratings in childhood, and the participant's disclosure of any reading problems in adulthood.

Principal Components Analysis was carried out on all reading ability variables between ages 7 and 33, and the strongest variables were selected for inclusion as outcomes in GWAS analysis. A composite score for overall reading ability, for use as an outcome for GWAS analysis, was calculated based on the selected reading variables. Specific outcomes for ages 7, 11, 16, 23, and 33 will also be analysed based on the strongest reading measures at each age.

Results of the overall GWAS for general reading ability will be discussed, along with the results of the association analyses at each age point. There will be a discussion of whether the genetic contribution to reading ability is constant, or something that changes with age.

The *g*-neuron hypothesis: Investigating a possible role of the von Economo neuron in general intelligence

Mr. Oliver J. Bruton

Carl von Ossietzky Universität, Oldenburg, Niedersachsen, Germany

General intelligence (*g*) is one of the most replicated and predictively valuable constructs known in the behavioural sciences. Although research has established that *g* is strongly linked to cerebral physiology, thus far neither a substantial neurobiological correlate nor a comprehensive theory incorporating neuronal mechanisms have been advanced. In the context of the *g*-neuron hypothesis, I propose that the von Economo neuron (VEN), a unique neuron type hitherto implicated in social, emotional, and interoceptive processing, may represent an essential constituent of the physiological foundation of *g*.

To this end, different lines of supportive evidence are presented beginning with findings from cognitive and systems neuroscience, which indicate that the brain regions and networks to which the presence of VENs is restricted in humans, show strong overlap with those ones pivotal for *g*. Additionally, studies investigating VENs in relation to psychiatric and neurological conditions are reviewed which suggest that VENs are selectively reduced and/or impaired in brain disorders known to be related to *g* (e.g., schizophrenia).

Furthermore, results from clinical gerontology are addressed, demonstrating that the brains of a select group of elderly subjects (“SuperAgers”) possessing conspicuously preserved fluid cognitive abilities are characterised by significantly elevated VEN densities. Lastly, findings from comparative psychology are described which point to a potential role of VENs in the emergence of the complex cognition exhibited by a number of large-brained species.

On the basis of this conspectus, a reductionist framework, reaching from cognitive theory to single neurons, is proffered. The tentative conclusion is drawn that VENs may influence individual differences in *g* by acting as “herald neurons” which rapidly establish the coherence of neuronal oscillations within a functionally invariant frontoparietal network subserving higher-order cognition, thus leading to enhanced mental efficiency.

Cross-battery cognitive-achievement relations: Developmental differences (WITHDRAWN)

Dr. Jacqueline M. Caemmerer[1], ***Ms. Kelly Mahaffy***[1], ***Dr. Timothy Z. Keith***[2], ***Dr. Matthew R. Reynolds***[3]

[1] University of Connecticut, Connecticut, United States
[2] University of Texas, Austin, Texas, United States
[3] University of Kansas, Lawrence, KS, USA

Studies that examine children's intelligence and academic achievement are often limited to singular tests. This approach may limit the generalizability of these relations across different tests, which has theoretical and applied implications. Developmental differences are also important to account for, as some evidence suggests cognitive-achievement relations shift throughout development.

In our study, six intelligence tests (KABC-II, WJ-III, WISC-III, WISC-IV, WISC-V, and DAS-II) and three achievement tests (KTEA-II, WIAT-II, WIAT-III) were included in cross-battery cognitive-achievement analyses. Participants included 3,927 youth aged 6 to 18 drawn from samples collected by Pearson.

Across-battery confirmatory factor analysis established a higher-order Cattell-Horn-Carroll model which included general intelligence (*g*) and six broad abilities as latent variables (verbal comprehension-knowledge (*Gc*), fluid reasoning (*Gf*), visual-spatial processing (*Gv*), working memory (*Gwm*), processing speed (*Gs*), long-term retrieval (*Gr*)), each estimated by 8–15 subtests. This model was used to test 3 cognitive-achievement models: Broad writing, broad math, and basic reading. Each achievement latent variable was estimated by 4–6 subtests.

Basic reading was significantly predicted by *Gc*, *Gr*, and *Gwm* (β = .40, .25, .22). Broad writing was significantly predicted by *Gc*, *Gr*, *Gwm*, and *Gs* (β = .29, .29, .23, .22). Broad math was significantly predicted by *Gf*, *Gc*, and *Gwm* (β = .71, .13, .05). General intelligence had large direct effects on basic reading, broad writing, and broad math (β = .75, .82, .87). While some cognitive abilities like *g*, *Gc*, and *Gwm* appear to have domain general influences across academic skills, others like *Gf*, *Gr*, and *Gs* influence specific academic domains.

In ongoing developmental analyses, interactions between age (a continuous measured variable) and each latent broad ability will be tested. Significant interactions will be examined to determine the differential influence of the broad ability on achievement across age. Results from the three cognitive-achievement models will be compared.

Teaching creative thinking through art to promote artistic gains: An experimental learning inquiry

Mrs. Lindsay L. Esola

Pennsylvania State University, Pennsylvania, United States

The Apple Project is a teaching intervention designed to adapt and implement a theory of experiential learning (Dewey, 1938/1986; Kolb, 1984) to assess whether students were able to enhance their creative thinking capabilities by engaging in a series of creative tasks. The project is based on Dietrich's (2004) deliberate, spontaneous and flow definitions of creativity as well as Eagleman and Brandt's (2017) concepts of breaking, blending and bending. The data collected from this case study demonstrates artistic growth when projects created before, during, and after scaffolded experiences were compared. The data was analyzed taking into account the serial order effect (Beaty, R. & Silva, P., 2012), which is why they not only went on to create more Apple Artwork, they also were asked to create a self portrait to compare to earlier work. The outcome of the study is a practical application of Brain based learning (Hardiman, 2012) for the art room.

Rethinking the relationship of working memory and intelligence: A perspective based on process overlap theory

Mr. Han Hao[1], ***Mr. Kevin P. Rosales***[1], ***Dr. Jean-Paul Snijder***[2], ***Dr. Kristof Kovacs***[3], ***Dr. Michael J. Kane***[4], ***Dr. Andrew R. A. Conway***[1]

[1] Claremont Graduate University, Claremont, California, United States
[2] Heidelberg University, Heidelberg, Germany
[3] Eotvos Lorand University, Budapest, Hungary
[4] University of North Carolina, Greensboro, North Carolina, United States

Psychometric theories of intelligence typically assume a causal relationship between latent cognitive abilities (general intelligence) and observations of performance (test scores). However, such assumptions are not necessary conditions of the observed covariance structure of test scores, and may have caused overinterpretations, if not misinterpretations, of the latent factors of intelligence. Process Overlap Theory (POT; Kovacs & Conway, 2016) proposed a computational framework of intelligence that does not rely on the latent common cause assumption and applies a sampling mechanism of cognitive processes. We re-analyzed data from Kane et al. (2004), which included tests of verbal and spatial working memory and verbal, spatial, and fluid reasoning. We tested latent variable models and network models to compare the traditional common cause approach to POT. As predicted, traditional models overestimated domain-general covariance in working memory and reasoning. In contrast, network models revealed distinct patterns of domain-general and domain-specific covariance across working memory and reasoning. We then simulated Kane et al. (2004) using a POT algorithm and observed the same pattern of results. We argue that cognitive models of working memory and reasoning overemphasize domain-general mechanisms because psychometric models overestimated domain-general covariance. Working memory and reasoning have more domain-specific overlap than current models suggest.

Phenotypic, genetic, and environmental covariance between sensory discrimination and cognitive ability: A comprehensive meta-analysis

***Mr. Matthew B. Jané*, Mr. Tylor J. Harlow, Dr. James J. Chrobak, Dr. Heather L. Read**

University of Connecticut, Storrs, Connecticut, United States

The positive manifold of inter-correlations between high-level neurocognitive abilities is one of the most consistent and replicated findings in all of psychology. This meta-analysis seeks to understand how the positive manifold extends to low-level sensory discrimination abilities, and to better understand the genetic and environmental nature of this association via the use of:

1. Correlation matrices (k = 14, N = 9303) of test batteries which include sensory discrimination and cognitive variables that are collected and fit to a general structural equation model. A random effects meta-analysis is deployed to pool the standardized path coefficients between general factors of cognition and sensory discrimination.
2. Phenotypic correlations (corrected for measurement error) between pitch discrimination (PD) and three neurocognitive tests (matrix reasoning, MR; vocabulary, VOC; digit span, DS) that are collected and pooled via a random-effects model (total: k = 41, N = 94,341).
3. Genetic correlations that are empirically predicted from phenotypic correlations based on a large sample dataset from Sodini et al. (2018; N = 108,035).
4. Intra-class correlations for monozygotic and dizygotic twins that are compiled to estimate the additive genetic, shared, and non-shared environmental variance components (ACE) for each cognitive and sensory discrimination variable (MR, VOC, DS, and PD; total: kMZ = 134, NMZ = 30,105 pairs, kDZ = 133, NDZ = 34,244 pairs).

Based on the genetic correlations and heritability estimates, the proportion of the correlation between pitch discrimination and cognitive abilities attributable to common genetic variance can be computed with a formula for bivariate heritability. The results of this meta-analysis demonstrate the high phenotypic correspondence between sensory discrimination and cognitive abilities and that this relationship is largely due to common genetic factors (i.e. genetic pleiotropy, linkage disequilibrium). In addition, this covariance is not specific to any one aspect of cognition nor any one modality of sensory discrimination.

Ability tilt over time: A test of investment theory

Mrs. Maria R Medrano Guillen*, *Dr. Karrie E. Elpers*, *Mr. Tyler Minnigh*, *Ms. Krista McManus*, *Dr. Thomas R. Coyle

The University of Texas, San Antonio, Texas, United States

Investment theories propose that investing resources into an area (math) necessarily results in fewer resources to invest in a competing area (verbal). Furthermore, theories of niche-picking propose that investment into an area leads to further investment in that area. Investment theories have been explored using ability tilt (hereafter tilt), the within-subject difference in math and verbal scores on the SAT and ACT, and preferences for STEM and humanities college majors. This research supports investment theories, suggesting that math tilt (math $>$ verbal) is positively correlated with math ability and negatively correlated with verbal ability and predicts preferences for STEM majors, while verbal tilt (verbal $>$ math) shows the opposite pattern and predicts preferences for humanities majors. Research has not examined how tilt changes over time in relation to environmental influences. The present study explores how tilt on the SAT and ACT (tilt1) and college major (STEM or humanities) predict tilt on the GRE (tilt2). Consistent with investment theories, the following predictions were made a priori: (1) tilt1 would significantly, positively predict tilt2 and (2) college major would significantly, positively predict tilt2.

The validity of self-assessed intelligence: Reproducible—modestly-sized—somewhat inflated

Ms. Sabine Patzl*, *Dr. Jakob Pietschnig

Department of Developmental and Educational Psychology, Faculty of Psychology, University of Vienna, Vienna, Austria

Background: Self-assessed intelligence (SAI) plays an important role in high-stakes situations like career decisions. Recent findings suggest that professional interests are primarily a function of self-assessed rather than 'true' abilities. However, previous meta-analytic accounts only revealed a moderate relationship between SAI and psychometric intelligence (IQ). However, ever-increasing numbers of publications addressing this very issue and the development of more refined research methods have rendered previous meta-analytic findings outdated. Because recent findings further suggest potential bias due to the virtual ubiquitous declining effects in empirical research, an update seems necessary.

Methods: We used three-level meta-analyses to synthesize effects from 98 studies (k = 242 effect sizes; N = 54,566) with and without corrections for measurement unreliability. Moreover, we used eight standard and more modern dissemination bias detection methods to identify evidence for possible effect inflation.

Results: Hedges and Olkin-typed analyses yielded an overall SAI and IQ correlation of r = .31. As expected, using the unreliability-corrected Hunter and Schmidt-typed approach led to a larger summary effect, yielding r = .39. Moderator analyses showed that associations with fullscale IQ differed significantly from those of specific domains. Correlations were highest for numerical ability followed by fullscale IQ, spatial, and other abilities. In contrast to previous findings, self-assessment methods (i.e., estimates obtained from absolute scales, relative scales with and without clearly specified comparison groups or mixed scales) did not significantly affect the results. Publication bias analyses indicated that the observed summary effect strength must be considered to be somewhat inflated.

Discussion: In all, we present evidence for a modestly-sized but reproducible association of intelligence with SAI. This association appears to be remarkably stable across moderators, generalizing over self-assessment methods, assessment order, participant sex, and sample composition (student sample vs. general sample) but differentiated according to ability type.

Socialization in kindergarten: Myth or reality? Differences in cognitive, creative, and social abilities in children attending and not attending kindergarten

Mrs. Elena Shepeleva[1], ***Mrs. Ekaterina Valueva***[2], ***Mrs. Victoriya Ovsyannikova***[3]

[1] Moscow State University of Psychology & Education, Moscow, Russian Federation
[2] Institute of Psychology, Russian Academy of Sciences, Moscow, Russian Federation
[3] National Research University Higher School of Economics, Moscow, Russian Federation

The purpose of the study was to explore the long-term prospects of kindergarten attendance for the development of children's creative, cognitive and social abilities, as well as emotional well-being. The study used methods for assessing cognitive abilities, creativity, the social intelligence test, emotional well-being questionnaire. The characteristics of the kindergarten attendance by the child were recorded in the questionnaire for parents aimed at assessing the family environment and the financial level of the family. The study involved students in grades 6–8 of five schools in Moscow and Bryansk. The total number of participants was 363. The results indicated that children who did not attend and attended kindergarten did not differ in levels of intelligence and emotional well-being. At the same time, it was discovered that for children who did not attend kindergarten, compared with children who visited kindergarten, social intelligence was more developed. The results can be associated with a better assimilation of social norms by children spending more time alone with adults than with peers, as well as with greater freedom of development of a child brought up at home.

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When less is more: Multi-task brain network reconfiguration is inversely associated with general intelligence

Mr. Jonas Alexander Thiele[1], ***Dr. Joshua Faskowitz***[2], ***Prof. Olaf Sporns***[2], ***Dr. Kirsten Hilger***[1]

[1] Julius-Maximilians University, Würzburg, Bavaria, Germany
[2] Indiana University, Bloomington, Bloomington, Indiana, USA

General intelligence is one of the most fundamental concepts in psychological science and is crucial for effective adaption of behavior to varying environmental demands. Changing external task demands have been shown to induce reconfiguration of functional brain networks and a global estimate of reconfiguration was proposed as neural foundation of individual differences in intelligence. Notably, associations between intelligence and task- or brain network-specific reconfiguration that would allow insights into involved cognitive processes and their potential common basis have not yet been investigated.

This study used fMRI data from 812 subjects of the Human Connectome Project to link general intelligence to brain network reconfiguration between eight different cognitive states. General intelligence was operationalized as latent g-factor derived from 12 cognitive tasks using bifactor analysis. Subject-specific functional connectivity matrices were estimated from resting state and seven different tasks. Functional brain connections were filtered based on their correlation with intelligence and reconfiguration was operationalized as cosine distance between the filtered connectivity matrices of two states.

Our results show that higher scores of general intelligence were associated with less brain network reconfiguration. This association was observed for all rest-task (ρ = –.23, $p <$ .001) and task-task (ρ = –.23, $p <$ .001) comparisons and for all functional brain networks except the motor system. Results were replicated in two independent samples (N = 138, N = 184) indicating that the observed effect generalizes to different intelligence measures and various cognitive demands.

The relationship between higher intelligence and less brain network reconfiguration suggests that higher intelligent people may have an intrinsic network architecture that is closer to the network architecture as required by various cognitive demands. Further, our results propose intelligence as an emergent property of a widely distributed multi-task brain network, potentially reflecting the neural equivalent of the positive manifold defining general intelligence.

List of Participants

Abdellaoui, Abdel	University of Amsterdam
Beaty, Roger	Pennsylvania State University
Bridges, Elinor	University of Edinburgh
Bruton, Oliver	Carl von Ossietzky Universität Oldenburg
Caemmerer, Jacqueline	University of Connecticut
Clark, Gregory	University of California Davis
Dürlinger, Florian	University of Vienna
Dworak, Elizabeth	Northwestern University
Esola, Lindsay	Pennsylvania State University
Euler, Matt	University of Utah
Fries, Jonathan	University of Vienna
Frischkorn, Gidon T.	University of Zurich
Gavrilova, Evgeniya	Moscow State University
Genç, Erhan	Leibniz Research Centre
Goriounova, Natalia	Vrije Universiteit Amsterdam
Haier, Richard	University of California Irvine
Hao, Han	Claremont Graduate University
Hilger, Kirsten	Julius Maximilians University
Hill, W. David	University of Edinburgh
Hulshoff Pol, Hilleke	University Medical Center Utrecht
Jané, Matthew	University of Connecticut
Kulikowski, Konrad	University of Social Sciences
Lee, James	University of Minnesota Twin Cities
Medrano, Maria	The University of Texas San Antonio
Likhanov, Maxim	ITMO University
Morris, Damien	King's College London
Patzl, Sabine	University of Vienna
Pietschnig, Jakob	University of Vienna
Rindermann, Heiner	Chemnitz University of Technology
Schubert, Anna-Lena	University of Mainz
Shepeleva, Elena	Moscow State University
Stoevenbelt, Andrea	Tilburg University
Thiele, Jonas	Julius-Maximilians University Würzburg
Westrick, Paul	The College Board
Willoughby, Emily	University of Minnesota Twin Cities
Woodley of Menie, Michael	Vrije Universiteit Brussel
Wooldridge, Adrian	*The Economist*

Useful Information

Zoom instructions

ISIR 2021 is held virtually via Zoom. Registered attendees will be sent a Zoom link shortly before the conference. **If you still need to register, please do so HERE.**

The meeting can be accessed via the Zoom desktop client, mobile device (iOS or Android), or in a browser window. Download the Zoom client here. **To access the meeting via the Zoom desktop client (any version):**

1. Open the Zoom desktop client.
2. Join a meeting using one of these methods:
    - Click **Join a Meeting** if you want to join without signing in.
    - Sign in to Zoom then click **Join**.
3. Enter the meeting ID number and your display name.
    - If you're signed in, your default name will appear.
    - If you're not signed in, enter a display name.
4. Select if you would like to connect audio and/or video and click **Join**.

For additional instructions (including mobile access), please refer to this page.

As a reminder, the **poster session** will be held on Friday, September 3^{rd} from 19:00 to 20:00 UTC. This will be structured to emulate a poster session at an in-person conference: Each poster will have its own breakout room hosted by the presenter, and attendees can go from one room to another at will.

ISIR elections

We eagerly solicit new Board members and nominations for future Presidents of our Society. For both forms of nomination, please email isir.president.nomination@gmail.com.

For president nominations please include in subject line: **President**.
For board member nominations please include in subject line: **Board Member**.

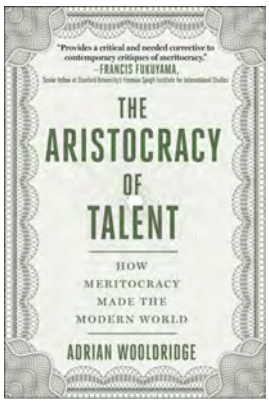
Future meetings

We usually have the conference in Europe and in the USA alternate years. 2022 is scheduled for Europe—see isironline.org for developments—and are seeking a host for 2023 in the USA. Please email admin@isironling.org if you'd like to discuss hosting the meeting.

Recent books from our ISIR community

Several of our featured speakers and regular attendees have new books on topics concerning intelligence. Some highlights are showcased below.

***The Aristocracy of Talent* by Adrian Wooldridge** (2021)



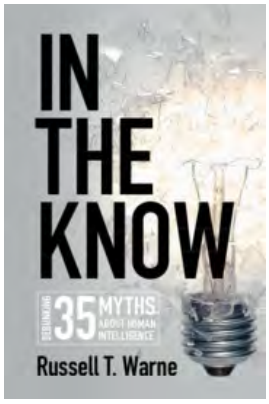
The Aristocracy of Talent

Meritocracy: the idea that people should be advanced according to their talents rather than their status at birth. For much of history this was a revolutionary thought, but by the end of the twentieth century it had become the world's ruling ideology. How did this happen, and why is meritocracy now under attack from both right and left?

Adrian Wooldridge traces the history of meritocracy forged by the politicians and officials who introduced the revolutionary principle of open competition, the psychologists who devised methods for measuring natural mental abilities and the educationalists who built ladders of educational opportunity. He looks outside western cultures and shows what transformative effects it has had everywhere it has been adopted, especially once women were brought into the meritocractic system.

Wooldridge also shows how meritocracy has now become corrupted and argues that the recent stalling of social mobility is the result of failure to complete the meritocratic revolution. Rather than abandoning meritocracy, he says, we should call for its renewal.

***In the Know: Debunking 35 Myths About Human Intelligence* by Russell Warne** (2020)

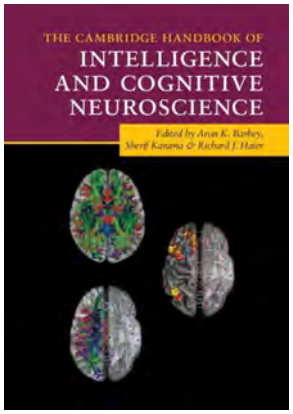


In the Know: Debunking 35 Myths About Human Intelligence

Emotional intelligence is an important trait for success at work. IQ tests are biased against minorities. Every child is gifted. Preschool makes children smarter. Western understandings of intelligence are inappropriate for other cultures. These are some of the statements about intelligence that are common in the media and in popular culture. But none of them are true. In the Know is a tour of the most common incorrect beliefs about intelligence and IQ. Written in a fantastically engaging way, each chapter is dedicated to correcting a misconception and explains the real science behind intelligence. Controversies related to IQ will wither away in the face of the facts, leaving readers with a clear understanding about the truth of intelligence.

- Gives non-experts a firm understanding of intelligence
- Highlights the severe mismatch between popular beliefs about intelligence/IQ and the scientific research on the topic
- Shows how the willingness of people to deny the existence of intelligence and/or its importance in everyday life is harmful
- Outlines why intelligence matters and the importance of acknowledging IQ differences

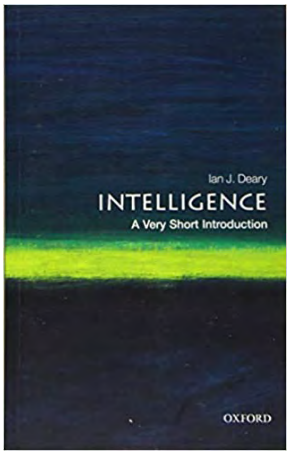
The Cambridge Handbook of Intelligence and Cognitive Neuroscience **edited by Aron K. Barbey, Sherif Karama and Richard Haier** (2021)



The Cambridge Handbook of Intelligence and Cognitive Neuroscience

This handbook introduces the reader to the thought-provoking research on the neural foundations of human intelligence. Written for undergraduate or graduate students, practitioners, and researchers in psychology, cognitive neuroscience, and related fields, the chapters summarize research emerging from the rapidly developing neuroscience literature on human intelligence. The volume focusses on theoretical innovation and recent advances in the measurement, modeling, and characterization of the neurobiology of intelligence differences, especially from brain imaging studies. It summarizes fundamental issues in the characterization and measurement of general intelligence, and surveys multidisciplinary research consortia and large-scale data repositories for the study of general intelligence. A systematic review of neuroimaging methods for studying intelligence is provided, including structural and diffusion-weighted MRI techniques, functional MRI methods, and spectroscopic imaging of metabolic markers of intelligence.

Intelligence: A Very Short Introduction (Second Edition) **by Ian J. Deary** (2020)



Intelligence: A Very Short Introduction (2nd ed.)

Some people are cleverer than others. This everyday observation is the subject of an academic field that is often portrayed as confused and controversial, when in fact, the field of intelligence holds some of psychology's best-replicated findings.

This Very Short Introduction describes what psychologists have discovered about how and why people differ in their thinking powers. Drawing on large scale data Ian Deary considers how many types of intelligence there are, and how intelligence changes with age. Along the way he tackles some of the most burning questions surrounding intelligence, such as whether larger brains are cleverer, and how genes and environments contribute to people's intelligence differences. He also considers the new field of cognitive epidemiology, which draws links between intelligence and better health, less illness, and longer life, and asks whether intelligence is increasing. In this new edition Deary also addresses the controversial question of whether men and women differ in intelligence. Throughout he provides a clear description of the data we can use to answer these questions and more.

Acknowledgements

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- Sincere thanks are also extended to Cesca Eaton and Emily Willoughby for preparing the program
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- We thank an Anonymous Donor for a generous gift to the Haier awardees
- Our thanks to all the Reviewers who read submissions for this conference
- Our thanks to all members who have given of their time most generously on numerous committees to enable the conference to run smoothly

See you in Vienna for ISIR 2022!