isironline.org

International Society for
Intelligence Research (ISIR)

2022

Annual Conference

July 25–27

Hosted by The University of Vienna

Cover design

Montage of photographs from Vienna, Austria. From top left to bottom right:

St. Stephen's Cathedral (Stephansdom); photograph by Miguel Mendez, licensed under Creative Commons Attribution 2.0 Generic (CC BY 2.0).

Austrian Parliament Building (Parlamentsgebäude); photograph by SPÖ Presse und Kommunikation, licensed under Creative Commons Attribution-Share Alike 2.0 Generic (CC BY-SA 2.0).

Exterior facade of the Main Building of the University of Vienna (Wien Universität Eingangsbereich); photograph by Thomas Ledl, licensed under Creative Commons Attribution-ShareAlike 3.0 Austria (CC BY-SA 3.0 AT).

View of Maria Theresien-Platz and the Kunsthistorisches Museum; photograph by Jorge Royan, licensed under Creative Commons Attribution-Share Alike 3.0 (CC SA 3.0).

Lateral and midsaggittal brain section illustrations, normal distribution, and subsequent program were created by Emily Willoughby (willo074@umn.edu); program design based on template at Github by Maximelucas, licensed under GNU General Public License v3.0.

Contents

About

Founded in 2000, ISIR is the focal scientific society for the world's researchers on human intelligence. While the focus of the society is on human intelligence, we are also interested in cognitive abilities in other species. Artificial intelligence is not a current focus of the society. Intelligence research is currently represented by two major journals: *Intelligence*, edited by Richard Haier, and the *Journal of Intelligence*, an open-access MDPI journal edited by Andrew Conway. Both journals welcome 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 22^{nd} ISIR Annual Conference 2022 is in the beautiful Austrian capital of Vienna with our local host Dr. Jakob Pietschnig. The conference will be held from Monday, July 25th to Wednesday the 27th in the Main Building of the University of Vienna (Universitätshauptgebäude, Universitätsring 1). Our social event will take place on Tuesday, July 26. The event will take place in the large ceremonial hall of the main building of the University of Vienna. There will be signs to direct you from the two entrances (as indicated on page 71) to the event.

We will have a strong and exciting showing of researchers, including invited speakers Abdel Abdellaoui and Anna-Lena Schubert, **Lifetime Achievement Awardee Aljoscha Neubauer**, an interview with our **Distinguished Contributor Matt McGue**, and **Holden Memorial Awardee Jochen Paulhus**. Further information and updates will be announced on the ISIR website as they arise.

ISIR President and Board 2022

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

We warmly welcome five new board members recently elected by the ISIR community: **Timothy Bates**, **Roberto Colom**, **Guy Madison**, **John Protzko** and **Andreas Demetriou**.

Organizing Committee

Local Host:	Jakob Pietschnig
Program Chair and Design:	Emily Willoughby

Timetable

*All times listed in the schedule are in **Central European Summer Time** (CEST).*

Schedule key:

LA: Lifetime Achievement Awardee

IS: Invited Speaker

HM: Holden Memorial Speaker

KL: Keynote Lecture

DC: Distinguished Contributor Interview

OP: Oral Presentation

SP: Student (oral) Presentation

Note: Student presenters are eligible for the Best Student Paper award.

Sunday, 24th of July

16:45–17:00	**Opening remarks**		
17:00–18:00	IS	**Matt McGue** University of Minnesota	Without merit: The costs and benefits of an imperfect system
18:00–21:30	**Welcome session and refreshments courtesy of the IMC**		

Monday, 25th of July

8:45–9:15	**Registration**		
9:15–9:30	**Welcome**		
9:30–10:30	KL	**Abdel Abdellaoui** University of Amsterdam	Gene-environment correlations across geographic regions affect genome-wide association studies
10:30–11:00	**Coffee Break**		
11:00–12:00	**Neuroscience I**		
11:00–11:20	SP	**Kirsten Hilger** Würzburg University	From explanation to prediction: Why cross validation and replication is essential in studying the biological bases of intelligence
11:20–11:40	SP	**Oliver Bruton** Carl von Ossietzky Universität	Von Economo neurons in frontal and parietal brain regions: Do they contribute to *g*?
11:40–12:00	OP	**Péter Ujma** Semmelweis University	Cognitive performance and the sleep electroencephalogram
12:00–13:00	**Lunch**		
13:00–13:40	IS	**Kristof Kovacs** Eötvös Loránd University	The (double) nature of *g*
13:40–14:40	**Education I**		
13:40–14:00	SP	**Christian Thurn** Swiss Federal Institute of Technology in Zürich	Quo vadis, student? Predicting secondary school streaming in Switzerland from students' intelligence, interest, and school grades
14:00–14:20	SP	**Simone Plak** Vrije Universiteit Amsterdam	SMILE: A simulation-based model of intelligence, learning, and education
14:20–14:40	OP	**Andreas Demetriou** Cyprus Academy of Sciences, Letters, and Arts	Cognitive and personality predictors of school performance from preschool to secondary school: An overarching model

14:40–15:40	**Mental Health**		
14:40–15:00	SP	**Jonathan Fries** University of Vienna	High intelligence is associated with mental health problems in a sample of intellectually gifted Europeans
15:00–15:20	SP	**Camille Williams** Paris Sciences et Lettres University	Highly intelligent individuals do not have more mental health disorders than the average
15:20–15:40	SP	**Stanisław Czerwiński** University of Gdańsk	Is an exceptional mind a troubled one? Investigating the nonlinearity of the relationship between intelligence and mental health using spline regression
15:40–16:10	**Afternoon tea**		
16:10–17:10	**Social and Life Outcomes I**		
16:10–16:30	SP	**Florian Dürlinger** University of Vienna	Associations of religiosity and cognitive abilities in European adults aged 50+ years
16:30–16:50	SP	**Chien-An Lin** University of Edinburgh	Smart people know how the economy works: Intelligence, economic knowledge and financial literacy
16:50–17:10	SP	**Tobias Wolfram** Bielefeld University	Estimating occupational heterogeneities in intelligence and non-cognitive traits—A comparative perspective
17:10–18:10	**Keynote II**		
17:10–18:10	KL	**Anna-Lena Schubert** Heidelberg University	Cognitive control and intelligence: A neurocognitive psychometrics perspective
18:30–21:00	**Poster session and drinks in courtyard**		

Tuesday, 26th of July

*All times listed in the schedule are in **Central European Summer Time** (CEST).*

9:10–10:10	**Holden Memorial Address for Distinguished Journalism**		
9:10–10:10	HM	**Jochen Paulus** Wiesbaden, Germany	Why journalists get it wrong: Some thoughts and stories about how psychological science ends up in the media
10:10–10:40	**Coffee Break**		
10:40–12:20	**Psychometrics and the Nature of *g***		
10:40–11:00	OP	**Jakob Pietschnig** University of Vienna	Expert perspectives on intelligence: What we agreed on then, what we agree on now, and what we believe about the future
11:00–11:20	SP	**Elina Tsigeman** Tomsk State University	Mind the gap: Persistent gender differences in spatial ability, even in STEM experts
11:20–11:40	SP	**Jordan Lasker** Texas Tech	Factor analysis and psychometric network analysis: Head-to-head in Carroll's data
11:40–12:00	SP	**Sabine Patzl** Technical University of Munich	Viewing self- and psychometrically assessed intelligence associations through the lens of the multiverse: A meta-analysis
12:00–12:20	IS	**Dylan Molenaar** University of Amsterdam	Testing for group differences in cognitive strategies to explain violations of measurement invariance
12:20–13:20	**Lunch**		
13:20–14:40	**Genetics, Biology and Evolution**		
13:20–13:40	OP	**Kristof Kovacs** Eötvös Loránd University	Hormonal maturity fractionates cognitive abilities in adolescence
13:40–14:00	SP	**Damien Morris** King's College London	Investigating bias in conventional twin study estimates of genetic and environmental influence for educational attainment
14:00–14:20	SP	**Alexandros Giannelis** University of Minnesota	A genome-wide association study of specific quantitative ability
14:20–14:40	SP	**Emily Willoughby** University of Minnesota	Biological annotation in a genome-wide association study of quantitative ability
14:40–15:10	**Afternoon tea**		

15:10–16:10	Cognitive Psychology I		
15:10–15:30	SP	**Chenyu Li** University of Zürich	Working memory capacity and strategy use in RAPM: A combined individual-differences and experimental investigation
15:30–15:50	OP	**Andra Biesok** Humboldt-Universität zu Berlin	The integration of figurative language comprehension in the CHC-model for healthy individuals
15:50–16:10	OP	**Adam Chuderski** Jagiellonian University	A new computerized test of fluid intelligence that requires relational structure mapping
16:10–17:10	**Invited Speaker**		
16:10–17:10	IS	**Steven Pinker** Harvard University	Rationality: What it is, why it seems scarce, why it matters
18:30–23:00	**Social event and banquet**		

Wednesday, 27th of July

*All times listed in schedule are in **Central European Summer Time** (CEST).*

9:10–10:10	**Lifetime Achievement Award Address**		
9:10–10:10	LA	**Aljoscha Neubauer** University of Graz	My checkered path through intelligence research—from cognitive psychology via neuro to social psychology and into the future
10:10–10:40	**Coffee Break**		
10:40–12:00	**Education II**		
10:40–11:00	OP	**David Giofré** University of Genova	An investigation of the female and male gaps in maths and reading using a large and representative Italian sample: The impact of differential item functioning and anxiety
11:00–11:20	OP	**Elsbeth Stern** Swiss Federal Institute of Technology in Zürich	The role of intelligence in educational decisions: Data from Switzerland indicate undesirable effects
11:20–11:40	OP	**Lisa Bardach** University of Tübingen	Intelligence, personality, and academic achievement: Investigating reciprocal within-person associations in adolescence
11:40–12:00	OP	**Mike Mhlolo** Central University of Technology, Free State	Creating tomorrow's stars today: Re-examining the STEM intervention strategy through Dinaledi Schools in South Africa
12:00–13:00	**Lunch**		
13:00–14:00	**Cognitive Psychology II**		
13:00–13:40	OP	**James Lee** University of Minnesota	Insights into the nature of intelligence from stage models of reaction time
13:40–14:00	OP	**Jörn Sparfeldt** Saarland University	How intelligence translates to successful complex problem solving: The mediating effect of the strategic behavior eigendynamic first

14:00–14:40	**Neuroscience II**		
14:00–14:20	OP	**George Spanoudis** University of Cyprus	Neural correlates of developing intelligence
14:20–14:40	OP	**John Protzko** Central Connecticut State University	The impact of focal cortical lesions on the development of cognitive ability: Testing causality after the longitudinal analysis of 1,600 children
14:40–15:10	**Afternoon tea**		
15:10–17:10	**Social and Life Outcomes II**		
15:10–15:30	OP	**Heiner Rindermann** Chemnitz University of Technology	The future of intelligence: A prediction of the Flynn effect until the year 2100 for about 80 countries
15:30–15:50	OP	**David Bann** University College London	Weakening of the cognition and height association from 1957 to 2018: findings from four British birth cohort studies
15:50–16:30	OP	**Timothy Bates** University of Edinburgh	Sophisticated deviants: Intelligence and radical economic attitudes
16:30–17:10	OP	**Gregory Clark** University of California	Assortative mating and the Industrial Revolution: England, 1754–2021
17:30–18:30	**Distinguished Contributor Interview**		
17:30–18:30	DC	**Matt McGue** University of Minnesota	Distinguished Contributor Interview
19:00–20:00	**Business meeting**		

Abstracts: Talks

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

LA : Lifetime Achievement Awardee

IS : Invited Speaker

HM : Holden Memorial Speaker

KL : Keynote Lecture

DC : Distinguished Contributor Interview

OP : Oral Presentation

PP : Poster Presentation

SP : Student Presentation

Note: Student presenters are eligible for the Best Student Paper award.

Gene-environment correlations across geographic regions affect genome-wide association studies

Abdel Abdellaoui KL

University of Amsterdam

Gene-environment correlations affect associations between genetic variants and complex traits in genome-wide association studies (GWASs). Here, we showed in up to 43,516 British siblings that educational attainment polygenic scores capture gene-environment correlations, and that migration extends these gene-environment correlations beyond the family to broader geographic regions. We then ran GWASs on 56 complex traits in up to 254,387 British individuals. Controlling for geographic region significantly decreased the heritability for socio-economic status (SES)-related traits, most strongly for educational attainment and income. For most traits, controlling for region significantly reduced genetic correlations with educational attainment and income, most significantly for BMI/body fat, sedentary behaviour, and substance use, consistent with gene-environment correlations related to regional socio-economic differences. The effects of controlling for birth place and current address suggest both passive and active sources of gene-environment correlations. Our results show that the geographic clustering of DNA and SES introduces gene-environment correlations that affect GWAS results.

Weakening of the cognition and height association from 1957 to 2018: Findings from four British birth cohort studies

Dr. David Bann*, *Dr. Liam Wright*, *Dr. Neil Davies*, *and Dr. Vanessa Moulton OP

University College London, United Kingdom

Taller individuals have been repeatedly found to have higher scores on cognitive assessments. Recent studies have found that this association can be explained by genetic factors, yet this does not preclude the influence of environmental or social factors that may change across time. We tested this using data from four British birth cohorts (born 1946, 1958, 1970, and 2001) with comparable data available at 10/11 and 14/17 years (*N* = 41,418). Height was measured at each age, and cognition via verbal reasoning, vocabulary/comprehension and mathematical tests. Taller participants had higher mean cognitive assessment scores in childhood and adolescence, yet the associations were weaker in later (1970 and 2001) cohorts. For example, the mean difference in height comparing the highest with lowest verbal cognition scores at 10/11 years was 0.57 *SD* (95% CI = 0.44–0.7) in the 1946 cohort, yet 0.30 *SD* (0.23–0.37) in the 2001 cohort. Expressed alternatively, there was a reduction in correlation from 0.17 (0.15–0.20) to 0.08 (0.06–0.10). This pattern of change in association was observed across all ages and cognition measure used, was robust to adjustment for social class and parental height, and modeling of plausible missing-not-at-random scenarios. Quantile regression analyses suggested that these differences were driven by differences in the lower centiles of height, where environmental influence may be greatest. Associations between height and cognitive assessment scores in childhood-adolescence substantially weakened from 1957 to 2018. These results support the notion that environmental and social change can markedly weaken associations between cognition and other traits.

Intelligence, personality, and academic achievement: Investigating reciprocal within-person associations in adolescence

Lisa Bardach[1], ***Nicolas Hübner***[1], ***Benjamin Nagengast***[1], ***Ulrich Trautwein***[1], ***Sophie von Stumm***[2]

OP

[1]University of Tübingen, Tübingen, Germany
[2]University of York, York, United Kingdom

Intelligence and personality traits have long been recognized as key predictors of students' academic achievement. However, little is known about their longitudinal and reciprocal associations. This study therefore charted the developmental interplay of intelligence, personality (Big Five) and academic achievement in 3,880 German secondary school students. The adolescents were assessed four times on intelligence (test of figural analogies), Big Five personality traits, and academic achievement in mathematics (standardized achievement tests) between the ages 11 and 14 years, i.e., in grade 5, 6, 7, and 8. We set up latent random-intercept cross-lagged panel models (RI-CLPs) to investigate reciprocal within-person associations between (a) academic achievement and intelligence, (b) academic achievement and personality, as well as (c) intelligence and personality.

Academic achievement and intelligence showed reciprocal within-person relations, with the strongest coefficients found for achievement longitudinally predicting intelligence. None of the reciprocal associations between personality and academic achievement reached statistical significance. The results further revealed negative within-person associations between Conscientiousness and Extraversion assessed at the first measurement point and intelligence assessed at the second measurement point. Overall, our work contributes to developmental theorizing on interrelations between personality, intelligence, and academic achievement in adolescence.

Sophisticated deviants: Intelligence and radical economic attitudes

Prof. Timothy C. Bates*, *Dr. Chien Lin

OP

University of Edinburgh, Edinburgh, United Kingdom

Conservative economic attitudes have been theorized as symptoms of low cognitive ability. Data typically suggest the opposite: linking conservative views weakly to higher, not lower, ability, but with very large between-study variability. Here, test a new model, linking cognitive ability not to liberal or conservative economics, but to economic extremism: How far individuals deviate from prevailing centrist views. In a pilot and two large pre-registered studies (total N = 2,100), demonstrated this association of intelligence with economic deviance. The findings suggest opportunities to understand the generation and mainstreaming of radical fringe social attitudes, especially is groups lacking value diversity.

The integration of figurative language comprehension in the CHC-model for healthy individuals

Andra Biesok*, *Prof. Matthias Ziegler

OP

Humboldt-Universität, Berlin, Berlin, Germany

Figurative expressions are an elementary part of everyday language. Much of human thinking is conceptualized through metaphors, proverbs, irony, idioms, sarcasm, and other instances of non-literal language. As a consequence, people get into contact with figurative language early in their development and have predominantly fewer problems understanding and producing it later in life. Figurative language comprehension influences social relationships and educational achievement. Psychological research has produced a plethora of knowledge on figurative language comprehension and production in healthy and especially clinical samples, without being able to integrate it into a framework and distinguish whether understanding the different forms of figurative language is governed by the same psychological processes. This study aims to integrate the comprehension of figurative language for healthy individuals in the Cattell–Horn–Carroll (CHC) model of intelligence. Therefore, a wide range of items for the comprehension of figurative language were selected. Based on a dataset of $N = 755$ individuals the items were examined for their unidimensionality. Moreover, different theoretically viable models were tested integrating figurative language understanding into the CHC-model. The integration into the CHC-model was based on a dataset of $N = 450$ individuals which were collected through the Berlin-Study-Ability-Test (BSAT), a test developed to test applicants for a bachelor's degree in psychology. We integrated the structure of figurative language understanding into the model of the BSAT which includes fluid and crystallized abilities comprehension using structural equation models. Relations with other non-cognitive constructs (personality traits and achievement motivation) were examined to explore the scores' nomological network as well. Results and implications are discussed.

Von Economo neurons in frontal and parietal brain regions: Do they contribute to *g*?

Mr. Francisco J. Fuentealba-Villarroel[1], ***Mr. Josué Renner***[1], ***Prof. Arlete Hilbig***[1], ***Mr. Oliver J. Bruton***[2], ***Prof. Alberto A. Rasia-Filho***[1] **SP**

[1]Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, Rio Grande do Sul, Brazil
[2]Carl von Ossietzky Universität, Oldenburg, Niedersachsen, Germany

Bruton (2021) proposed a theoretical framework, suggesting that a special class of nerve cells referred to as von Economo neurons (VENs) may be intrinsically linked to general intelligence (*g*). The central postulate of his "*g*-neuron-hypothesis" states that VENs may influence individual differences in *g* by rapidly implementing the coherence of neuronal oscillations, thus creating the unobstructed and efficient flow of information between frontal and parietal brain regions known to relate to intelligence.

Previously, VENs had only been described as found in frontal areas such as the anterior cingulate cortex (ACC), the dorsolateral prefrontal cortex (DLPFC) and anterior Insula. Based on his supposition, Bruton (2021) thus predicted the existence of parietal VENs. This conjecture is backed by a very recent post-mortem investigation conducted by Fuentealba-Villarroel, Renner, Hilbig, Bruton and Rasia-Filho (2022), who for the first time described the presence of spindle-shaped neurons in the human posteromedial cortex (PMC), including the Precuneus, which were interpreted as likely representing VENs.

The Precuneus is a multimodal parietal area with widespread links to regions involved by way of example in working memory and executive functioning. Furthermore, it plays a vital role in the task-negative default-mode network (DMN) which is widely regarded as the functional antagonist of a task-positive central-executive network (CEN). The efficient interplay between these two networks, which has been related to intelligence, may be facilitated by the VEN-bearing regions in both the frontal and parietal lobes.

The implications of these findings are discussed and further suggestions for research into the "*g*-neuron-hypothesis" are outlined.

A new computerized test of fluid intelligence that requires relational structural mapping

Dr. Jan Jastrzębski, Mr. Michał Ociepka, Dr. Adam Chuderski OP

Jagiellonian University in Krakow, Krakow, Poland

We present Graph Mapping – a simple and effective computerized test of fluid intelligence (reasoning ability). The test requires relational structure mapping – a key component of the reasoning process, as suggested by five decades of cognitive science research and theorizing on relational and analogical reasoning. Participants are asked to map a pair of corresponding nodes across two mathematically isomorphic but visually different graphs. The test difficulty can be easily manipulated – the more complex structurally and dissimilar visually the graphs, the higher response error rate. Graph Mapping offers high flexibility in item generation, ranging from trivial to extremely difficult items, supporting progressive item sequences suitable for correlational studies. It also allows multiple item instances (clones) at a fixed difficulty level as well as full item randomization, both particularly suitable for within-subject experimental designs, longitudinal studies, and adaptive testing. The test has short administration times and is unfamiliar to participants, yielding practical advantages. Graph Mapping has unidimensional structure. It has excellent psychometric properties: Its convergent validity (e.g., loadings on the reasoning ability factor) and reliability is comparable to the three leading traditional fluid reasoning tests (Raven's Advanced Progressive Matrices, Cattell CFT-3, and Geometric Analogies). The convenient software freely available online allows a researcher to design the optimal test variant for a given study and sample. Besides psychometric and practical advancements it yields, Graph Mapping also contributes to the theory of intelligence by suggesting that the core of fluid intelligence consists of the ability to validly represent, process, and apply relational information.

Assortative mating and the Industrial Revolution: England, 1754–2021

Prof. Gregory Clark[1,2], ***Prof. Neil Cummins***[2]

OP

[1]University of California, Davis, Davis, USA
[2]London School of Economics and Political Science, London, United Kingdom

Using a new database of 1.7 million marriage records for England 1837-2021 we estimate assortment by occupational status in marriage, and the intergenerational correlation of occupational status. We find the underlying correlations of status groom-bride, and father-son, are remarkably high: 0.8 and 0.9 respectively. These correlations are unchanged 1837–2021. There is evidence this strong matching extends back to at least 1754. Even before formal education and occupations for women, grooms and brides matched tightly on educational and occupational abilities. We show further that women contributed as much as men to important child outcomes. This implies strong marital sorting substantially increased the variance of social abilities in England. Pre-industrial marital systems typically involved much less marital sorting. Thus the development of assortative marriage may play a role in the location and timing of the Industrial Revolution, through its effect on the supply of those with upper-tail abilities.

Is an exceptional mind a troubled one? Investigating the nonlinearity of the relationship between intelligence and mental health using spline regression

***Mr. Stanisław K. Czerwiński*, Dr. Paweł A. Atroszko, Prof. Roman Konarski** SP

University of Gdańsk, Gdańsk, Poland

Despite intelligence being generally related to better mental health, individuals with extremely high levels of intelligence (also often referred to as gifted) are frequently viewed to be socially maladjusted, emotionally unstable, eccentric, and are presented in pop culture as “mad genius”. Moreover, qualitative data even shows intellectually gifted individuals referring to their high intelligence as a disability. Although this view has been present for decades, the scientific data on this subject is highly inconsistent and suffers from a number of methodological limitations.

In this study, to test whether the relationship between general intelligence and mental health is nonlinear in such a way that at extreme values of intelligence the relationship turns from positive to a negative one the data from eight waves of the 1970 British Cohort Study (BCS70) was used (*N* range from 2,864 to 7,984), with intelligence being assessed at age 10, and mental health being assessed with several different measures at ages 16, 26, 30, 34, 42, 46 and 50 (16 dependent variables overall). Spline regression, which divides the dataset into intervals, creates a separate regression for each interval and then smooths out the breakpoints was used for analysis, alongside more commonly used polynomial quadratic regression.

The results showed that for most tested model comparisons, the nonlinear models were significantly better than the corresponding linear models. At high values of intelligence, individuals might begin to experience unique mental health issues. These may outweigh the positive effects of intelligence. Intellectually gifted individuals have a large potential to have a positive impact on the functioning of the whole society. Recognizing and understanding their problems can prove to be of great importance.

Cognitive and personality predictors of school performance from preschool to secondary school: An overarching model

Prof. Andreas Demetriou OP

Cyprus Academy of Sciences, Letters, and Arts, Nicosia, Nicosia, Cyprus
University of Nicosia, Nicosia, Nicosia, Cyprus

We review research examining how school performance from preschool to secondary school relates with cognitive, self-awareness, language, and personality processes. We outline the architecture of mind, hierarchically organized into a general factor, g, underlying distinct mental processes (i.e., executive, reasoning, language, cognizance, and personality processes). *g* develops shifting from executive to reasoning and cognizance processes from preschool to adolescence; personality also changes, consolidating in adolescence. There are three major trends: 1) All processes are highly predictive of school achievement if measured alone, each accounting for more than ∼20% of its variance. 2) When measured together, cognitive processes (executive functions and representational awareness in preschool and fluid intelligence after late primary school) dominate as predictors (over ∼50%), drastically absorbing self-concepts and personality dispositions which drop to ∼3-5%. 3) Predictive power changes according to the processes forming *g* at each school level: attention control and representational awareness in preschool (∼85%); fluid intelligence, language, and working memory in primary school (∼53%); fluid intelligence, language, self-evaluation, and school-specific self-concepts in secondary school (∼70%). Stability and plasticity of personality become predictive in secondary school. A theory of educational priorities in line with developmental priorities is proposed, arguing that executive and awareness processes, information management, and reasoning, self-evaluation, and flexibility in knowledge building must dominate in preschool, primary, and secondary school, respectively.

Associations of religiosity and cognitive abilities in European adults aged 50+ years

Mr. Florian Dürlinger*, *Mr. Jonathan Fries*, *Dr. Jakob Pietschnig SP

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

Background: Negative associations of religiosity and cognitive abilities are well-replicated findings of psychological research. In the past, effect directions have typically been observed to be negative, but the observed effect strength varied substantially between different studies. More importantly, the causal mechanisms that lead to this negative effect remain unclear. In fact, some evidence suggests that religiosity might benefit cognitive abilities in older participants, thus pointing towards possible changes of effect strength or even direction over the lifespan.

Methods: Here, we investigate associations and their cross-temporal changes of self-reported religious behaviors with three measures of cognitive function (memory, numeracy, verbal fluency) as well as a proxy for psychometric *g* in participants from 29 countries aged 50+ years (N = 14,000+) in three waves of the Survey of Health, Ageing, and Retirement in Europe (SHARE).

Results: In a multilevel random-coefficients logistic regression approach, we observed decreases of absolute associations for verbal fluency and praying, but not for memory, numeracy or our proxy of *g*. The observed associations were differentiated according to type of reported behaviors, indicating negative associations of *g* with praying (r = –.108) but no associations of *g* with participation in religious events (r = .014).

Discussion: Our study shows that the well-established negative association between intelligence and religiosity is differentiated according to cognitive performance domain, showing larger effects for higher *g*-loaded measures than lower-*g* tests. Longitudinal change assessments showed some evidence for cross-temporally decreases of absolute effects, thus indicating lower associations in older ages. Our results thus support the idea that religiosity may serve as a protective factor against cognitive decline in old age.

High intelligence is associated with mental health problems in a sample of intellectually gifted Europeans

Mr. Jonathan Fries[1], ***Dr. Tanja G. Baudson***[2,3,4], ***Dr. Kristof Kovacs***[5], ***Dr. Jakob Pietschnig***[1]

SP

[1]Department of Developmental and Educational Psychology, University of Vienna, Vienna, Austria
[2]HS Fresenius Heidelberg University of Applied Sciences, Heidelberg, Germany
[3]Institute for Globally Distributed Open Research and Education (IGDORE)
[4]MENSA in Deutschland gGmbH, Germany
[5]Institute of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary

Background: High intelligence is a well-known predictor of favorable health outcomes and longer lifespans. However, recent evidence suggests that the proposed linear relationship between health and cognitive ability might not extend to the upmost end of the intelligence spectrum, indicating that intellectually gifted individuals exhibit high prevalences in an array of specific physical and mental health conditions, so-called overexcitabilities. Presently, only few targeted investigations of this research question have been carried out, and none outside the USA. Here, our objective was to replicate and extend previous accounts to numerous uninvestigated overexcitabilities in a sample of intellectually gifted Europeans.

Methods: We conducted a preregistered survey among members of MENSA, the world's largest society of individuals scoring in the highest two percent of the intelligence distribution. In all, 615 (307 female) members of the chapters from Austria, Germany, Hungary, Switzerland, and the United Kingdom participated.

Results: Compared to reference populations, the intellectually gifted sample showed considerably elevated rates of several conditions, such as autism spectrum disorders (*risk ratio* = 2.25), chronic fatigue syndrome (*RR* = 5.69), depression (*RR* = 4.38), generalized anxiety (*RR* = 3.82), or irritable bowel syndrome (*RR* = 3.76). Previously reported conditions such as asthma, allergies, or autoimmune diseases were within the general population range.

Discussion: We demonstrate that gifted individuals face specific health challenges compared to the general population. Contrary to previous work, mental health was markedly more affected than physical health. The mechanism underlying this phenomenon currently remains speculative, because our investigation yielded only limited evidence for the previously endorsed psychoneuroimmunological explanation. Our results partially contrast earlier findings and call into question whether "overexcitability" is a useful term to describe health issues experienced by intellectually gifted individuals.

A genome-wide association study of specific quantitative ability

Mr. Alexandros Giannelis*, *Dr. Emily A. Willoughby*, *Dr. Gretchen Saunders*, *Dr. Matt McGue*, *Dr. James J. Lee **SP**

Department of Psychology, University of Minnesota Twin Cities, Minneapolis, MN, USA

Long-established psychometric models suggest that intelligence consists of specific cognitive abilities, in addition to a higher-order general factor. While genetic influences on the general factor have been documented, little is known about the genes underlying specific abilities. In this study, we are using results from multiple genome-wide association studies (GWAS), in order to identify a genetic latent factor of quantitative ability. A model specifying the existence of a specific quantitative ability factor, beyond intelligence and non-cognitive skills, fits well with observed genetic correlations. We perform a multivariate GWAS of 354,963 people, identifying 93 loci associated with latent quantitative ability. The loci are enriched for genes expressed in brain tissues. Quantitative ability shows negative genetic correlations with internalizing traits, and a positive genetic correlation with being employed as a mathematician.

An investigation of the female and male gaps in maths and reading using a large and representative Italian sample: The impact of differential item functioning and anxiety

Dr. David Giofrè[1], ***Mr. Tommaso Feraco***[2], ***Ms. Ottavia Epifania***[2], ***Dr. Enrico Toffalini***[2] **OP**

[1]University of Genova, Genova, Italy, Italy
[2]University of Padova, Padova, Italy, Italy

International comparisons of students' achievement showed that a growing number of young people struggle with numbers and maths. Data from international surveys also indicates that in Italy, 43% of students reported that they feel helpless or very nervous when doing maths, which is considerably higher than the average of OECD countries (31%).

Giofrè and co-authors (2020), using a large and representative dataset of the Italian population (INVALSI data on over 13 million observations), showed that males outperformed females in maths, while the opposite was true for reading. However, the causes of these differences remained elusive. With this presentation we aim to provide a better understanding of causes behind the male/female differences in maths and reading.

In a first study, we used INVALSI data with a focus at the item level. We evaluated the possible presence of items with a larger differential item functioning (DIF). Results showed that a minority ($\sim$10%) of items presented with a somewhat larger DIF, and were mostly biased in favour of males. However, results remained virtually unchanged when items with a larger DIF were excluded.

In a second study, we investigated whether anxiety mediates the relationship between gender and performance in both maths and reading. A multilevel Bayesian path analysis showed that anxiety had a relevant effect on performance. However, only about 30% of the association between gender and performance is mediated by anxiety.

To conclude, DIF is unlikely to be a factor explaining female/male differences in maths. Conversely, anxiety significantly impacts the performance in both maths and reading, with females showing more anxiety symptoms. Accounting for anxiety impacts on the female/male gap but does not eliminate that in maths and reading.

From explanation to prediction: Why cross validation and replication is essential in studying the biological bases of intelligence

Dr. Kirsten Hilger SP

W'urzburg University, W'urzburg, Germany

Although a large number of studies identified neural characteristics to covary significantly with individual differences in intelligence, meta-analytical comparisons revealed little consistency between reported findings. Potential explanations include small sample sizes, the use of different tasks during which neural activation was recorded, and variations in intelligence assessments. Moreover, while former studies frequently observed correlations of medium to large effect sizes, recent large-sample studies could often not replicate findings and report much smaller effects (explained variance in intelligence: ∼5%). In this talk, Dr. Kirsten Hilger proposes that the combination of large samples together with cross-validated predictive modeling approaches presents a promising means to increase the robustness and generalizability of research about the biological bases of intelligence. Internal cross-validation splits the sample into subsamples. The statistical model is fitted (trained) on only one part of the sample, while it is then tested on the withheld part of the sample. This method results in a more realistic estimate of the generalization error, i.e., the error we would make when transferring the model to the whole population. In contrast, external cross validation tests the final prediction model in a completely independent sample that could differ in various aspects such as the intelligence assessment. In this talk, it will first be demonstrated on two neuroscientific studies (MRI, EEG) how the detrimental effect of overfitting leads to highly overestimated correlations between intelligence and brain characteristics. Secondly, it will be shown how cross-validation reduces this overfitting effect. Finally, it will be stated that the combination of both internal and external cross validation, as implemented in recent machine learning approaches, could contribute to more valid research findings about the neurobiological bases of intelligence. However, large and phenotypically well-characterized samples are essentially required - a problem that can be overcome by international collaborations and data sharing initiatives.

The (double) nature of *g*

Kristof Kovacs KL

ELTE Eötvös Loránd University, Budapest, Hungary

The general factor of intelligence or psychometric *g* is one of the most important constructs in the social sciences: it reliably predicts life outcomes such as success in education and work, income, or longevity. Paradoxically, its nature solicits one of the longest standing debates in psychology: after more than a century of its discovery, there is still no consensus about what kind of thing *g* is—or even if it is a thing in the first place. According to *g*-theory, *g* represents a general mental ability (psychological *g*) that has a causal influence on performance on all tests. This is a sufficient, but not necessary explanation of what psychometric *g* statistically represents: the pattern of all-positive correlations between psychometric ability tests with diverse content. Unfortunately, the domain-general approach to cognition that *g*-theory offers is in sharp disagreement with the received view in cognitive psychology and neuroscience, maintaining the divide between Cronbach's two disciplines of psychology: the correlational and the experimental. In the last two decades, several alternative explanations of the all-positive correlations have been proposed that do not conceptualize g as a single domain-general ability, rather as a 'cognitive ability index' composed of several different but correlated specific abilities. Arguably, it would be beneficial for the field to distinguish '*g* as explanans' (that which contains the explanation, the social scientist?s *g*) and 'g as explanandum' (that which needs to be explained, the psychologist?s *g*). The findings about g as explanans are practically agnostic to the debate about the nature of *g* as explanandum. Whether *g* is a single ability causing tests to correlate or the statistical consequence of the correlations between specific abilities, the explanatory power of cognitive ability is unchallenged. At the same time, variation in intelligence is probably easier to explain with a focus on its components.

Hormonal maturity fractionates cognitive abilities in adolescence

Dr. Kristof Kovacs[1], ***Prof. Ilona Kovács***[2,3], ***Dr. Patrícia Gerván***[2], ***Ms. Katinka Utczás***[3], ***Ms. Gyöngyi Oláh***[2], ***Ms. Zsófia Trózna***[4], ***Dr. Andrea Berencsi***[1], ***Ms. Hanna Szakács***[2], ***Dr. Ferenc Gombos***[2]

OP

[1]ELTE Eötvös Loránd University, Budapest, Hungary
[2]Pázmány Péter Catholic University, Budapest, Hungary
[3]Research Centre for Natural Sciences, Budapest, Hungary
[4]University of Physical Education, Budapest, Hungary

Background: Cognitive abilities undergo large-scale development in adolescence, with different abilities manifesting different trajectories. These changes are driven not solely by chronological age, but also by schooling and biological maturation. Yet, since these factors correlate, it is difficult to dissociate their unique effect. The effect of schooling has been successfully disentangled from chronological age in previous studies, but the independent effect of age and maturity have not been unraveled.

Methods: We performed 'bone age' assessment on female adolescents (*N* = 117, age: 11–15). Bone age is obtained through a non-invasive, ultrasonic measurement of the wrist indicating skeletal maturity which, in turn, is a reliable proxy for biological (hormonal) maturation. Cognitive ability was assessed with 11 subtests of the Wechsler Intelligence Scale for Children IV—WISC-IV. We explored the independent effect of chronological and biological age on abilities with partial correlations and linear regressions.

Results: We found that biological maturity has an independent effect on Working Memory and Processing Speed, while the opposite was the case for Verbal Comprehension. That is, those with higher chronological age perform better on tests of Verbal Comprehension, independently of maturity, while in adolescents with the exact same chronological age those who are more biologically mature, in terms of hormonal development, have higher working memory capacity and increased processing speed. Full Scale performance appears to be affected by both chronological age and biological maturation, independently.

Discussion: Our results demonstrate that biological maturity provides another means to fractionate human intelligence. Additionally, individual differences in intelligence in general, and Working Memory and Processing Speed in particular, might reflect variation in the onset and pace of biological maturation. This result has implications for educational practice.

Factor analysis and psychometric network analysis: Head-to-head in Carroll's data

Mr. Jordan Lasker SP

Texas Tech, Lubbock, Texas, USA

John Carroll's survey of factor analytic studies laid the groundwork for Cattell-Horn-Carroll (CHC) theory, supporting a three-stratum model of cognitive abilities with a dominant general factor atop a hierarchy of group factors. Mainstream test makers subsequently altered test construction practices to conform to CHC theory.

I sought to assess whether the empirical evidence was consistent with CHC. Using confirmatory methods, I assessed Carroll's data with factor and network models. In order to ensure the results were charitable towards both types of models, the CFAs were based on exploratory analyses like the network model. I conducted simulations to assess the ability to discriminate among higher-order, bifactor, correlated group factor, and network models. Results indicated that network models outperformed theory- or EFA-based factor models in most cases and that the power to discriminate between models was usually substantial, even in the bifactor case. Moreover, it appeared that if we allowed *g*, a bifactor interpretation of Carroll's data fit better than a higher-order one.

The results of these tests suggested that the evidence in favor of the CHC and, perhaps, *g* and other configurations of group factors, may be more tenuous than previously acknowledged. If CHC continues to be regarded as an empirically robust framework for understanding human intelligence, then it ought to be stated that network theories such as mutualism may be even more robust.

Behavior genetic and convergent validity evidence regarding the structure of ability was also mustered for this endeavor.

Insights into the nature of intelligence from stage models of reaction time

Prof. James J. Lee[1], ***Dr. Emily A. Willoughby***[1], ***Dr. Christopher F. Chabris***[2]

OP

[1]University of Minnesota Twin Cities, Minneapolis, Minnesota, USA
[2]Geisinger Health System, Lewisburg, Pennsylvania, USA

Scores on tests of general intelligence (*g*) show a negative correlation with reaction time (RT) on simple cognitive tasks; that is, individual with higher scores tend to be faster. Although this relationship has been recognized for some time, the efforts to decipher its deeper meaning for the nature of individual differences in cognition are perhaps not as well known as they should be. It is a particularly auspicious time for work of this kind; genome-wide association studies of *g* and related traits have begun to highlight aspects of brain architecture and synaptic function, and biophysically realistic models of RT that invoke synaptic mechanisms such as GABA-mediated inhibition of neuronal firing may provide the necessary explanatory bridge between these findings and high-level behavior.

In this presentation I review several studies (all published or presented previously) that attempt to partition RT into distinct stages and determine whether *g* is correlated with only one of these stages but not the others. Each of these studies adopted a distinct methodological approach from the experimental psychology of attention and performance: dual-task interference, the method of additive factors, and diffusion decomposition. Each approach revealed certain properties of the RT stage associated with g: its position in the stream of processing (early, middle, or late), whether it is serial or parallel, what kinds of experimental manipulations affect it, and whether the duration of the stage varies from trial to trial. The convergence of these various approaches strongly suggests that *g* is correlated exclusively with a central information-processing stage posing a serial bottleneck. This stage is affected by the difficulty of the decision called for by the task but not by perceptual demands, and its duration from trial to trial varies as a result of the stochasticity inherent in the evidence-gathering process.

Working memory capacity and strategy use in RAPM: A combined individual-differences and experimental investigation

Mr. Chenyu Li[1], ***Dr. Tengfei Wang***[2], ***Ms. Gaomin Sun***[2]

SP

[1]University of Zürich, Zürich, Switzerland
[2]Zhejiang University, Hangzhou, Zhejiang, China

Working memory is a system responsible for simultaneously holding and processing information for a short while. Individual differences in working memory capacity (WMC) have long been recognized as a reliable predictor of fluid intelligence, but its underlying mechanism remains elusive. The current study aims to investigate the hypothesis that WMC predicts Gf mainly via strategy use by using a combined individual-differences and experimental approach. Strategy use was assessed by both eye-tracking and questionnaire. Eye movements were monitored while participants were solving Raven's Advanced Progressive Matrices (RAPM). In Study 1, a total of 214 participants completed three complex span tasks and RAPM. The results showed that WMC was only predictive of strategy use across difficult items, rather than easy items. Strategy use, as assessed by eye-tracking, partly mediated the relationship between WMC and performance on difficult items. In Study 2, working memory load was imposed when participants performed RAPM in the experimental group. The results indicated that working memory load increased the use of eliminative strategy. Furthermore, the inferior performance of the experimental group to the control group was fully accounted for by the differences in strategic behaviors. Taken together, these findings suggest that strategic behaviors in fluid intelligence measures emerge as an important variable for understanding the association between WMC and fluid intelligence.

Smart people know how the economy works: Intelligence, economic knowledge and financial literacy

Mr. Chien-An Lin*, *Timothy C. Bates SP

Department Psychology, The University of Edinburgh, Edinburgh, Scotland, United Kingdom

Intelligence correlates positively with many financial outcomes, but why? One important relationship to understand is the degree to which intelligence is associated with better economic knowledge, but this has not been tested extensively. Here in two large, preregistered studies (N = 1,356), we tested the relationship between intelligence, economic knowledge and financial literacy (including knowledge, competence, and time preference). We found: i) Intelligence showed a strong positive relationship with economic knowledge; ii) Intelligence was associated with better financial literacy and iii) Greater economic knowledge was positively related to better financial literacy. All three predictions were supported and replicated, with a large relationship (r = .37 to .52) between intelligence and economic knowledge. These findings have implications for a higher awareness of economic functions, and improved use of economic information which improves lifetime financial wellbeing.

Without merit: The costs and benefits of an imperfect system

Prof. Matt McGue IS

University of Minnesota Twin Cities, Minneapolis, MN, USA

Increasing economic inequality in much of the developed world has led critics, from both the political left and the political right, to question the legitimacy of meritocratic practices. Criticisms include fostering the development of a non-empathetic and arrogant elite, exacerbating economic inequality, and being based on a faulty assumption of equal opportunity. Nonetheless, meritocratic practices enjoy widespread support among the general public, albeit within limits. I review findings from longitudinal research undertaken at the University of Minnesota as well as elsewhere to: 1) identify the major individual difference factors that appear to contribute to meritocratic success, and 2) explore the extent to which background factors convey unequal opportunity. While critics are correct in concluding that a “pure meritocracy” is unattainable, it is difficult to envision an alternative system not based on core meritocratic principles that is both efficient and fair.

Testing for group differences in cognitive strategies to explain violations of measurement invariance

Dylan Molenaar IS

Department of Psychology, University of Amsterdam

Measurement invariance is the well-known prerequisite that the measurement properties of intelligence test items should be invariant across groups if those groups are compared on the cognitive abilities underlying the test. Various statistical approaches are available to test for measurement invariance. If an item is subject to differences in its measurement properties (i.e., a violation of measurement invariance), ideally, these differences are theoretically interpretable in terms of the item content and the groups under consideration. However, often, items that violate measurement invariance seem theoretically sound, and it is ambiguous why such violations occur. This is problematic as in such situations, it is unclear what to do with the item in the group comparison: If the item is theoretically sound, why omit it? In this talk, it is demonstrated how item response times, as a proxy measure of the response process, can be used to test whether a violation of measurement invariance can be explained by differences in the cognitive strategies underlying the item scores. Consequently, results from a measurement invariance analysis can be separated into meaningful violations and (still) uninterpretable violations.

Creating tommorow's stars today: Re-examining the STEM intervention strategy through Dinaledi Schools in South Africa

Prof. Michael K. Mhlolo OP

Central University of Technology - Free State, Bloemfontein, Free State, South Africa

The Dinaledi Schools Project (DSP) has its genesis in the White Paper 1 on education transformation, which was publicised during the infancy of South African democracy in 1995. The paper described the pernicious legacy of apartheid on STEM in paragraphs 49 and 50 as follows:

> There is a dearth of Black students with STEM qualifying for normal entry to higher education, fewer still continuing in STE–based programmes, and a trickle entering STEM professional and technological fields in the economy. […] If this cycle is wasteful from an educational point of view, it is catastrophic from the perspective of national developmental needs.

Responding to the pernicious legacy, in 2001 the cabinet adopted the national STEM strategy, and the most significant initiative to emerge out of that strategy was the DSP. Although the initiative has achieved several important gains, there are fears that it might not have achieved the level of positive impact that was intended. This study is aimed at an in-depth understanding of how and why certain outcomes were not achieved. A Capability Approach theory was used to analyse the conversion factors that were prioritised and those that were ignored in the implementation of the DSP. There is significant consensus in research that personal characteristics (such as giftedness, motivation, passion, resilience, and attitudes) have more influence on how a person can convert the means/resources into a functioning or achievement. This suggests that gifted students should have been identified before resources were provided. However, results show that the DSP prioritised the provision of external resources without considering the potential of the students. This could explain why the programme failed to make significant impact at the national level. The study recommends that the DSP is still a noble initiative that should just focus on gifted students instead of average students.

Investigating bias in conventional twin study estimates of genetic and environmental influence for Educational Attainment

Mr. Tobias Wolfram[1,2], ***Mr. Damien Morris***[3]

SP

[1]Department of Sociology, University of Bielefeld, Bielefeld, Germany
[2]Department of Sociology, ENSAE/CREST, Paris, France
[3]SGDP centre, King's College London, London, United Kingdom

Heritability estimates for educational attainment (EA) average 41–43% across international studies using the Classical Twin Design (CTD) while estimates of shared environmental influence are among the highest for any behavioural trait, averaging 31–36%. However, high spousal correlations reported for EA suggest CTD estimates may be biased by unmodelled assortative mating. Moreover, high correlations for dizygotic twins relative to non-twin siblings suggest CTD estimates might partly consist of twin-specific shared environments. We investigated this question in the German TwinLife sample by comparing results from a CTD model fit to twin-only data with results from Nuclear Twin and Family Design (NTFD) models fit to twin, sibling, and parent data from the same 982 families. Models assuming phenotypic assortment and social homogamy were compared. Our CTD model estimated heritability at 34% and shared environmental influence at 43%. By contrast, our best-fitting NTFD model (a phenotypic assortment model) estimated heritability at 51% and sibling shared environments at just 10%, with 16% of the variance attributed to twin-specific shared environments that aren't shared by non-twin siblings. Furthermore, the parent-offspring correlation for EA was entirely explained by genetic transmission under this model. These results suggest the far-reaching conclusions sometimes drawn from high CTD-based estimates of shared environmental influence for EA or high parent-offspring correlations for EA may be misplaced.

Lifetime Achievement Award Address

My checkered path through intelligence research—from cognitive psychology via neuro to social psychology and into the future

Prof. Aljoscha C. Neubauer LA

University of Graz, Graz, Austria

Coming from an early neuroscience background in my PhD research I became quickly fascinated by H.J. Eysenck's notion of a 'biological intelligence measurement' (vs. psychometric intelligence). Starting out in the early 1990s with chronometric explorations of intelligence I moved on to what became my main lifetime topic, Rich Haier's neural efficiency hypothesis, its modifications, restrictions, and qualifications. Then, becoming fascinated by the hitherto neglected field of creativity research, my next focus was on the intelligence-creativity interface, again from behavioral as well as from neuroscience perspectives. Recently, I connected this to the actual enhancement debates that have become eminent even in philosophy, cf. the debates around transhumanism and posthumanism, in both, human intelligence being a central target; but interestingly the debate currently is mostly led without contributions from psychological intelligence research. In parallel to that, my other current passion is on the person perception approach to intelligence, namely the idea that sometimes self- vs. other-perceptions of a target person's intelligence can vary considerably in accuracy with respect to psychometrically measured verbal, numerical, and spatial intelligence. I will finish with a personal view on the future of intelligence research.

Viewing self- and psychometrically assessed intelligence associations through the lens of the multiverse: A meta-analysis

Sabine Patzl[1], ***Dr. Jakob Pietschnig***[2]

SP

[1]Technical University of Munich, Munich, Germany
[2]University Of Vienna, Vienna, Austria

Previous meta-analytic accounts revealed a moderate relationship between self- and psychometrically assessed intelligence. However, the role of potentially moderating variables in combination with differing analytical approaches has so far not been examined. Moreover, ever-increasing publication numbers, the development of more refined research synthesis methods (e.g., for the investigation of dissemination bias), and biases due to declining effects in empirical research have rendered previous meta-analytic accounts outdated and the impact of moderators and analytical decisions unclear. We used multi-level meta-analyses, multiverse approaches, as well as specification curve to synthesize 242 effect sizes from 98 studies (N = 54,566). Examinations of all (reasonable) meta-analytical specifications according to differing selection and analysis criteria yielded summary effects ranging from r = –.07 to .78 which averaged r = .36 (median = .35) with 50% of the data showing values from r = .29 to .42. Meta-regression analyses fit well to the observed pattern of our specification curve analyses, revealing that the association generalized over assessment order, participant sex, sample composition, and self-assessment methods but was differentiated according to ability type. Compared to general cognitive ability, correlations were stronger when numerical ability than when spatial or less-standard cognitive ability domains (e.g., naturalistic intelligence) were assessed. Furthermore, the application of eight standard and more modern dissemination bias detection methods revealed that traditional meta-analytical approaches would yield summary effects that must be considered to be somewhat inflated. In all, our results show that self- and psychometrically assessed intelligence associations are best described as moderate positive associations, which appear to be largely robust in regard to various moderators and when different types of analytical approaches are applied.

Holden Memorial Address for Distinguished Journalism

Why journalists get it wrong: Some thoughts and stories about how psychological science ends up in the media

Jochen Paulus

HM

Wiesbaden, Germany

Holden Memorial Address for Distinguished Journalism. IQ tests are dubious, highly gifted people are unfit for life and Howard Gardner is the leading intelligence researcher. These are at least the impressions you might get if you tried to inform yourself in popular media about intelligence. Of course you would also find a lot of correct information, but how could you tell what is true if you didn't know beforehand?

There are reasons why journalists get it wrong. They don't have much time because they have to produce a lot to make a living. So they can't do much research. On the bright side this minimizes the chances that they come across any facts which might challenge their pre-conceived ideas (which are at least politically correct).

But researchers are not completely innocent. It's not always easy to find out which statements of real or not so real experts are correct or at least the current majority opinion in psychological science, which are personal pet theories and which have been disproved long ago. Is there anything that can be done about it?

Expert perspectives on intelligence: What we agreed on then, what we agree on now, and what we believe about the future

Dr. Jakob Pietschnig*, *Mr. Benedikt Steininger

OP

University of Vienna, Vienna, Austria

Background: In 1994, Linda Gottfredson published her account of mainstream science on intelligence. Therein, she formulated core statements about the knowns of intelligence, which 52 expert intelligence researchers endorsed at that time. In the three decades since this publication, the development of novel methods, models, and hypotheses has expanded our understanding of intelligence and led to new ideas and perspectives about the future of intelligence research. Therefore, it seems necessary to evaluate if and how the former consensus may have changed and what researchers believe about future developments.

Methods: We adapted 27 statements from Mainstream Science on Intelligence and another 13 from articles in the special issue on the Future of Intelligence Research in Intelligence. In all, 76 corresponding authors (63 self-identified as IQ-researchers) from articles published in *Intelligence* or the *Journal of Intelligence* indicated their agreement in an online survey.

Results: Self-identified IQ-researchers showed stronger average agreement with consensus statements (g = 0.814; p = .003) than non-IQ-researchers. Participants agreed most with statements about positive effects of larger IQs, whilst those about measurement fairness of IQ tests in terms of participant ethnicity, cultural background, or sex were least endorsed. In most cases, belonging to the IQ-researcher group or not did not yield differences in endorsments about the future of intelligence research (i.e., development of novel intelligence conceptualizations and methods; relevance of artificial intelligence).

Discussion: Here, we show that the consensus about central aspects of intelligence and related research seems to have shifted over the past three decades. This means that efforts need to be made to reestablish a consensus about the knowns and unknowns about intelligence. The observed group differences between researchers that identify as IQ-researchers and those that do not illustrate a need of more collaborative work to convincingly replicate core findings of intelligence research for other disciplines.

SMILE: A simulation-based model of intelligence, learning, and education

Ms. Simone Plak[1], ***Dr. Alexander O. Savi***[2], ***Prof. Martijn Meeter***[1]

SP

[1]Vrije Universiteit Amsterdam, Amsterdam, Netherlands
[2]Universiteit van Amsterdam, Amsterdam, Netherlands

How do people differ in intelligence? And what mechanisms drive these differences? These questions motivate two distinct fields in psychology: that of inter-individual differences, and that of intra-individual mechanisms. Individual differences have been the dominant focus of intelligence research, whereas mechanisms are mostly studied in for instance the cognitive sciences. However, to further our understanding of intelligence, both approaches need to be unified in a single formal theory. We introduce such a theory: a simulation-based model of intelligence, learning, and education (SMILE).

SMILE describes how mechanisms at the individual level produce emergent phenomena at the population level. To construct SMILE, we first defined a set of key phenomena to explain (i.a., the positive manifold and increasing heritability coefficients with age). Next, we posited a learning mechanism and sources of individual differences (i.a., differences in cognitive capacity and schooling quality) based on a review of the empirical record, and formalized these assumptions in a set of distributions and operations. In simulations, SMILE successfully describes how individuals learn over the course of their life, through interactions with their environment, and how this leads to educational attainment and intelligence. By analyzing the intelligence test scores of our simulated population at various ages, we show that our model explains the key phenomena defined.

By bridging the gap between the two divided fields, SMILE propels understanding of the mechanisms underlying intelligence. Importantly, it does so in a formal fashion, which permits rigorous evaluation, continuous updating, and in the long run, revelation of intervention opportunities. Our simulation-based approach is specifically contributory, as it allows our model to capture a broad range of findings, including differences in inborn capacity, and environmental differences affecting development through the influence of prior learning on future learning. Thereby, SMILE provides plausible explanatory principles for developing intelligence, based on robust empirical phenomena.

The impact of focal cortical lesions on the development of cognitive ability: Testing causality after the longitudinal analysis of 1,600 children

Dr. John Protzko[1], ***Dr. Roberto Colom***[2], ***Dr. Sherif Karama***[3]

[1]Central Connecticut State University, New Britain, CT, USA
[2]Universidad Autónoma de Madrid, Madrid, Spain
[3]Montreal Neurologic Institute, Montreal, Canada

OP

Intelligence develops and there are numerous theories to explain how. However, these theories are limited by the fact that they are inherently correlational in nature. To put developmental theories to severe tests, evidence beyond more longitudinal data that relies on causal assumptions from developmental outcomes is required. One way for moving forward involves looking for exogeneous effects on specific cognitive abilities to test whether exogeneous shocks alter developmental pathways. Interventions that have historically aimed at increasing intelligence have been criticized for having 'hollow' effects or teaching to the test; such criticisms, if valid, undercut such evidence's ability to test developmental theories. Focal cortical lesions, damage to specific areas of the brain, are often exogeneous in the specificity of their effects. It is effectively random that damage happens to one specific area of the brain, causing local deficits, versus another nearby location. When such lesions happen in childhood, there is a unique chance to test multiple developmental theories of intelligence. Here we put a number of developmental theories of intelligence to the test by looking at the long-term effects of focal cortical lesions in a large sample of 1,600 children. By comparing children who have lesions in regions that alter specific intellectual abilities to those who have lesions in areas not affecting intellectual abilities, we can test the effects of exogeneous shocks to intelligence and confirm what developmental models can account for the diffusion or locality of effects. We present such evidence in a preregistered study and discuss the implications for a number of developmental theories of intelligence.

The future of intelligence: A prediction of the F(L)ynn effect until the year 2100 for about 80 countries

Prof. Heiner Rindermann*, *Mr. David Becker

OP

Department of Psychology, Chemnitz University of Technology, Chemnitz, Germany

In the 20th century, there was an increase in IQ test scores of about 3 IQ points per decade, usually referred to as the Flynn (FLynn) effect. It was observed throughout the developed world, followed later by the developing world.

More recent results point to an end of the FLynn effect or to its reversal in the developed world. In addition, the quality of the supporting conditions of intelligence development can hardly be further improved or there are diminishing returns to further improvements (e.g., education, health). Finally, low birth rates among the educated and immigration from countries with lower levels of cognitive ability weaken the demographic basis for further FLynn effects.

In two previous attempts, we tried to predict intelligence development in the 21st century up to the year 2100 (Rindermann & Thompson, 2011; Rindermann, 2018). The models included assumptions about further ways to improve environmental conditions relevant to intelligence, about larger possible improvements at lower IQ levels, about different possible target points of development, about differences in birth rates, about migration, and about immigrants' catch-up development.

We contrast those models with three statistical models based on past development: (1) Trends calculated by subtracting between all individual pairs of student assessment measurement points (e.g., PISA 2018 minus PISA 2006 or TIMSS 2019–TIMSS 2007). (2) Linear regressions based on all given student assessment measurement points between 1995 and 2019. (3) Nonlinear regressions for the same data.

We compare the results based on the three statistical models and discuss the limitations of statistical approaches based on past development: First, the results differ considerably depending on the method. Second, single outliers lead to strong deviations. Third, simply extrapolating past development can lead for some countries to absurd results in the long run (e.g., IQs around 10 or 200). Theoretical considerations remain indispensable.

Cognitive control and intelligence: A neurocognitive psychometrics perspective

Prof. Anna-Lena Schubert KL

Heidelberg University, Heidelberg, Baden-Württemberg, Germany

Cognitive control—also referred to as executive attention, cognitive control, executive control, inhibitory control, or executive functions—acts an umbrella term for self-regulatory higher-order cognitive processes contributing to goal-directed behavior (Diamond, 2013). Individual differences in cognitive control play a central role in theories about the elementary processes underlying individual differences in intelligence. However, recent debates in the fields of cognitive psychology and individual differences research have shown that typical measures of cognitive control have severe psychometric problems: (a) the inconsistent use of difference scores to measure cognitive control; (b) the neglect of speed-accuracy trade-offs; (c) low reliabilities; (d) low convergent validities; and (e) low predictive validities. In my talk, I will discuss the necessity of rethinking the measurement of cognitive control, caution against using seemingly established measures of cognitive control to study individual differences in intelligence and demonstrate how recent theoretical and methodological developments may help to overcome these problems using model-based approaches and neuroscientific measures of cognitive control.

Neural correlates of developing intelligence

Dr. George Spanoudis[1], ***Dr. Anna Tourva***[2]

[1]University of Cyprus, Nicosia, Nicosia, Cyprus
[2]Cyprus Ministry of Education, Culture, Youth and Sports, Nicosia, Cyprus

OP

Elementary cognitive processes (processing speed, attentional control, and working memory) have been proven to be major predictors of individual differences in intelligence over the last three decades. Research indicated that latencies of event-related potentials (ERPs) linked with higher-order processing (P2, N2, and P3) may account for about 80% of variance of individual differences in intelligence. The present study explored the relationship between these three elementary cognitive processes and fluid intelligence by measuring ERPs. One hundred twenty-eight children performed four tasks while an EEG was recorded: (1) a visual Inspection Time Task measuring processing speed; (2) an Attentional Network Task evaluating attentional control; (3) the Sternberg Working Memory Task to assess working memory; and (4) the Wechsler Abbreviated Scales of Intelligence to assess intelligence. The children ranged in age from 6:5 to 18:10 years. The results showed that older children displayed lower P1 amplitudes compared to the adolescents and younger children in all three locations (frontal, central, and parietal). Further, adolescents exhibited lower N1 amplitudes compared to younger children in frontal, central and parietal locations and across all three tasks assessing elementary processes. The younger children demonstrated higher P3 parietal amplitudes and lower P3 frontal amplitudes in comparison to the older children. This research extends our knowledge of the complex relationship between elementary cognitive processes and fluid intelligence.

How intelligence translates to successful complex problem solving: The mediating effect of the strategic behavior *Eigendynamic First*

Prof. Jörn R. Sparfeldt[1], ***Mr. Julius J. Weise***[1], ***Prof. Samuel Greiff***[2] OP

[1]Saarland University, Saarbruecken, Saarland, Germany
[2]University of Luxembourg, Esch-sur-Alzette, Luxembourg

Intelligence and complex problem solving (CPS) are closely related. However, little is known about the mechanisms that translate intelligence into successful CPS. Strategic behaviors during CPS are associated with successful problem solving performance; additionally, intelligence is associated with more optimal strategic behaviors while solving complex problems. Therefore, strategic behaviors might mediate the intelligence-CPS relationship.

In real world settings, individuals are frequently confronted with dynamic changes over time (without active interventions). Correspondingly, so-called eigendynamic effects, describing increases or decreases in outcome variables over time without the individual's intervention, are an important feature in CPS tasks. To identify eigendynamic effects from the start while exploring the system is an effective strategic behavior when systems are comprised of different effect types. In this study, we hypothesized that the strategic behavior to identify eigendynamic effects early on when exploring the system was related to CPS performance and mediated the relationship between intelligence and CPS performance.

In a sample of *N* = 262 German high school students, intelligence was assessed by the Berlin Intelligence Structure test (Jäger, 1997) and CPS by MicroDYN (Greiff et al., 2012). The hypotheses were examined using regression and mediation analyses.

Results revealed that the strategic behavior to identify eigendynamic effects early on predicted CPS performance when exploring the problem situation (knowledge acquisition phase) and when working towards a solution (knowledge application phase) in single CPS tasks as well as in a set of CPS tasks comprising of different effect types. In mediation models the strategic behavior to identify eigendynamic effects early on mediated the intelligence-CPS performance relation in the knowledge acquisition phase, but not in the knowledge application phase.

We discuss these findings in the light of how students interact with complex and dynamic systems, pointing to the importance of this strategic behavior for the relationship between intelligence and CPS.

The role of intelligence in educational decisions: Data from Switzerland indicate undesirable effects

Prof. Elsbeth Stern[1], ***Prof. Sarah Hofer***[2], ***Dr. Ursina Markwalder***[1], ***Dr. Esther Ziegler***[3] **OP**

[1]Swiss Federal Institute of Technology (ETH) Zürich, Zürich, Switzerland
[2]Ludwig Maximilian University (LMU), München, Bavaria, Germany
[3]LernConsulting, Zürich, Switzerland

During the second half of the 20th century, university education became more socially inclusive for cognitively talented students. There is, however, evidence for a decline in upward educational mobility in more recent cohorts. In three studies based on data from 2,236 students, we describe and analyze the role of intelligence in admission to the academic school track (Gymnasium) in Switzerland. The successful completion of Gymnasium allows access to university and is limited to the top 20% of a cohort.

In Study 1, Raven's Advanced Progressive Matrices Test was applied to 995 Gymnasium students in Grades 9–11 (*M* age = 15.6 years). We found that 52% of these students did not belong in the top 20% (percentile rank PR < 80) according to the test norms (false positives).

Study 2 took place at the end of Grade 6 just before tracking started. A sample of 725 students (*M* age = 12.4 years) received two nonverbal intelligence subtests. Sixty-five percent of the students in Gymnasium had a PR < 80, while 51% of the intelligent students with a PR $\geq$ 80 did not attend Gymnasium after Grade 6 (false negatives). This bias could not fully be explained by grade differences.

In Study 3 (*N* = 516 6th-Graders; *M* age = 12.7 years), a broader intelligence measure was used, and the families' socioeconomic status (SES) was assessed. In addition, there was a second measurement point at the end of Grade 8 to investigate conditions of later transition to Gymnasium. Study 3 indicated that SES had a considerable influence on the likelihood of attending Gymnasium, both for the transition after primary school and the later transition. Among students with a PR $\geq$ 80, those with above-average SES were four times more likely to attend Gymnasium than were lower-SES students.

Overall, our results indicate a worrying trend toward marginalizing the role of intelligence in admission to higher education.

Quo vadis, student? Predicting secondary school streaming in Switzerland from students' intelligence, interest, and school grades

Dr. Christian Thurn[1], ***Dr. Ursina Markwalder***[1], ***Dr. Peter A. Edelsbrunner***[1], ***Mr. Marco Stühlinger***[2], ***Prof. Elsbeth Stern***[1] **SP**

[1]Swiss Federal Institute of Technology (ETH) Zürich, Zürich, Switzerland
[2]Sekundarschulzentrum Niederhasli Niederglatt, Niederhasli, Switzerland

In Switzerland, students in grade 7 are assigned to different groups in secondary school based on their achievements in primary school. About 80% of the students are placed in secondary school stream A (higher ability group) or B (lower ability group), while 20% go to the academic track (Gymnasium). Many studies showed that assignment to ability groups is not solely based on student's cognitive abilities (Becker & Lauterbach, 2016; Becker & Schoch, 2018). In our study, we examined how intelligence, interest, and school grades predict students' assignment to the secondary school streams A and B in Switzerland.

A total of 212 7th graders (46% female) from 12 classes in the canton of Zürich participated. Intelligence was assessed via the nonverbal Raven SPM, interest in Math, German, and English via 3 items each (ordinal ω = .77 to .79). In addition, we asked for students' recent school grades in Math, German, and English.

In a logistic regression model, we predicted students' assignment to school stream A or B from their intelligence, interest, and grades. Only the school grade in German reliably predicted ability group, with an odds ratio of 15.30, 95% CI [5.04; 46.46]. That is, for each increase of half a grade in German, the odds of belonging to group A increased 15 times.

This result questions the validity of school streaming in Switzerland. Especially intelligent non-native German speaking students might be prevented from developing their full potential. This is in accordance with studies from Germany showing that second-generation immigrants experience problems in school streaming (Lüdemann & Schwerdt, 2013), and that the grade in German is highly predictive of the school stream (Bos et al., 2004).

We will discuss how intelligence tests could be used to discover student's cognitive potential, and which implications on school streaming are currently evaluated in Switzerland.

Mind the gap: Persistent gender differences in spatial ability, even in STEM experts

Ms. Elina Tsigeman[1], ***Dr. Maxim Likhanov***[2], ***Prof. Yulia Kovas***[3] SP

[1]Tomsk State University, Tomsk, Russian Federation
[2]ITMO University, St. Petersburg, Russian Federation
[3]Goldsmith University of London, London, United Kingdom

A large body of research shows gender and engagement in STEM activities are related to individual differences in spatial ability (SA). Although, studies that examine individual differences in SA are often limited to singular tests (e.g., mental rotation) and to engagement in singular activities (e.g., STEM-related) and show inconsistent findings.

This study examined performance on 10 small-scale SA tests of adolescents with expertise in STEM (N = 667, 252 females, M age = 15, SD = 1.2); in Arts (N = 280, M age = 15, SD = 1.2) and in Sports (N = 444, M age = 14.3, SD = .7), and compared them with unselected peers (N = 864, 413 females, M age = 15.4, SD = 1.1).

Consistent with previous research, STEM experts outperformed all other samples on all SA tasks (*Pillai's Trace* = .352, $F_{20,3984}$ = 42.48, p < .001, η_p^2 = 0.17). Arts and Sports experts showed results similar to the unselected sample. We also replicated gender differences in SA favouring males, with medium effect sizes on all tasks (η_p^2 vary from 0.17 to 0.67). Negligible interaction (η_p^2 = .05) between gender and area of expertise was found. Remarkably, the effect size of gender differences were stronger in the sample of STEM experts (η_p^2 = 0.90) in comparison to the unselected sample (η_p^2 = 0.81) and Arts and Sports experts (η_p^2 = 0.74).

Taken together, the findings support previously established links between spatial ability and STEM-related expertise. In contrast, such links were not found for expertise in arts and sports. Consistent with previous research, we found gender differences in SA for all samples, including STEM experts.

Cognitive performance and the sleep electroencephalogram

Dr. Péter P. Ujma

OP

Semmelweis University, Institute of Behavioural Sciences, Budapest, Hungary

Neuroimaging tools offer an insight into the cerebral mechanisms underlying individual differences in cognitive ability. Most neuroimaging studies utilize magnetic resonance imaging, while electroencephalographic (EEG) studies are less prominent. I present findings that suggest that the sleep EEG is at least as promising as a biomarker of cognitive ability as magnetic resonance imaging.

Sleep EEG features, especially EEG spectral composition, exhibit very strong intra-individual stability, considerable inter-individual variability and very high heritability, rendering it a promising biomarker of psychological traits, including intelligence. I present a series of previous studies (including two meta-analyses) from our laboratory and others which linked sleep EEG features to intelligence or other aspects of cognition. Sleep spindles, prominent NREM sleep oscillations generated in thalamocortical circuits and also implicated in memory, were especially strongly implicated.

In upcoming work I am using regularized regression in a large ($N > 3000$) sleep cohort with EEG and cognitive data to perform a multivariate prediction of cognitive performance (the first principal component of neuropsychological tests) from the relative spectrum of the sleep EEG. The resulting "poly-EEG score" is significantly associated with cognitive performance in an independent holdout sample ($N \sim 800$, $r \sim 0.11$) as well as with IQ in a fully independent sample of healthy young participants ($N = 158$, $r = 0.17$). Sleep spindles are the most prominent predictors of cognitive performance, but other frequency ranges are also implicated, suggesting that individual differences in neuronal functioning captured by the sleep EEG spectrum partially underlie cognitive performance. The performance of this EEG-based predictor approximates that of MR-based or genetic predictors, even though the training sample is much smaller. Further work will incorporate more EEG features and possibly more data to allow for even better prediction of cognitive performance and a better mechanistic interpretation of findings.

Highly intelligent individuals do not have more mental health disorders than the average

Ms. Camille M. Williams[1], ***Dr. Hugo Peyre***[1,2,3], ***Dr. Nicolas Gauvrit***[2] ***Ms. Ghislaine Labouret***[1], ***Mr. Judicael Fassaya***[1], ***Ms. Adoracion Guzman***[1], ***Dr. Franck Ramus***[1] **SP**

[1]Laboratoire de Sciences Cognitives et Psycholinguistique, Département d'Études Cognitives, École Normale Supérieure, EHESS, CNRS, PSL University, Paris, France
[2]Department of Child and Adolescent Psychiatry, Robert Debré Hospital, APHP, Paris, France
[3]INSERM UMR 1141, Paris Diderot University, Paris, France
[4]Université de Lille, Lille, France

Although intelligence is associated with greater physical health and longevity, some suggest that highly intelligent individuals are more likely to develop mental health disorders. These latter studies, however, often suffer from sampling bias, the absence of a control group, or insufficient sample size. We addressed these caveats by examining the difference in the prevalence of mental health disorders between individuals with high and individuals with average cognitive abilities (CA) in the UK Biobank.

We included participants with an age-standardized general intelligence score relative to the UK population (Williams et al., in prep.). Individuals with High CA had a CA score 2 SD above the UK mean (*N* = 16,137) and individuals with an average CA had a CA score within 2 SD of the UK mean (*N* = 236,273).

We examined the difference in prevalence between the high and average CA groups across 32 phenotypes, including mental health disorders, trauma exposure, allergies, and other traits, using self-report questionnaires and medical diagnoses.

The prevalence differed between the high and average CA group across 15/32 phenotypes and did not depend on sex and/or age. The high CA group was less likely to suffer from general anxiety (OR = 0.69) and PTSD (OR = 0.67). Individuals with high CAs were less neurotic (β = –0.12), felt less socially isolated (OR = 0.85), and were less likely to have experienced childhood stressors and abuse as well as adulthood stressors or catastrophic trauma (OR = 0.69–0.90). The high CA group generally had more allergies (e.g., eczema; OR = 1.13–1.33), was more likely to be myopic (OR = 1.11), and to have ever tried cannabis (OR = 1.25). In the exploratory analyses, the prevalence between the average CA group and the low CA group (individuals with CA score 2 SD under the UK mean) differed across 12/32 phenotypes.

Highly intelligent individuals are less likely to suffer from some mental health disorders.

Biological annotation in a genome-wide association study of quantitative ability

Dr. Emily A. Willoughby*, *Mr. Alexandros Giannelis*, *Dr. Gretchen Saunders*, *Prof. James J. Lee

SP

University of Minnesota Twin Cities, Minneapolis, MN, USA

Over the past decade, genome-wide association has shed remarkable light onto the biological functions of genes implicated in general cognitive ability and educational attainment. However, less is known about the genetic expression of specific cognitive abilities, such as quantitative and verbal reasoning, in tissues and cells. Giannelis et al. previously reported the results of a novel GWAS of quantitative ability using genomic structural equation modeling and prior genome-wide association studies in order to identify a latent genetic factor of quantitative ability net of years of education, general cognitive ability, and non-cognitive ability. This led to the identification of 93 lead SNPs specific to this latent factor in a combined sample of 354,963 participants.

Here we report preliminary findings of the biological function of these SNPs using the annotation software tools DEPICT and MAGMA. Both methods reveal that protein-coding regions associated with these lead SNPs are differentially and significantly expressed in brain tissue, particularly in the occipital and temporal lobes, visual cortex, cingulate gyrus, hippocampus, and cerebellum. To examine expression patterns at the level of gene set functions, we used MAGMA to test enrichment of common variants from the Gene Ontology (GO) biological processes and cellular components databases. Significantly enriched cell types were predominantly expressed in the nervous system, particularly in neurogenesis, regulation of neuron differentiation and projection, and synaptic functions such as calcium ion binding and GABA receptors.

In summary, biological annotation in a novel GWAS of quantitative ability provides evidence that even net of cognitive ability and educational attainment, genetic variants associated with mathematical reasoning are expressed in distinct brain structures and synaptic components—unique biological expression that may, in part, differentiate the Newtons and von Neumanns from the Darwins and Dostoyevskys.

Estimating occupational heterogeneities in intelligence and non-cognitive traits—A comparative perspective

Mr. Tobias Wolfram SP

Bielefeld University, Bielefeld, Germany
CREST-ENSAE, Paris, France

Since the advent of modern psychometrics, researchers tried to reliably quantify the cognitive variation between occupations. However, a precise estimation of intelligence over dozens or even hundreds of (groups of) jobs requires very large representative samples of valid information on both intelligence and profession. Past research therefore either suffered from questionable generalizability to the general population or was only able to reconstruct estimates for a small number of abstract, highly clustered occupational groupings.

Using a recent probability sample of more than 40,000 British households we for the first time provide representative occupational intelligence estimates. We leverage external auxiliary information on abilities, skills, interests, and knowledge required for different jobs in combination with survey-statistical methods from the toolkit of small area estimation to increase the precision of our estimates by a significant margin, enabling us to reliably cover a total of 359 occupational groups, even in cases where the number of respondents available seems prohibitively small.

The constructed ranking correlates strongly with sociological and economical measures of occupational attainment ($r = 0.86$ for occupational status, $r = 0.62$ for median occupational income). Using random-effects models, we find that a quarter of the variation in cognitive ability exists between occupations (ICC = 0.26).

To comparatively interpret our results, we furthermore construct occupational rankings for various non-cognitive traits (big five, risk-taking, gratification delay, and self-efficacy) that exhibit a high level of face validity. In all cases, most variation exists within occupations (ICC = 0.04–0.1). Looking at sociodemographic measures of stratification (age, sex, and years of education), only sex (ICC = 0.33) clusters more strongly within occupations than cognitive ability. Overall, intelligence remains the central psychological dimension along which the labor market is structured.

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.

PP: Regular Poster Presentation **SP**: Student Poster Presentation

Note: Student presenters are eligible for the Best Student Poster award.

Students with high anxiety get tired faster: Evidence from functional EEG integration analysis

Evgeniia Alenina[1], ***Ilya Zakharov***[2], ***Maxim Likhanov***[3], ***Prof. Yulia Kovas***[4] **SP**

[1]Tomsk State University, Tomsk, Russian Federation
[2]Psychological Institute of Russian Academy of Education, Moscow, Russian Federation
[3]ITMO University, St. Petersburg, Russian Federation
[4]Goldsmith University of London, London, United Kingdom

Students usually become drowsy and lose concentration before completing the 40-minute learning session. This mental fatigue affects the learning process and academic performance. Current study aims to explore whether fatigue is also associated with individual differences in anxiety. In particular, to investigate whether anxiety moderates the link between mental fatigue and task performance. Students (18–23 years old) from different regions in Russia completed lexical, arithmetical, and mathematical tasks while their alertness/fatigue was measured during a 40-minute session. The method detects a mental fatigue-onset by tracking the EEG frequency profile during the task by comparing the prevalence of alpha (8–12 Hz) and theta (6–8 Hz) oscillations. The efficiency of information processing during task completeness was measured via the identification of variations in functional integration changes at different time points. Transition to lower concentration and performance was associated with a decrease in alpha Weighted Phase Lag Index (wPLI). The expected results suggested variations in alpha-connectivity and associated with relative changes in vigilance moderated with different anxiety levels. Overall, the results contribute to the emergent body of evidence suggesting that 40 minutes may not be an optimal duration for learning a session.

What is the cost of defeat for gifted adolescents?

Ms. Madlena Arakelyan SP

Yerevan State Medical University after Mkhitar Heratsi, Yerevan, Armenia

Introduction: Gifted children and youth have difficulties in education, in the psychological adjustment process etc. The aim is to evaluate the adaptive capacity, the functional state of the gifted adolescents' organisms under external potential stressor.

Methods: The research has been conducted in schools of Yerevan, RA. The initial sample consisted of 500 high school students aged 16–18. Renzulli's Three-Ring Conception of Giftedness was used to reveal gifted adolescents. The following instruments were used to measure three components: Cattel's Culture Fair Intelligence Test for cognitive abilities (the IQ range was 130–144); Torrance Tests of Creative Thinking and Academic motivation questionnaire by M. I. Lukyanova and N. V. Kalinina.

In the course of study 35 of 500 participants were defined as gifted. The quasi-experimental design has been used with 35 participants in the comparison and experiment group each. For comparative analyses, we used Cardiograph's signal analysis software developed in L. A. Orbeli Institute of Physiology NAS RA.

As a potential stressor, the intellectual workload was selected. The ECG indicators have been recorded for 5 minutes each before and after the intellectual workload. We are presenting the results through PARs–indicator of complex heart rate assessment, with a scale of 1–10.

Results: According to the results, gifted adolescents demonstrate expressed - (5–6 scales) and moderate - (2–4) functional tension levels. The levels of pronounced - (7–8) and Overstrain - (9) were recorded only after the intellectual workload, fixing the maximum degree of tension. The picture of the control group is as follows: moderate-59%, expressed-26%, norm-14%.

Conclusions: The level of stress in gifted adolescents is higher than that of the control group and rises in case when the task wasn't solved. This means that the functional resources of these adolescents are reduced, they are under the stress, the chronic nature of which can cause many psychophysiological difficulties.

The immigrant's personality: Deep-rooted individual differences of immigrants and natives strongly affect natives' preferences towards admitting immigrants into the UK

Mr. Nico Buettner[1], ***Prof. James Tilley***[1], ***Prof. Sara Hobolt***[2]

SP

[1]University of Oxford, Oxford, United Kingdom
[2]London School of Economics and Political Science, London, United Kingdom

This paper aims at contributing to the literature on immigration attitudes by examining the impact of immigrants' personality profiles on natives' preferences towards said immigrants in a novel, preregistered conjoint experiment based on representative survey data from Britain. We employ a more fine-grained and yet theoretically more well-rounded item inventory, namely the Big Five Aspect Scales (BFAS) to measure personality for both immigrants and respondents (DeYoung et al. 2007). Crucially for the scope of this conference, the BFAS incorporates the aspect of Intellect into the domain of personality, which has been shown to be closely conceptually and empirically related to fluid intelligence (Nusbaum & Silvia 2011; Oleynick et al. 2007). This notion is supported by historical debates among some personality psychologists who have argued that intelligence constitutes an integral part of personality (DeYoung et al. 2005; Zillig et al. 2002).

Overall, this paper shows that immigrants' personalities have a strong causal effect on natives' propensities to admit immigrants into the UK. Most notably, we find that immigrants scoring higher on the personality aspects of Intellect, Industriousness, Enthusiasm, Compassion and Politeness, those who score lower on Volatility as well as with medium Assertiveness scores receive more favorable evaluations from British natives. However, the effect for Intellect is weaker than expected purely based on economic considerations. More precisely, we find that an immigrant's degree of Industriousness is about twice as predictive of natives' support compared to an immigrant's level of Intellect although intelligence is about twice as predictive of earnings as Conscientiousness. This finding suggests that natives reward immigrants, who can and want to put their fate into their own hands and do not conceptualize themselves as victims of their circumstances instead of absolute economic potential.

Validation and correlates of Raven's-like progressive matrices

Kayla M. Garner*, *Dr. William Revelle

SP

Northwestern University, Evanston, IL, USA

The International Cognitive Ability Resource (ICAR) (Condon & Revelle, 2014; Dworak et al. 2021; Revelle et al., 2020) is a public access tool for evaluating individual differences in cognitive ability and encompasses a variety of cognitive ability domains, including those measuring fluid intelligence and abstract reasoning. One such ICAR domain comprises 64 Raven's-like progressive matrices initially developed by Dr. Yin Wah Fiona Chan, and was administered as part of the Synthetic Aperture Personality Assessment (SAPA) project to participants worldwide (N = 196,919) through a massively missing at random sampling procedure. The Raven's-like progressive matrices demonstrated high internal consistency (ω_h = .70, ω_t = .96, minimum split half reliability = .93, average r = .26). The progressive matrices were moderately associated with the full 60-item ICAR composite (r = .46) as well as the letter and number series (r = .39), matrix reasoning (r = .40), three-dimensional rotation (r = .41), and verbal ability (r = .32) domains of ICAR. The progressive matrices were also notably correlated with SAPA Personality Inventory (SPI; Condon, 2018) marker dimensions of openness (.12), intellect (.15), and emotional stability (.11) as well as neuroticism (-.15), conservatism (-.14), impulsivity (-.14), anxiety (-.14), conformity (-.14), and irritability (-.12). Additional analysis is planned to examine the validity of the Raven's-like progressive matrices by evaluating how scores relate to occupation, education, sex, and age.

Cognizance in cognitive development: A longitudinal study

Prof. Smaragda Kazi[1], ***Dr. Elena Kazali***[2], ***Prof. Nikolaos Makris***[3], ***Prof. George Spanoudis***[4], ***Prof. Andreas Demetriou***[5]

SP

[1]Panteion University of Social and Political Sciences, Athens, Greece
[2]Hellenic Open University, Athens, Greece
[3]Democritus University of Thrace, Alexandroupoli, Greece
[4]University of Cyprus, Nicosia, Cyprus
[5]University of Nicosia, Cyprus Academy of Sciences, Letters, and Arts, Nicosia, Cyprus

The study explored longitudinally how cognizance mediates between executive and reasoning process from 4 to 10 years of age. Four-, 6-, and 8-years old children were tested twice by executive (inhibition, flexibility in shifting, and working memory), cognizance (awareness of perceptual and inferential origins of knowledge, first- and second-order ToM, and awareness of similarities and differences between cognitive processes), and reasoning tasks (deductive and Raven-like fluid reasoning tasks). Perceptual awareness, first-order ToM, and simple inductive and deductive reasoning were acquired at preschool; inferential awareness, awareness of cognitive processes, and relational and deductive reasoning were mastered later in childhood.

The various processes preserved their relative functional autonomy; however, there were two factors standing for their interactions: one for the state of ability at a time and one for general change dynamics.

Latent change score modeling and latent transition analysis showed that cognizance was the best proxy of the general change factor collecting reasoning and executive influences early and leading transitions to higher level reasoning later.

The time course of analogical mapping in low and high ability participants

Mr. Bartłomiej Kroczek*, *Prof. Adam Chuderski

SP

Jagiellonian University, Cracow, Poland

Geometric analogies is a hallmark test measuring fluid intelligence. However, despite many specific models of analogy, it remains elusive which of its component processes are critical for cognitive ability, and how they unfold during a course of analogy. We focused on analogical mapping – establishing the relational structure shared by two geometric patterns and inferring the missing elements in one pattern from the other one. In the analogy literature, some models predicted that the complete relational structure can be considered in parallel, whereas some other models postulated that mapping is incremental, accessing a small part of the structure, and moving to other parts in steps.

Eye tracking was used to assess precisely how incremental mapping is and whether it is related to cognitive ability. In a newly designed geometric A:B::C:D task, pattern D was generated from C according to the same shape transformations that generated pattern B from A. The six possible response options differed systematically in correct transformations, from no transformation matching, via partial match, up to the full match. In Study 1 (N = 109), the relational match of options fixated on by participants was initially low but increased monotonically over the course of analogy.

The number of corresponding eye fixations predicted 68% variance in relational match of the final response. Study 2 (N = 56) replicated the findings using a more ecologically valid and less demanding task variant. The data suggest strictly incremental mapping. It was similarly incremental in high and low ability participants, but high ability participants displayed more valid patterns of fixations, devoting most time to correct transformations, and ignoring clearly incorrect ones. The results implicate that all participants mapped corresponding transformations one by one, but high ability participants focused on more relevant transformations.

Heterogeneous creativity: Schizophrenia patients match healthy controls on remote semantic associations but fall behind on insight problems

Hanna Kucwaj*, *Prof. Adam Chuderski SP

Jagiellonian University, Krakow, Poland

What can we learn about creativity from psychopathology? On the one hand, loose conceptual boundaries, overinclusive thinking, frequent neologisms as well as aberrant, idiosyncratic associations—all observed in schizophrenia—may facilitate creative thinking. On the other hand, patients with schizophrenia suffer from profound deficits in attention, working memory, and reasoning ability. To track how schizophrenia can affect creativity, we asked 51 schizophrenia patients and 51 healthy controls to solve six remote semantic associates and three insight problems—two tasks involving creative thinking, but relying on a different set of skills. Specifically, remote associates rely mainly on less constrained semantic and associative processes, while insight problems engage more constrained analytical thinking involving a wider spectrum of cognitive abilities (e.g. working memory, reasoning). The two groups were matched on the fluid intelligence test (Cattell's CFT-3) to exclude a possible interpretation of group differences in creative thinking in terms of reasoning ability. Firstly, the correlation between remote associates and insight problems was significant in neither group. Secondly, schizophrenia patients were as effective in remote associates as were matched healthy controls. Lastly, schizophrenia patients were significantly less effective in insight problems (M = 28%), as compared to matched controls (M = 45%), likely due to deficits in cognitive abilities crucial for more complex, multistage processing. The results suggest that creativity may be a heterogeneous construct that depends on a variety of cognitive functions. Finding remote associations may primarily involve searching semantic memory that does not depend strongly on cognitive ability. Complex creative tasks, such as insight problems, may require more structured problem representations and reasoning processes strongly loading attention and working memory.

Development and validation of a two-dimensional rotation ability scale

Kendall A. Mather*, *Dr. David M. Condon SP

University of Oregon, Eugene, OR, USA

Despite their known influence in STEM fields, spatial abilities remain an under assessed aspect of cognition. One explanation could be a lack of affordable, valid instruments for measuring various aspects of spatial ability. We evaluate the validity of a set of public-domain, two-dimensional rotation items using a sample from the SAPA project (*N* = 1,395,181). We examine the psychometric properties of the 2D rotation items and their relationship to various other cognitive abilities and personality traits. We also identify the highest performing college majors (*N* = 136) and occupations (*N* = 367) on the 2D rotation items and on a set of 3D rotation items. In addition, we apply the BISCUIT statistical learning technique to examine the job characteristics most strongly related to 2D- and 3D-rotation ability, using ratings for the occupations on more than 200 job characteristics available on the O*NET. Findings suggest adequate unidimensionality for the 2D rotation items, and the presence of lower-order factors which reflect differences across items in mental rotation demands. Among the other cognitive abilities assessed, 2D rotation ability was most strongly associated with general ability, followed by letter and number series problem-solving and matrix reasoning. The relationship for 2D rotation with 3D rotation was weaker than expected, but stronger than the relationships shown for 2D rotation with verbal ability, propositional reasoning, and compound remote associates problem-solving. The highest scoring majors and occupations, and the most strongly related job characteristics were similar—but not identical—across the 2D- and 3D- rotation measures. These findings point to potentially meaningful differences in spatial reasoning demands across areas of expertise.

Structural architecture and brain network efficiency link polygenic scores to intelligence

Dorothea Metzen[1], ***Dr. Christoph Fraenz***[2], ***Dr. Caroline Schlüter***[1], ***Prof. Manuel C. Voelkle***[3], ***Dr. Larissa Arning***[1], ***Dr. Fabian Streit***[4], ***Prof. Huu Phuc Nguyen***[1], ***Prof. Onur Güntürkün***, ***Prof. Sebastian Ocklenburg***[1,5], ***Prof. Robert Kumsta***[1,6], ***Dr. Erhan Genç***[2] **SP**

[1]Ruhr-University Bochum, Bochum, Germany
[2]Leibniz Research Centre for Working Environment and Human Factors (IfADo), Dortmund, Germany
[3]Humboldt University, Berlin, Germany
[4]Central Institute of Mental Health, Mannheim, Germany
[5]Medical School Hamburg, Hamburg, Germany
[6]University of Luxembourg, Luxembourg, Luxembourg

Intelligence is highly heritable. Genome-wide association studies (GWAS) have shown that thousands of alleles contribute to variation in intelligence with small effect sizes. Polygenic scores (PGS), which combine these effects into one genetic summary measure, are increasingly used to investigate polygenic effects in independent samples. Whereas PGS explain a considerable amount of variance in intelligence, it is largely unknown how brain structure and function mediate this relationship. Here we show that individuals with higher PGS for educational attainment and intelligence had higher scores on cognitive tests, larger surface area, and more efficient fiber connectivity derived by graph theory. Fiber network efficiency as well as surface of brain areas partly located in parieto-frontal regions were found to mediate the relationship between PGS and cognitive performance. These findings are a crucial step forward in decoding the neurogenetic underpinnings of intelligence, as they identify specific regional networks that link polygenic predisposition to intelligence.

The thermodynamic nature of general intelligence

Prof. Helmuth Nyborg PP

University of Aarhus, Aarhus, Denmark

General intelligence (*g*, Spearman, 1904, 1927) is today seen as a central causal node in a nexus of correlated traits. However, its physical nature and evolution still elude us, so "The highest priority in *g* research … is to discover how … structures and physiological processes cause individual differences in the brain" (Jensen, 1998, pp. 549–579).

To follow suit, we first established that cranial capacity [cm^3] and migratory IQ+ (evolutionary proxy for Δg) correlate inversely with declining free insolar energy (proxy = Wm^{-2}) (Pearson r = –0.773, p < .0001, r^2 = 0.579; Spearman r = –0.699), and Pearson r = –0.952, p < .0001, r^2 = 0.907; Spearman r = –0.821, respectively) in anatomically modern humans, as a function of their prehistoric latitudinal, but not longitudinal, migration. We submit that declining insolation increases competition by latitude for capturing and transducing free energy (Boltzmann, 1886; Lotka, 1922). This elicits adaptive thermodynamic selection for restructuring and optimization of a neurophysiological correlated vector, of prime survival value because it facilitates critical eduction of relations and correlations in increasingly more competitive multidimensional material environments (Nyborg, 1994, 1998).

We then established that multigenerational exposure to different average ecozone insolation conditions elicit distinct, adaptive, ecotypic, polygene related covariant trait responses, ordered by average latitude. We submit that differential long-term polygene fixations to local average ecozone insolation levels explain this.

We finally present a thermodynamic graph network model to ease visualization and quantification of a series of coupled correlated vector modules. The model reflects causal relations between insolation, biomass production, competition, neurophysiological *g*-nexus optimization, and covariant trait polygene fixations in anatomically modern humans.

Possibly, with thermodynamic network modeling of the brain's "purely physical and chemical aspects …physiology will achieve the greatest of all its triumphs" (Spearman, 1927, p. 403).

On the highway of human cognition: Brain structure-function coupling and its relation with general intelligence

Ms. Johanna Popp[1], ***Mr. Jonas Thiele***[1], ***Dr. Joshua Faskowitz***[2], ***Dr. Christoph Fraenz***[3], ***Dr. Erhan Genç***[3], ***Prof. Olaf Sporns***[2], ***Dr. Kirsten Hilger***[1]

SP

[1]Julius-Maximilians-University, Würzburg, Germany
[2]Department of Psychological and Brain Sciences, Indiana University, Bloomington, USA
[3]Leibniz Research Centre for Working Environment and Human Factors (lfADo), Technical University Dortmund, Dortmund, Germany

Individual differences in general intelligence have a biological basis within the structure and function of the human brain. Network neuroscience investigations revealed neural correlates in various properties of structural and functional brain networks. However, whether the agreement between structural and functional connections, the structural-functional brain network coupling, is related to individual differences in intelligence remains an open question.

In this preregistered study, we used open data from 1,026 adults of the Human Connectome Project, derived structural connectivity from diffusion weighted imaging (DWI), functional connectivity from resting-state fMRI, and estimated general intelligence with a latent *g*-factor derived from 12 cognitive ability tests. Structural-functional brain network coupling was assessed with communication measures that model potential functional interactions on the basis of structural networks and do thus allow for direct mapping of structural to functional connectomes.

At the whole brain level, we observed no significant associations between intelligence and structural-functional brain network coupling for any of the communication models. However, respective associations varied critically between different communication models and at the level of distinct brain regions. We therefore constructed a 5-fold cross-validated prediction model to show that brain region- and communication model-specific coupling features can significantly predict individuals' intelligence scores (correlation between predicted and observed scores: $r = .30$, $p < .001$).

Our results provide new insights into the neural underpinnings of efficient information processing by proposing that optimal region-specific network communication strategies could serve as a neural basis of individual differences in general intelligence.

The genetics of specific cognitive abilities

Ms. Francesca Procopio[1], ***Mr. Quan Zhou***[2], ***Mr. Ziye Wang***[1,2], ***Ms. Agnieszka Gidziela***[2], ***Dr. Kaili Rimfeld***[1,3], ***Dr. Margherita Malanchini***[1,2], ***Prof. Robert Plomin***[1] **SP**

[1]King's College London, London, United Kingdom
[2]Queen Mary University of London, London, United Kingdom
[3]Royal Holloway University of London, Surrey, United Kingdom

Research has consistently converged on the conclusion that general cognitive ability (*g*) is about 50% heritable and its heritability increases across the lifespan. However, much less is known about the genetics of specific cognitive abilities (SCA). To bridge the gap in the literature, we conducted a meta-analytic review of 863,041 monozygotic-dizygotic twin comparisons from 80 publications that investigated SCA. We categorised measures of SCA using the middle level in the three-level Cattell-Horn-Carroll (CHC) hierarchical model of intelligence, which includes 16 broad factors such as fluid reasoning, processing speed, and quantitative knowledge. Twin comparisons were available for 11 of the 16 CHC domains. The average heritability across all SCA is 55%, similar to the heritability of *g*. However, there is substantial differential heritability between the SCA, ranging from 40% to 74%. Furthermore, the developmental changes in heritability for SCA do not mirror the increasing heritability found for *g*. We also investigated the heritability of SCA independent of *g* (*g*-corrected SCA (SCA.*g*)). A surprising finding is that SCA.*g* remains substantially heritable (53% on average), even though 25% of the variance of SCA that covaries with *g* has been removed. Our review frames expectations for genomic research that will use polygenic scores to predict SCA and SCA.*g*. Genome-wide association studies of SCA.*g* are needed to create polygenic scores that can predict SCA profiles of cognitive abilities and disabilities independent of *g*. These could be used to foster children's cognitive strengths and minimise their weaknesses.

Predicting cognitive ability using multi-modal imaging variables in a machine learning model

Mr. Javier Santonja[1], ***Dr. Francisco J Román***[1], ***Dr. Kenia Martínez***[1], ***Dr. Sergio Escorial***[2], ***Dr. María Ángeles Quiroga***[2], ***Dr. Juan Álvarez-Linera***[3], ***Dr. Roberto Colom***[1] **SP**

[1]Universidad Autónoma de Madrid, Madrid, Madrid, Spain
[2]Universidad Complutense de Madrid, Madrid, Madrid, Spain
[3]Hospital Ruber Internacional, Madrid, Madrid, Spain

Research findings reveal that outcomes from univariate neuroimaging analyses are unlikely to yield sound associations between brain and cognitive differences. Applying machine learning algorithms to multivariate brain structural and functional patterns to predict cognition can lead to more powerful insights.

Here we applied an optimized ensemble model to a group of 189 individuals, who completed the same fluid reasoning test (PMAT24), to predict whether the individual shows average or high cognitive ability scores. After extensive pre-processing, 621 multi-modal brain imaging variables from 68 cortical regions were fed to the model, equally distributed between structural T1-weighted, structural DTI, and resting-state functional MRI data. Variables of lesser relevance were iteratively taken out from the model until the predicting capability dropped below 85%.

Preliminary results show that combining multi-modal imaging variables helps the model to maintain the desired level of predicting capability, even with a relatively low number of predictors. Also, the expected predicting capability is not achieved when using variables from only a single imaging modality.

Multi-modal brain signal complexity predicts human intelligence

Jonas Alexander Thiele*, *Aylin Richter*, *Kirsten Hilger

SP

University of Würzburg, Würzburg, Germany

Spontaneous brain activity builds the foundation for cognitive processing during various external demands. A huge number of neuroimaging studies identified specific characteristics of intrinsic brain dynamics to be associated with individual differences in general cognitive ability, i.e., intelligence. However, respective research is inherently limited by low temporal resolution, thus, preventing any conclusions about the complexity of neural fluctuations within the range of milliseconds.

Here, we used resting-state electroencephalographical (EEG) recordings from 144 healthy adults to investigate whether individual differences in intelligence (measured by Raven's Advanced Progressive Matrices) can be predicted from the complexity of temporally highly resolved intrinsic brain signals. We compared different operationalizations of brain signal complexity (Multiscale entropy, Shannon entropy, Fuzzy entropy, and specific characteristics of microstates) concerning their relation to intelligence.

The results indicate that associations with intelligence are of small effect sizes and vary across different spatial and temporal scales. Specifically, higher intelligence scores were associated with lower complexity in local but higher complexity in global aspects of neural processing, and related to greater inter-hemispheric lateralization as well as to less activity of task-negative brain regions. Finally, we combined multiple measures of brain signal complexity to show that intelligence scores of unseen participants can significantly be predicted with multi-modal complexity models within the sample (k-fold cross-validation) as well as in an independent sample (external replication, $N = 57$).

In sum, our results highlight the temporal and spatial dependency of associations between intelligence and intrinsic brain dynamics, proposing multi-modal approaches as promising means for future neuroscientific investigations.

List of Participants

Abdellaoui, Abdel	University of Amsterdam
Alenina, Evgeniia	Tomsk State University
Arakelyan, Madlena	Yerevan State Medical University
Bann, David	University College London
Bardach, Lisa	University of Tübingen
Bates, Timothy	University of Edinburgh
Biesok, Andra	Humboldt-Universität zu Berlin
Bruton, Oliver	Carl von Ossietzky Universität
Buettner, Nico	University of Oxford
Chuderski, Adam	Jagiellonian University
Clark, Gregory	University of California
Czerwiński, Stanisław	University of Gdańsk
Demetriou, Andreas	Cyprus Academy of Sciences, Letters, and Arts
Dürlinger, Florian	University of Vienna
Fries, Jonathan	University of Vienna
Garner, Kayla	Northwestern University
Giannelis, Alexandros	University of Minnesota
Giofrè, David	University of Genova
Hilger, Kirsten	Würzburg University
Kazali, Eleni	Panteion University of Social and Political Sciences
Kovacs, Kristof	ELTE Eötvös Loránd University
Kroczek, Bartłomiej	Jagiellonian University
Kucwaj, Hanna	Jagiellonian University
Lasker, Jordan	Texas Tech
Lee, James	University of Minnesota Twin Cities
Li, Chenyu	University of Zürich
Lin, Chien-An	The University of Edinburgh
Mather, Kendall	University of Oregon
McGue, Matt	University of Minnesota Twin Cities
Metzen, Dorothea	Ruhr-University Bochum
Mhlolo, Mike	Central University of Technology
Molenaar, Dylan	University of Amsterdam
Morris, Damien	SGDP centre, King's College London
Neubauer, Aljoscha	University of Graz
Nyborg, Helmuth	University of Aarhus
Patzl, Sabine	Technical University of Munich
Paulus, Jochen	Wiesbaden, Germany
Pietschnig, Jakob	University of Vienna

Pinker, Steven	Harvard University
Plak, Simone	Vrije Universiteit Amsterdam
Popp, Johanna	Julius-Maximilians-University
Procopio, Francesca	King's College London
Protzko, John	Central Connecticut State University
Rindermann, Heiner	Chemnitz University of Technology
Santonja, Javi	Universidad Autónoma de Madrid
Schubert, Anna-Lena	Heidelberg University
Spanoudis, George	University of Cyprus
Sparfeldt, Jörn	Saarland University
Stern, Elsbeth	Swiss Federal Institute of Technology Zürich
Thiele, Jonas	University Würzburg
Thurn, Christian	Swiss Federal Institute of Technology Zürich
Tsigeman, Elina	Tomsk State University
Ujma, Péter	Semmelweis University
Williams, Camille	Paris Sciences et Lettres University
Willoughby, Emily	University of Minnesota Twin Cities
Wolfram, Tobias	Bielefeld University

Useful Information

Green meeting: Our ISIR Vienna conference will be participating in a global effort to reduce our carbon footprint. The aim is to organize the event according to the criteria of the Austrian Eco-label for Green Meetings/Events, meaning that we will strive to use only recyclable materials and ensure that conference hotels are accessible by public transportation. See https://www.umweltzeichen.at/en/green-meetings-and-events/home for more information.

Navigating Vienna

Getting around: Vienna provides a variety of transportation options, including subway, tram, bus and rail. The conference will be held in the Main Building of the University of Vienna. See maps of the Main building, university campus, airport and railway lines on the following pages.

The international airport of Vienna is the 17th largest airport in Europe. To reach the city center from the airport, the best means of transport is currently the S Bahn S7, the City Airport Train (CAT) or taxi, and is approximately 25 minutes by car or 45 minutes by rail from the university.

Social event: Our main social event will be a banquet held on Tuesday, July 26, which will take place in the large ceremonial hall of the main building of the University of Vienna. There will be signs to direct you from the two entrances (as indicated on page 71) to the event.

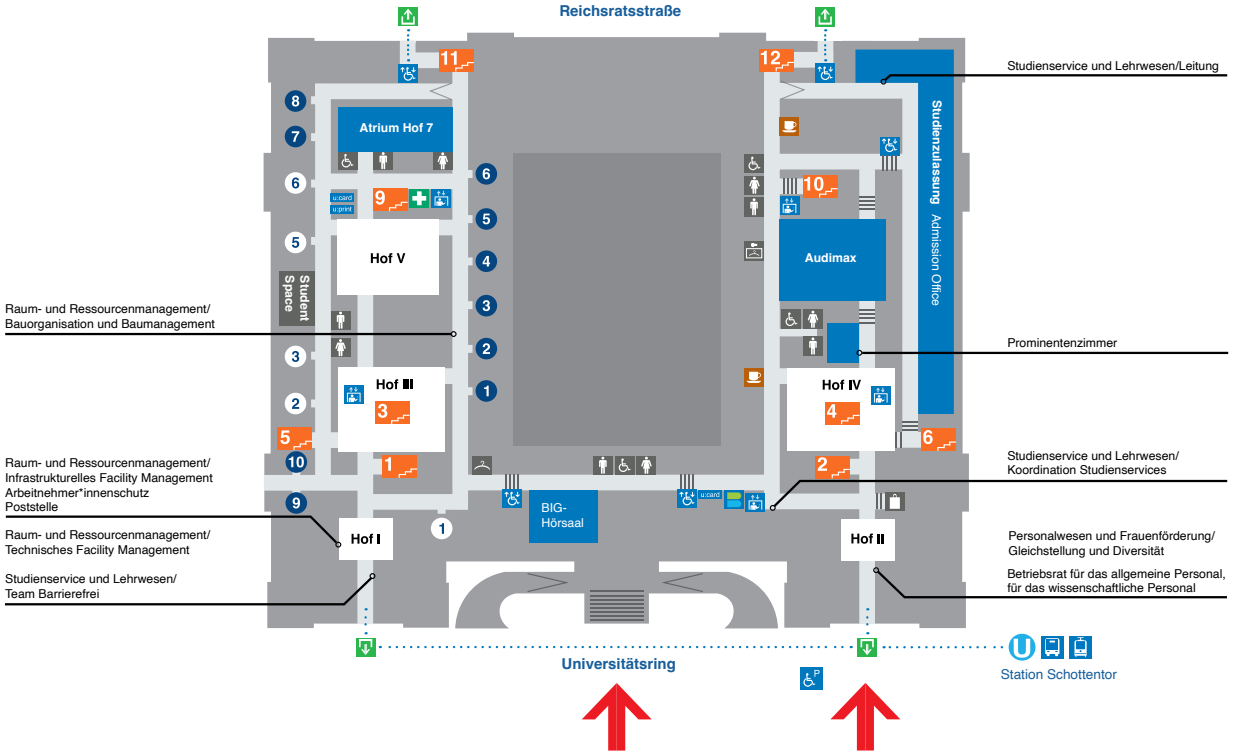
Things to do: Vienna is home to a wide variety of historical and natural wonders. You can read more about what to do in Vienna here: https://www.wien.info/en/recommendations/vienna-in-three-days. You may also find the following PDFs to be helpful:

- Shopping, wining and dining: https://isironline.org/wp-content/uploads/2022/01/einkaufen-essen-und-trinken-de-en-de-data.pdf
- Vienna tips for all the family: https://isironline.org/wp-content/uploads/2022/01/familienbroschuere-en-de-data.pdf
- Things to do in Vienna: https://isironline.org/wp-content/uploads/2022/01/Things-to-Do-in-Vienna.pdf

Main Building Entrances

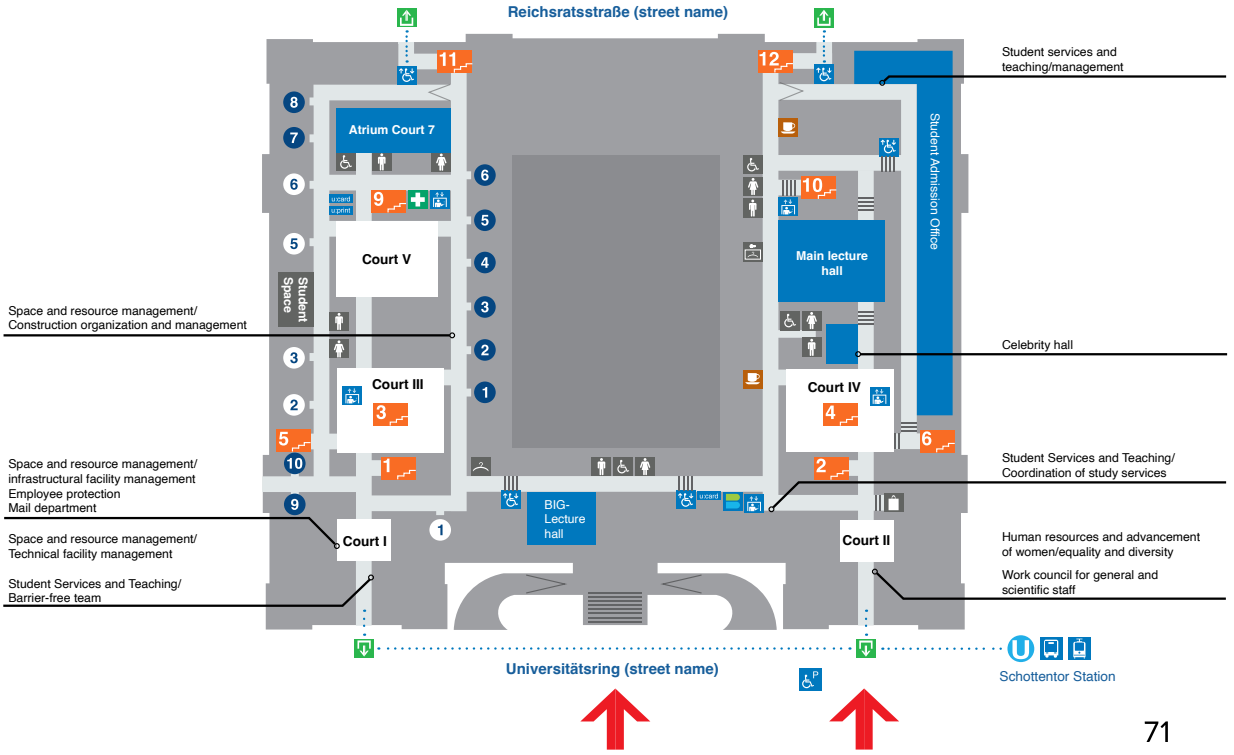
Hauptgebäude der Universität Wien

Tiefparterre – TP



Main building of the University of Vienna

Ground Floor

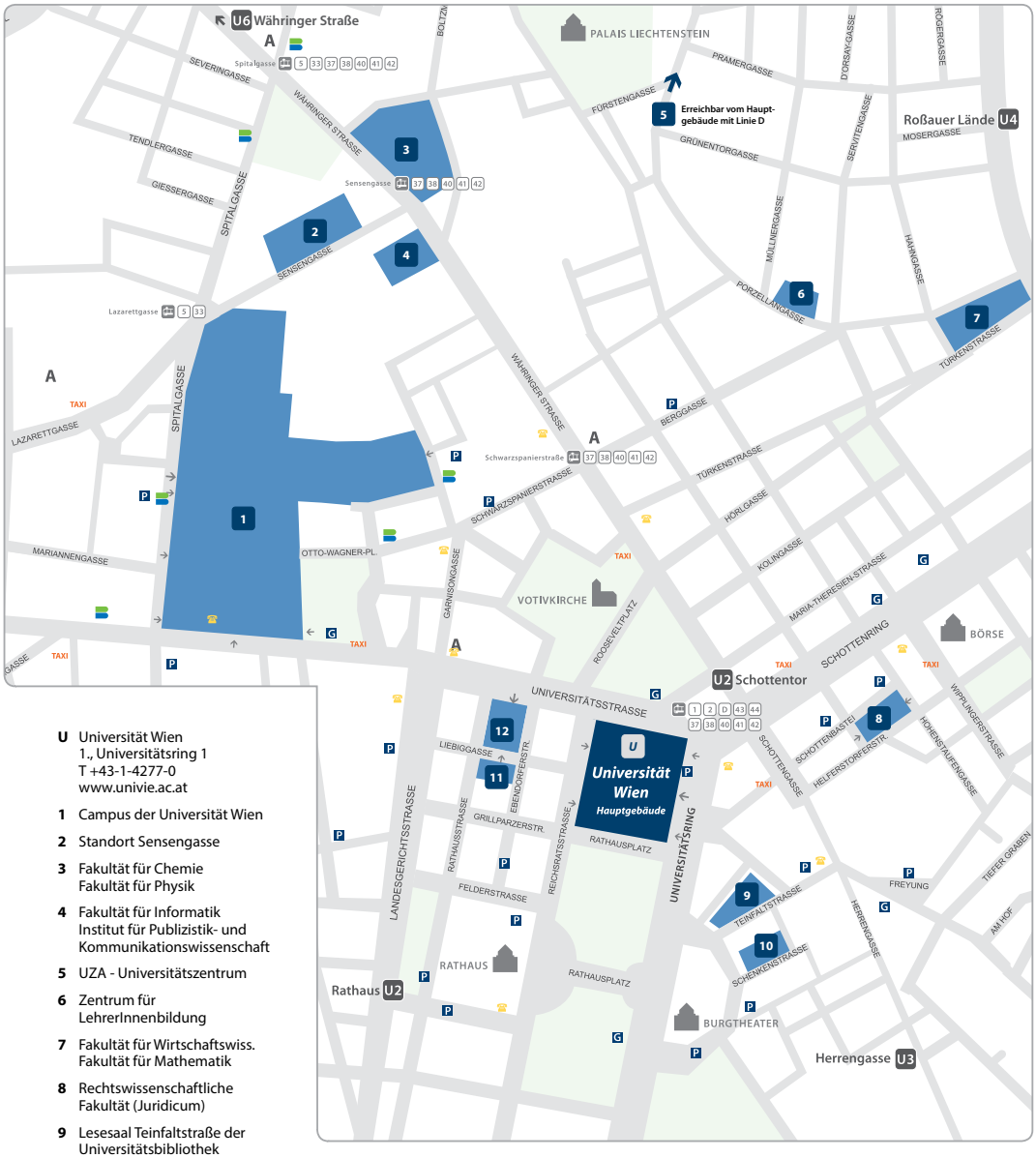


Other Useful Maps

Umgebungsplan

Area Map

universität wien



U Universität Wien
1., Universitätsring 1
T +43-1-4277-0
www.univie.ac.at

1 Campus der Universität Wien

2 Standort Sensengasse

3 Fakultät für Chemie
Fakultät für Physik

4 Fakultät für Informatik
Institut für Publizistik- und Kommunikationswissenschaft

5 UZA - Universitätszentrum

6 Zentrum für LehrerInnenbildung

7 Fakultät für Wirtschaftswiss.
Fakultät für Mathematik

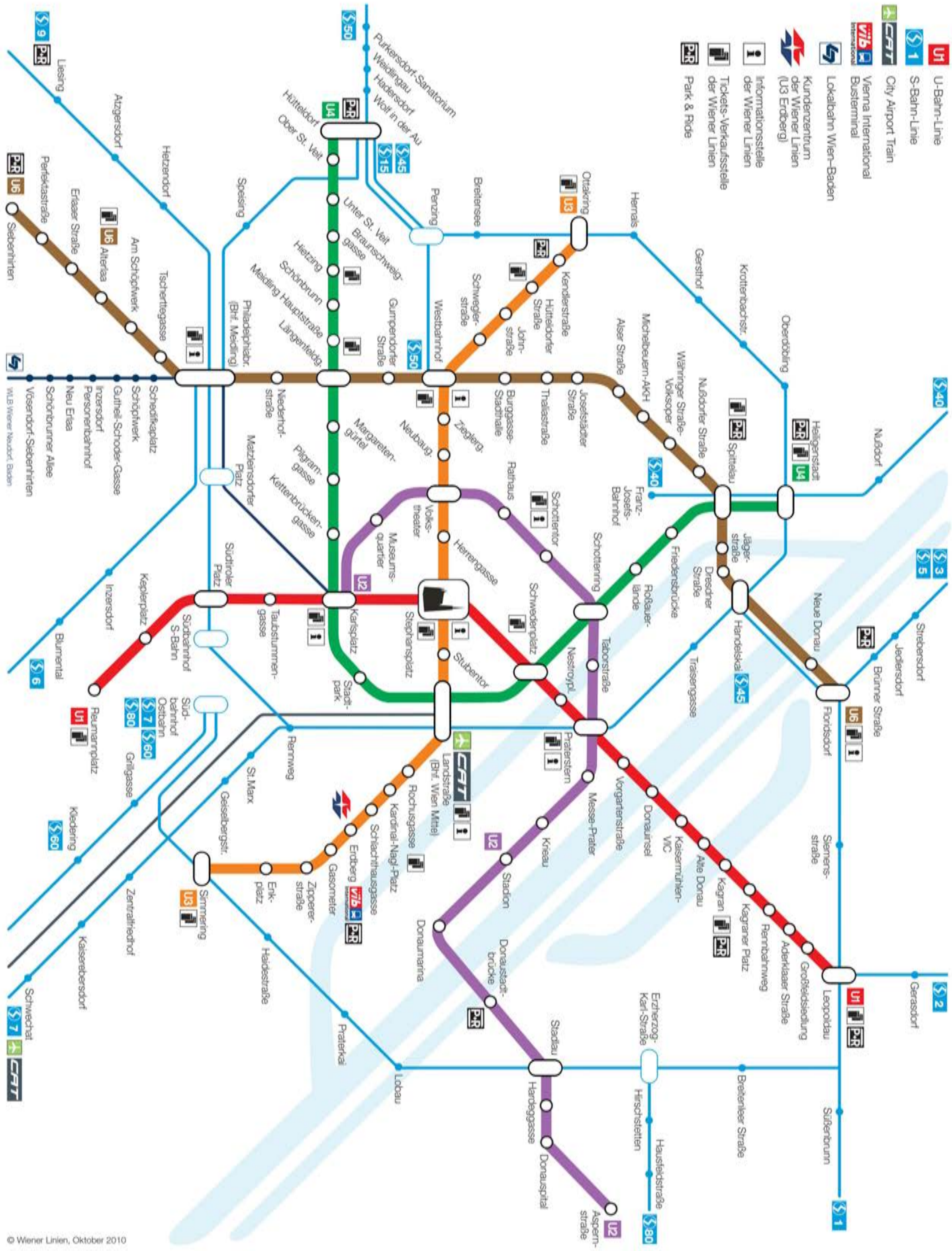
8 Rechtswissenschaftliche Fakultät (Juridicum)

9 Lesesaal Teinfaltstraße der Universitätsbibliothek

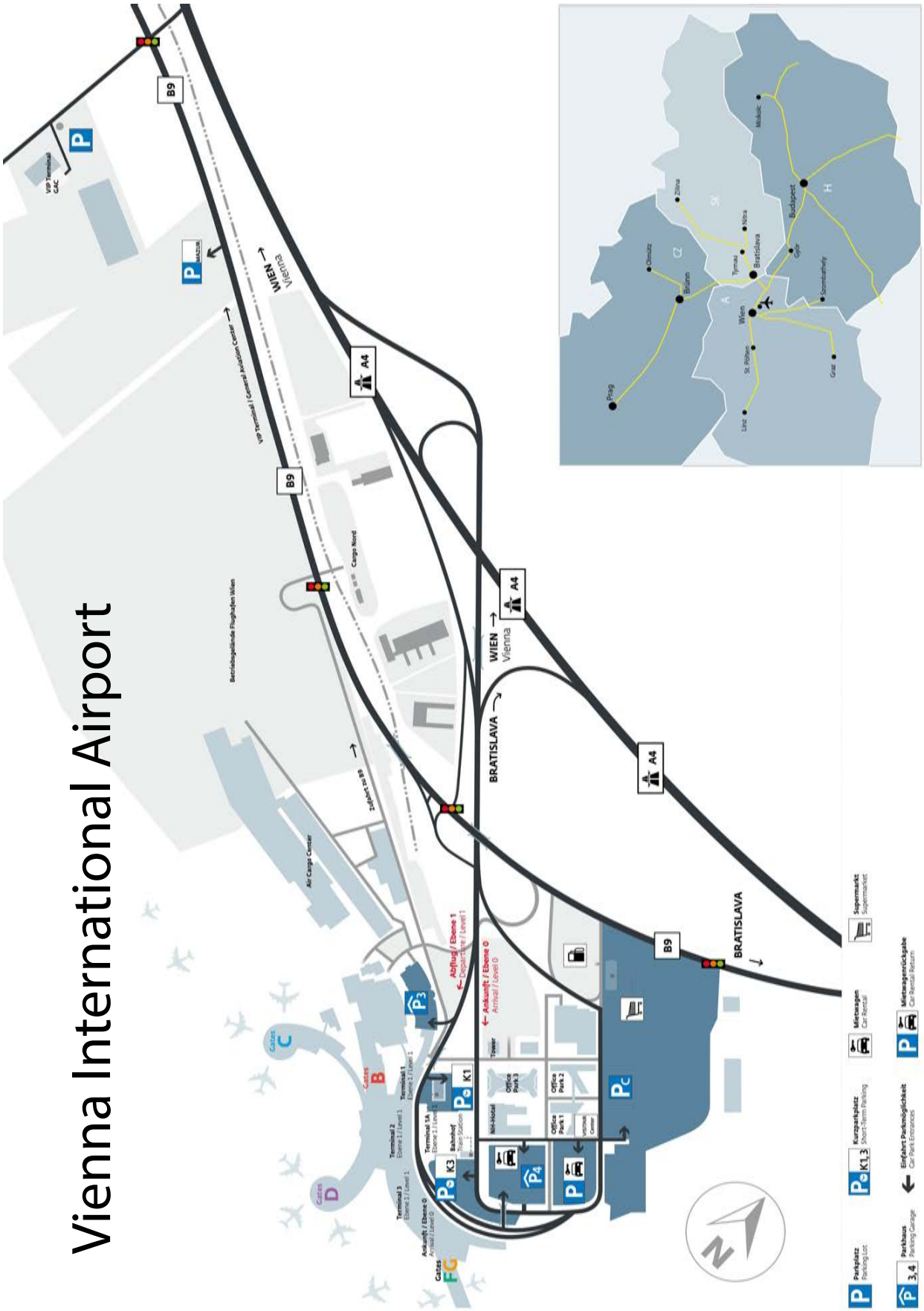
10 Standort Schenkenstraße

11 Fakultät für Psychologie

12 Neues Institutsgebäude (NIG)


U-Bahn-Linie
S-Bahn-Linie
City Airport Train
Vienna International Busterminal
Lokalbahn Wien–Baden
Kundenzentrum der Wiener Linien (U3 Erdberg)
Informationsstelle der Wiener Linien
Tickets-Verkaufsstelle der Wiener Linien
Park & Ride
Siebenhirten
Perfektastraße
Erlaaer Straße
Alterlaa
Am Schöpfwerk
Tscherttegasse
Meidling Hauptstraße
Längenfeldgasse
Gumpendorfer Straße
Westbahnhof
Burggasse-Stadthalle
Thaliastraße
Josefstädter Straße
Alser Straße
Michelbeuern-AKH
Währinger Straße-Volksoper
Nußdorfer Straße
Spittelau
Heiligenstadt
Hütteldorf
Ober St. Veit
Unter St. Veit
Braunschweiggasse
Hietzing
Schönbrunn
Kettenbrückengasse
Pilgramgasse
Margaretengürtel
Karlsplatz
Stadtpark
Landstraße (Bhf. Wien Mitte)
Schwedenplatz
Roßauer Lände
Friedensbrücke
Ottakring
Kendlerstraße
Hütteldorfer Straße
Johnstraße
Schweglerstraße
Zieglergasse
Neubaugasse
Volkstheater
Herrengasse
Stephansplatz
Stubentor
Rochusgasse
Kardinal-Nagl-Platz
Schlachthausgasse
Erdberg
Gasometer
Zippererstraße
Enkplatz
Simmering
Reumannplatz
Keplerplatz
Südtiroler Platz
Taubstummengasse
Nestroyplatz
Praterstern
Vorgartenstraße
Donauinsel
Kaisermühlen-VIC
Alte Donau
Kagran
Kagraner Platz
Rennbahnweg
Aderklaaer Straße
Großfeldsiedlung
Leopoldau
Rathaus
Schottentor
Schottenring
Taborstraße
Messe-Prater
Krieau
Stadion
Donaumarina
Donaustadtbrücke
Stadlau
Hardeggasse
Donauspital
Aspernstraße
Jägerstraße
Dresdner Straße
Handelskai
Neue Donau
Floridsdorf
Museumsquartier
Niederhofstraße
Philadelphiabrücke (Bhf. Meidling)
Liesing
Atzgersdorf
Hetzendorf
Speising
Penzing
Breitensee
Hernals
Gersthof
Krottenbachstr.
Oberdöbling
Nußdorf
Franz-Josefs-Bahnhof
Traisengasse
Strebersdorf
Jedlersdorf
Brünner Straße
Siemensstraße
Süßenbrunn
Gerasdorf
Erzherzog-Karl-Straße
Hirschstetten
Breitenleer Straße
Hausfeldstraße
Lobau
Praterkai
Haidestraße
Zentralfriedhof
Kaiserebersdorf
Schwechat
Kledering
Grillgasse
St. Marx
Geiselbergstr.
Rennweg
Matzleinsdorfer Platz
Südbahnhof S-Bahn
Südbahnhof Ostbahn
Inzersdorf
Blumental
Purkersdorf-Sanatorium
Weidlingau
Hadersdorf
Wolf in der Au
Schedifkaplatz
Schöpfwerk
Gutheil-Schoder-Gasse
Inzersdorf Personenbahnhof
Neu Erlaa
Schönbrunner Allee
Vösendorf-Siebenhirten
WLB Wiener Neudorf, Baden
© Wiener Linien, Oktober 2010

Vienna International Airport



Acknowledgements

- Sincere thanks to our local host Jakob Pietschnig and other conference organizers
- Our thanks to The Institute for Mental Chronometry for supporting ISIR 2022
- 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
- We are very grateful to our sponsors for supporting this year's conference:
  - City of Vienna for sponsoring our social event
  - Vienna Meeting Fund
  - Schuhfried GmbH

Future meetings

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


See you in the USA for ISIR 2023!

Notes