#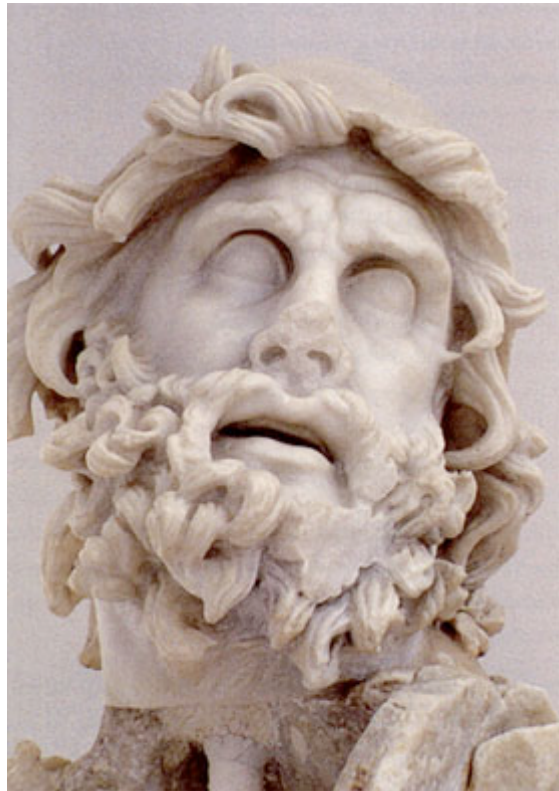 THE TWELFTH ANNUAL CONFERENCE OF THE INTERNATIONAL SOCIETY FOR INTELLIGEN RESEARCH: LIMASSOL, CYPRUS, DECEMBER 8-10, 2011

So it is that the gods do not give all men the gifts of grace…neither good looks nor intelligence nor eloquence.

Odysseus, speech to the suitors of Penelope

Homer's *Odyssey*.

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International Society for Intelligence Research
The Twelfth Annual Conference of the ISIR
December 8-10, 2011
Limassol, Cyprus

Thursday, December 8

8:30 - 8:50 AM **Opening Announcements and Awards**
Lifetime Achievement Award: Robert Plomin.

8:50 - 10:30 AM **T1: Talks, generally about the structure of intelligence**
8:50 - 9:10 AM T1.1: Forward and backward digit span measure different components of intelligence. *Kristof Kovacs*
9:10 - 9:30 AM T1.2: Processing speed and accuracy measured on complex items: Their relations on different difficulty levels and their associations with intelligence scores. *Yury S. Dodonov*
9:30 - 9:50 AM T1.3: Response time and intelligence: can diffusion model provide new insights? *Yulia A. Dodonova*
9:50 - 10:10 AM T1.4: Spearman's Law of Diminishing Returns: A Statistical Artefact? *Aja L. Murray*

10:10 - 10:30 AM **Coffee Break**

10:30 - 12:00 AM **Symposium 1**: **New Approaches to the Legacy of Charles Spearman**
Organizer: *Jan te Nijenhuis*

12:00 - 1:30 PM **Lunch**

1:30 - 3:00 PM **Symposium 2: A Cross-Cultural Perspective on Individual Differences in Cognition**
Organizer**:** *Sergey Malykh*

3:00 - 3:20 PM **Coffee Break**

3:20 - 4:00 PM **T2: Talks, generally about population differences**
3:20 - 3:40 PM T2.1: Sex differences in drawing a horizontal line increase with age: A meta-analysis**.** *Jakob Pietschnig*
3:40 - 4:00 PM T2.2: Differentiation with respect to the *g* factor in the Hungarian standardization samples of the WISC-IV and WAIS-IV. *Jelte M. Wicherts*

4:00 - 5:00 PM **Business Meeting**

5:30 - 6:30 PM **Interview**. *Douglas K Detterman*

6:30 - 8:30 PM **Welcome Reception and Posters**

8:30 - 10:10	**AM**	**T3: Talks, generally about cognition**
8:30 - 8:50	AM	T3.1: The relationship between inspection time task and intelligence in young children. *George Spanoudis*
8:50 - 9:10	AM	T3.2: The interplay of intelligence and temperament in the course and effectiveness of cognitive processes. *M. Stolarski*
9:10 - 9:30	AM	T3.3: Predictive validity of SAT non-*g* variance: results for sex and race. *Thomas Coyle*
9:30 - 9:50	AM	T3.4: Intelligence judgement and appraiser's intelligence. *Svetlana V. Yaroshevskaya*
9:50 - 10:10	AM	T3.5 Typical intellectual engagement and cognition in the ninth decade of life: the Lothian birth cohort 1921. *Sophie von Stumm*

10:10 - 10:30 AM   **Coffee Break**

10:30 - 12:00 AM   **Symposium 3**: **New Insights From Twin Research Into Individual Variation in Intelligence, Motivation and Achievement**
Organizer: *Yulia Kovas*

12:00 - 1:30 PM   **Lunch**

1:30 - 2:20 PM   **Annual Constance Holden Symposium (Symposium 4): Rubbing Public Opinion the Wrong Way**
Organizer: Linda S. Gottfredson; Featured speaker: Lone Frank

2:20 - 3:20	**PM**	**T4: Talks, generally about neuroscience**
2:20 - 2:40	PM	T4.1: Changes in gray and white matter after four weeks of videogame practice. *Roberto Colom*
2:40 - 3:00	PM	T4.2: Cortical thickness correlates of change in IQ in children and adolescents. *Miguel Burgaleta*
3:00 - 3:20	PM	T4.3: Relevance of scoring for finding intelligence in the brain. *Francisco J. Román*

3:20 - 3:40 PM   **Coffee Break**

3:40 - 5:00	**PM**	**T5: Talks, generally about intelligence and life outcomes**
3:40 - 4:00	PM	T5.1: Associations between intelligence in adolescence and indicators of health and health behaviours in midlife in a cohort of Swedish women. *Karin Modig*
4:00 - 4:20	PM	T5.2: Intelligent children make happier adults**.** *Magda Chmiel*
4:20 - 4:40	PM	T5.3: The market place for Intelligence: 2009 version. *Earl Hunt*
4:40 - 5:00	PM	T5.4: Genotype by environment interactions in cognitive ability tested in 14 different studies. *Dylan Molenaar*

5:30 - 6:30 PM   **Featured Speaker:** *Louis D. Matzel*
Dopaminergic Regulation of Selective Attention and the Expression of "Intelligence" in Genetically Heterogeneous Mice

8:30 - 10:10	**AM**	**T6: Talks, generally about intelligence and educational outcomes**
8:30 - 8:50	AM	T6.1: The VPR model in Project Talent. *Jason T. Major*
8:50 - 9:10	AM	T6.2: Classification of students in two-year colleges: A latent class model approach. *Heather Turner*
9:10 - 9:30	AM	T6.3: Psychomotor ability is a more robust predictor of literacy than is cognitive performance during pre-school ages. *Keith Widaman*
9:30 - 9:50	AM	T6.4: Intelligence and education: What develops? For whom? *Wendy Johnson*
9:50 - 10:10	AM	T6.5: Aurorra Battery Intelligence Assessment Under Triarchic Theory**.** *Ana M. Salgado*

10:10 - 10:30	**AM**	**Coffee Break**

10:30 - 12:20	**AM**	**Symposium 5**: **Studies on the Neurotransmitter and Biological Basis on Human Intelligence** Organizer: *Con Stough*

12:20 - 1:50	**PM**	**Lunch**

1:50 - 3:00	**PM**	**Symposium 6: Society, Intelligence and the Economy** Organizer**:** *Werner W. Wittmann*

3:00 - 3:20	**PM**	**Coffee Break**

3:20 - 4:20	**PM**	**T7: Talks, generally about health**
3:20 - 3:40	PM	T7.1: Intelligent children become healthier adults: Findings from a 40 year longitudinal study in Luxembourg**.** *Marius Wrulich*
3:40 - 4:00	PM	T7.2: Towards understanding the associations between health literacy and physical health**,** *René Mõttus*
4:00 - 4:20	PM	T7.3: What explains the association between low cognitive ability and Mortality Risk: Socio-economic Status, Health Behaviours, cardiovascular risk factors, or information processing speed? Evidence from the third National Health and Nutrition Examination Survey (NHANES-III).*Gareth Hagger-Johnson*

4:20 – 5:00	**PM**	**Students Awards**

PAPERS,
SYMPOSIA
and
POSTERS

(abstracts are organised in order of presentation time)

Thursday, December 8

T1: Talks, generally about the structure of intelligence
(Thursday, 8.50-10.30)

T1.1: Forward and backward digit span measure different components of intelligence

Kristof Kovacs*[,1], Sandor Rozsa[2], Natasa Ko[2]

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Digit span, the task in which subjects have to repeat a series of single digits, has been an essential instrument for the last century both in intelligence testing and in research on memory. Cattell's first mental test in 1890 already included a task measuring memory span for consonants, and span for digits as a measure of intelligence in children was introduced in the first modern-day IQ-test, the Binet-Simon Scales. Digit span was also part of the American adaptation of Binet's test, the so-called "Stanford-Binet", with the additional requirement for examinees to recall digits backwards. Since then the two versions of the digit span task, the forward and the backward span, have coexisted. In contemporary intellectual measures such as subsequent versions of the Wechsler Intelligence Scale for Children (WISC), the Wechsler Adult Intelligence Scale (WAIS), and the Wechsler Memory Scale examinees have to recall digits in both the original and in reversed order, and the results of the two tasks are combined into a single sub-scale score.

The theoretical relationship between the two versions of the the digit span task, however, is not clarified: is backward digit span simply a more difficult measure of the same ability (or abilities) measured by forward digit span, or does it measure something above and beyond the storage and recall of single digits?

The present study investigates the relationship between the two digit span tasks under two frameworks. The first is the fluid/crystallized intelligence (Gf-Gc) model, according to which "backward span memory test (...) is more complex than a test of forward span memory. It is a considerably better measure of Gf [fluid intelligence] and consequently a poorer measure of SAR [Short-Term Acquisition and Retrieval] than is forward memory span" (Horn, 1989, p. 91.). The second is the theory of working memory (e.g. Baddeley & Hitch, 1974), which implies that whereas forward span taps storage processes and therefore is a measure of short-term storage, backward span also taps the central executive.

Large (N=1000+) and representative standardization samples of adults (WAIS-IV) and children (WISC-IV) from Hungary were analyzed, using partial correlation as well as structural equation modeling. We found that the executive component that backward span taps, in addition to storage and retrieval, is clearly responsible for the task's correlation with Gf. However, only in 6-10 year olds did the additional component correlate with Gc as well: above age 11, simple storage processes, but not the central executive are tapped by Gc. That is, we show that the executive processes measured by backward span correlate with fluid, but not with crystallized components of intelligence. The implications of this result both for assessment and research are discussed.

T1.2: Processing Speed and Accuracy Measured on Complex Items: Their Relations on Different Difficulty Levels and Their Associations with Intelligence Scores

Yury S. Dodonov* & Yulia A. Dodonova

* ys.dodonov@gmail.com; Moscow City University of Psychology and Education

Response time (RT) for simple tasks is related to intelligence level. In addition, a number of results obtained in recent decades are consistent with the so-called "complexity hypothesis", which predicts that the magnitude of correlation between response time and intelligence increases as the speeded task becomes more complex. However, these relations hold only for relatively simple speeded tasks. For example, Jensen claimed that RT becomes less related to intelligence when the difficulty level of tasks is such that individuals differ in their accuracy scores. Little is known about how the correlation between processing speed and cognitive ability changes for tasks where the average RT is above a certain threshold - common for simple speeded tasks (e.g., Jensen's 2-sec threshold). Several studies have addressed this question, using obviously complex speeded tasks (e.g., response to intelligence tests items, under speeded condition). In cases involving such obviously complex speeded tasks, the question of the association between RT and cognitive ability becomes the question of the relation between speed of test taking and accuracy in intelligence tests.

In this study (N=102), we analysed how the relationship between processing speed and accuracy level changes with increasing difficulty of items that are more complex than those commonly used in speeded tasks, but still easier than those used in intelligence tests. We also analysed associations between the accuracy and processing speed for these items, on the one hand, and intelligence, measured by Raven's APM, on the other hand. Our study used 46 four-letter anagrams as items for the speeded task. The anagrams differed in their levels of difficulty. For this sample, weighted mean time for correct responses ranged from about 1,500 ms for the easiest items to about 5,700 ms for the most difficult items. Correct responses varied from 99 percent for the easiest items to 32 percent for the most difficult ones. Two measures of difficulty (sample mean RT and percent correct) were highly correlated and were also related to an independent measure of complexity (frequency of response word). For further analyses, the anagrams were grouped according to their difficulty. The weighted mean response time and the number of correct responses for each participant were calculated separately for every group of items.

In the groups of simple items, RT was significantly correlated with accuracy level (-.40). The association weakened as items became more difficult and was close to zero in the group with the most difficult items (-.03). For easy items, participants who were faster also gave more correct responses, but this relationship did not hold for more complex items. Overall processing speed and accuracy in our task were moderately correlated with intelligence scores. However, these associations also changed, depending on the difficulty level. The highest correlation between processing speed and intelligence was observed in the group with the easiest items; this association decreased as the difficulty of the anagrams increased. Accuracy scores showed an opposite trend. The highest correlation between accuracy score and intelligence was observed in the group with the most difficult items; the correlation decreased as the level of difficulty went down.

The implications of these findings for analysing individual performance in tasks where participants differ reliably in both accuracy and processing speed are discussed. Discussion also covers how the difficulty of items affects the relationship between individual performance in speeded tasks and cognitive ability.

T1.3: Response Time and Intelligence: Can Diffusion Model Provide New Insights?

Yulia A. Dodonova* & Yury S. Dodonov

* ya.dodonova@mail.ru; Moscow City University of Psychology and Education

Studies on individual performance in elementary cognitive tasks that go beyond the simple analysis of average processing speed necessarily involve advanced algorithms to account for regularities in response time (RT) data. Of the various sophisticated quantitative models that can be applied to RT analysis, Ratcliff's (1978) diffusion model seems to be a prominent one. This model aims to explain error rates and RT distributions in simple two-choice tasks. The model is a continuous version of a random walk model; information processing is conceptualised in terms of evidence accumulation that terminates at one of two decision boundaries when the amount of information is enough for the decision. Thus, the RT distributions of correct and error responses are regarded as first-passage time distributions; the model produces estimates of parameters that describe the rate of evidence accumulation (drift rate), the amount of evidence needed to make a decision (boundary separation and starting point) and the amount of time taken for non-decision processes. The full version of the diffusion model discussed in this presentation also includes parameters that describe across-trial variability in each of the above parameters.

The model is considered to provide an excellent fit for RT data that are derived from various tasks and experimental conditions. The model's parameters are claimed to be useful for explaining the effects of different factors (e.g., aging) and experimental manipulations (e.g., task complexity) on RT distributions. With respect to individual differences in higher-order cognitive ability, Ratcliff (2010) reported that a single parameter (drift rate) could explain a large proportion of variance of intelligence scores. In another paper, Ratcliff (2007) demonstrated how diffusion model could explain the worst performance rule (slower RTs are more strongly related to intelligence than faster RTs). In addition, van Ravenzwaaij, Brown and Wagenmakers (2011) demonstrated that the diffusion model, with its drift rate parameter, could provide a unifying account for several other regularities that are commonly observed in the field. These regularities include stronger correlation between g and the standard deviation of RT than between g and mean RT, stronger correlation between g and inspection time than between g and mean RT, and others.

In this presentation, we will first point out the basic assumptions of the diffusion model, including the assumption of much smaller variance in the non-decision components of processing than in the decision component, and we will analyse the empirical data that supports or contradicts the plausibility of these assumptions. Second, we will analyse the values of the parameters that are normally obtained by fitting the diffusion model to the experimental data, and the relations between the parameters. Again, we will point out several trends that deserve the special attention of researchers. Third, we will focus on theoretical interpretations of the diffusion model's parameters and address the question whether their behaviour in real experiments corresponds with theoretical predictions. Finally, we will compare the conclusions that can be derived from the diffusion model analysis of empirical RT distributions and from conventional analyses of distribution moments. To address the above issues, this presentation will make use of empirical data as well as computer simulations and published results in the field. Throughout our analysis, our main question will be whether the diffusion model can provide "a new way of thinking about the concept of intelligence", as van Ravenzwaaij et al. (2011) claim.

T1.4: Spearman's Law of Diminishing Returns: A Statistical Artefact?

Aja L. Murray[*,1], Hayley Dixon[1], Wendy Johnson[1,2,3] & Thomas J. Bouchard Jr.[3]

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According to "Spearman''s Law of Diminishing Returns" (SLODR) higher levels of general cognitive ability are associated with more differentiated cognitive performance across ability tests. Here we present evidence that suggests that the phenomenon cannot be reliably tested using traditional methods when there are even very small departures from normality in subtest score distributions. In this study, SLODR effects were greater when general ability was estimated on the basis of subtests which yielded more positively skewed distributions of scores. In addition, SLODR direction was a function of the average subtest skewness in a battery, with SLODR associated with positive skewness and reverse SLODR associated with negative skewness. Contrary to previous speculation, task difficulty appears to be a relatively less important moderator. By comparison with a new method that did not share its limitations, we also found evidence to substantiate the concerns surrounding the validity of using the ratio of g-saturation as estimated by the first principal component in low to high ability groups as a method of testing SLODR. We argue that, together, these results imply problems with the manner in which SLODR has commonly been tested and raise the possibility that previous confirmations of SLODR were unreliable.

S1: New Approaches to the Legacy of Charles Spearman
(Thursday, 10.30-12.00)

Symposium Chair**:** Jan te Nijenhuis (JanteNijenhuis@planet.nl)

Symposium Summary

In this symposium we will explore new approaches to classic themes from the work of Charles Spearman. They will take the form of applying a novel methodological perspective or applying a novel theoretical perspective, with studies from the Netherlands, the U.S., and Dominica.

The three classic themes are 1) Spearman's insight that life tasks differ in "hierarchical intellective rank" (*g* loading), 2) Spearman's Law of Diminishing Returns (SLODR), and 3) Spearman's hypothesis.

Linda Gottfredson, Kathy Stroh, and Eileen Sparling will show that much public policy aims to reduce *g*-based inequalities by reducing differences in *g*. It ignores a more feasible alternative for enhancing the health and well-being of vulnerable populations: manipulating the complexity (*g* loading) of the tasks it expects the populace to perform. We illustrate the promise of a *cognitive ergonomics* with our efforts to increase the cognitive accessibility to patients of critical tasks in diabetes self-management.

Michael Woodley, Sacha Brown, Kari Celeste Ross, and AJ Figueredo extend Spearman's Law of Diminishing Returns, testing differential K-theory. They examined the relationship between several cognitive abilities with respect to life history speed (individual differences in preferences towards the development of a either fast life history characterized by high mating effort or a slow life history characterized by high somatic and parenting effort). They predicts that life history speed may control the degree to which separate cognitive abilities are brought into correlation with one another via homogenized development, or the degree to which they are developed independently. Detailed findings will be reported.

Sacha Brown[1], Michael Woodley[2], Kari Celeste Ross[1], and AJ Figueredo present a second test of SLODR, testing differential K-theory. Evolutionary theory proposes that the ability to estimate one's own mate value is an important aspect of securing reproductive opportunities. Creativity and intelligence are both traits that contribute to mate value and are hypothesized to correlate with life history strategy (LHS).
It is hypothesized that fast LHS individuals living in unstable environments benefit from the ability to transfer skills across domains, leading to greater similarity in skill across cognitive domains (e.g. Cognitive Integration Effort). Detailed findings will be reported.

Jan te Nijenhuis will show that many studies have been conducted on differences in mean intelligence test scores between ethnic groups. Spearman's hypothesis states that the group differences on the subtests of IQ batteries can best be explained in terms of differences in the complexity of the tasks, that is, the demands they make on the general factor of mental ability, the *g* factor. Several psychometric meta-analyses show that Spearman's hypothesis is now supported for most major test batteries and most major racial groups and can be considered to be an empirical fact. Mean differences in intelligence between groups can be almost perfectly explained by the complexity of the subtests in an IQ battery.

S1.1: Spearman and the Cognitive Ergonomics of Health Disparities

Linda Gottfredson[*,1], Kathy Stroh[2], & Eileen Sparling[1]

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Nature-nurture debates still rage over the origins and malleability of differences in general intelligence (Spearman's *g*). They are fueled by the fact that IQ differences are correlated with many good and bad life outcomes. These differences are usually labeled "inequalities" when observed within a population and "disparities" when observed between groups. Although the means to narrow intelligence differences still elude us, eradicating the inequalities and disparities they produce has become a national priority in education, health, and other social arenas.

By their very nature, attempts to reduce an inequality set the goal of reducing variation in the population, and interventions typically attempt this by reducing variance in cognitive ability, regardless of how interventionists conceive it (IQ, *g,* knowledge, literacy, etc.). To skeptics who doubt that variation in *g* can be meaningfully narrowed, the retort is always: "But how would *you* solve the problem?" The unnamed problem is, in essence, human variation in an important trait, and the unspoken assumption is that "solving" it is a moral and political imperative.

But is that true? Is variation in *g* really the problem to be solved? And, are futile attempts to eradicate it the only constructive response to individual and group differences in *g*? One of Spearman's (1904) insights suggests an alternative—to increase the cognitive accessibility of the complex tasks that institutions generate, rather than boosting the *g* of people who must now perform them. His insight was that there are large cognitive differences among *both* tasks and people. The power of *g* to generate differences (inequalities) in human performance is contingent on the *complexity (g loading) of the tasks* evoking its use. Spearman provided a practical example: An individual's "intellectual fitness for any given post...depends on...the hierarchical intellective rank [*g* loading] of the duties involved in the post."

His example embodies two conceptual shifts: (1) *g*-based "inequalities" will expand (or contract) in a population—*without any change in the distribution of g*—whenever life tasks become more (or less) cognitively demanding, and (2) improving fitness is often a more appropriate and achievable goal than is equalizing fitness. The implications for policy and practice are, first, to stop focusing so exclusively on changing a population's distribution of intelligence and consider changing or redistributing the cognitive demands it experiences. And, second, stop setting exclusively norm-referenced goals (more *equal* rates of illness and death) and adopt more criterion-referenced goals (*lower* rates of illness and death).

We illustrate this alternative approach, *cognitive ergonomics,* with our project to improve diabetes self-management in Delaware, especially among high-risk, high-cost, cognitively vulnerable patients. Following (1) above, we are analyzing the cognitive demands and criticality of key duties in the "job" of diabetes self-care. We are also gathering health providers' accounts of the most serious cognitive errors their patients make. On (2) above, we will use these findings to restructure patient education and supervision. We will re-sequence patient instruction according to the criticality of self-care tasks and restructure guidance in self-management to bring it within closer cognitive reach.

S1.2: Is there an effect of Spearman's Law of Diminishing Returns (SLODR) from life history speed? Evidence for the CD-IE hypothesis

Michael Anthony Woodley[*,1], Sacha Devine Brown[2], Kari Celeste Ross[2], & Aurelio José Figueredo[2]

*Michael.Woodley03@gmail.com; [1]Ross University, Dominica; [2]Department of Psychology, University of Arizona, Tucson, Arizona

We examined the relationship between several cognitive abilities with respect to life history speed (individual differences in preferences towards the development of a either fast life history characterized by high mating effort or a slow life history characterized by high somatic and parenting effort [Figueredo, Vásquez, Brumbach & Schneider, 2004]). (1) Fluid Cognitive Ability, as measured by the Abstraction factor from the Shipley Institute of Living Scales (SILS) and the 18-item short form of the Raven's Advanced Progressive Matrices (APM-18); (2) Crystallized Cognitive Ability, as measured by the Vocabulary factor in the SILS; and (3) Creative Ability or fluency. The cognitive differentiation-integration effort (CD-IE) hypothesis predicts that while there might be no "main effect" of K (the factor latent in diverse life history measures) predicting g, life history speed may control the degree to which separate cognitive abilities are brought into correlation with one another via homogenized development, or the degree to which they are developed independently. The capacity to cultivate separate abilities benefits individuals living at the carrying capacity of their environment, where cognitive specialization can serve to reduce competition. Evenly developed abilities benefit individuals living in unstable environments, where the domain general skills can be transferred across socio-cultural niches as a means of mitigating the effects of ecological instability on fitness (Woodley, 2011).

Using data from a previously reported study (Ross & Figueredo, 2009), we found that the correlation between the Vocabulary and Abstraction subscales of the SILS did not vary significantly with speed of life history. Using data from another previously reported study (Brown & Figueredo, 2010), however, we found that the magnitude of the correlation between Fluid Cognitive Ability (as measured by the APM-18) and Creative Performance (a combination of Panel-Rated Creative Output and Self-Reported Creative Achievement) did vary inversely with speed of life history, as predicted by CD-IE, at a level closely approaching the conventional cutofff for statistical significance (β=-.11, p=.0575). Furthermore, we found that the magnitude of the correlation between the Panel-Rated Creative Verbal Output and the Panel-Rated Creative Drawing Output varied significantly and inversely, as predicted by CD-IE, with speed of life history (β=-.16, p=.0038). As before (Brown & Figueredo, 2010), we also found that Self-Estimated Intelligence in the Artistic, Music, Dance, Architectural, Writing, Humor, Scientific, Theater, Culinary, and Invention domains all converged upon a general Creative Achievements Factor. However, none of the magnitudes of the loadings from this general Self-Estimated Creative Achievements Factor exhibited the predicted *negative* significant relations to slower life history strategy in any of the domains assessed.

The verbal and abstraction factors in SILS were found not to significantly correlate with one another (r=-.21, p=.21), indicating a ceiling effect. On these grounds the apparent null result can be disregarded. The creativity measure and fluid cognitive ability measure did correlate significantly however (r=.13, p<.05), As did Panel-Rated Creative Verbal Output and the Panel-Rated Creative Drawing Output (r=.43, p=.0001), indicating that these variables share common variance, hence a CD-IE effect was found.

S1.3: Special application of Spearman's Law of Diminishing Returns (SLODR): Self-efficacies in creative and intellectual domains and life history strategy

Sacha Devine Brown[*,1], Michael Anthony Woodley[2], Kari Celeste Ross[1], & Aurelio José Figueredo[1]

* SDBrown@email.arizona.edu; [1]Department of Psychology, University of Arizona, Tucson, Arizona; [2]Ross University, Dominica

Evolutionary theory proposes that the ability to estimate one's own mate value is an important aspect of securing reproductive opportunities (e.g., Buss & Schmitt, 1993). Creativity and intelligence are both traits that contribute to mate value (e.g., Miller, 2000). Previous research suggests that although not highly correlated, Intellectual Self-Efficacy (ISE) significantly predicts tested intelligence (Ross & Figueredo, 2009). Subsequent research has also indicated that Creative Self-Efficacy (CSE) significantly predicts creative performance (Brown & Figueredo, 2010), and that this correlation is substantially higher and might be attributable to the effects of runaway sexual selection. Despite these relations and previous predictions of theorists (e.g. Rushton, 2004), neither tested intellectual nor creative ability nor ISE and CSE significantly correlated with life history strategy (LHS) (e.g., Ross & Figueredo, 2009). LHS theory pertains to how an organism allocates bioenergetic & material resources. For instance, the theory proposes that in stable environments slow LHS should be favored (high investment in few offspring) and in unstable environments fast LHS should be favored (low investment in many offspring).

The cognitive differentiation-integration effort (CD-IE) hypothesis attempts to integrate intelligence research with life history theory (Woodley, 2011) by suggesting a potential explanation for both the lack of intrinsic correlation between g and K (the factor latent in diverse LHS measures) and the SLODR phenomenon. According to the hypothesis, fast LHS individuals living in unstable environments benefit from the ability to transfer skills across domains, leading to greater similarity in skill across cognitive domains (e.g. Cognitive Integration Effort). Cognitive specialism avoids competition extremes for slow LHS individuals in stable environments, which should lead to greater differences in skill across cognitive domains (e.g. Cognitive Differentiation Effort). The correlation between an underlying cognitive factor & individual cognitive domains should be positively related in fast LHS individuals and negatively in slow LHS individuals. We hypothesized that similar effects should be seen in reported cognitive ability self-efficacies and LHS, explaining previous non-significant findings. We applied the CD-IE hypothesis to reported self-efficacy in 12 creativity and 5 intellectual domains using CPEM.

The magnitude of the loadings from the SEI factor exhibited *positive* significant relations to slower LHS in all of the domains assessed, which was opposite of the predicted negative direction. For creativity, the magnitude of the loadings from the SEC factor only exhibited the predicted *negative* significant relation to slower LHS in the domain of Dance and was otherwise non-significant. Woodley proposes that the apparent anti-CD-IE effect among the SEI factor correlations could be due to slower life history strategists may be more intellectually engaged and actively seek out cognitive challenges. Subsequently, their high-g may permit cognitive deficiencies due to unevenly developed abilities to be compensated for via cognitive 'work-arounds' (e.g, Johnson, Jung, Colom & Haier, 2008). He also suggests that fast life history strategists, may mistake preferred mental fitness displays as evidence of specialism– a fast life history artist may self-report specialism in the art domain, even though s/he uses art to generate multidimensional indicators of *g* (social sensitivity, mating intelligence, a capacity to utilize color, metaphor, etc.).

S1.4: Explaining group differences in *g* using Spearman's hypothesis: Psychometric Meta-Analyses

Jan te Nijenhuis*, University of Amsterdam, the Netherlands

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Many studies have been conducted on differences in mean intelligence test scores between ethnic groups. Often cultural factors are used to explain these differences. However, Spearman's hypothesis states that the group differences on the subtests of IQ batteries can best be explained in terms of differences in the complexity of the tasks, that is, the demands they make on the general factor of mental ability, the *g* factor. In a review of many studies Jensen (1998) reports a correlation of .63 between subtests' *g* loadings and mean group differences on those subtests, hypothesizing that a psychometric meta-analysis will show that this value is a strong underestimate of the true effect.

Psychometric meta-analysis (Hunter & Schmidt, 2004) estimates what the results of studies would have been if all studies had been conducted without methodological limitations or flaws. The results of perfectly conducted studies would allow a clearer view of underlying construct-level relationships (Schmidt & Hunter, 1999). Psychometric meta-analysis is based on the principle that there are statistical artifacts in every dataset and that most of these artifacts can be corrected. In the present meta-analyses we corrected for five statistical artifacts that alter the value of outcome measures: (1) sampling error, (2) reliability of the vector of *g* loadings, (3) reliability of the vector of group differences in intelligence, (4) restriction of range of *g* loadings, and (5) deviation from perfect construct validity.

Several psychometric meta-analyses of Spearman's hypothesis were carried out using the software package developed by Schmidt and Le (2004) showing Jensen was correct: (1) meta-analysis of IQ batteries showed a strong relation between ethnic group differences and the subtests' *g* loading: a true correlation of .91, based on a very large total *N*. Group identity was tested as a moderator, but no evidence was found: all different ethnic groups showed similar or in some cases virtually identical results; (2) meta-analysis on item data from Raven's Progressive Matrices used many fewer studies and much smaller studies than the meta-analysis on IQ batteries. Still, we found a meta-analytical correlation of .83, which is highly similar to the value for IQ batteries, suggesting the meta-analytical methodology is basically sound; (3) meta-analysis of IQ batteries yielded a rho = .91. However, there are still outliers: when matched on total IQ with majority group members Blacks and immigrants perform better on Short-term Memory and less well on Spatial Visualization, attenuating the correlation. In a meta-analysis of only Dutch data leaving out the outliers increased the true correlation between *g* loadings and group differences substantially, bringing its value very close to 1.00; (4) Subtests with a substantial verbal component measure to an undesirable extent proficiency in the language of the test taken and underestimate the level of *g* of the tested nonnative speakers. Our analysis showed that language-biased subtests underestimate IQ for minority groups, but the effects are small: a mean underestimation was found of only 2-3 IQ points for all studies.

Spearman's hypothesis is now supported for most major test batteries and most major racial groups and can be considered to be an empirical fact. Mean differences in intelligence between groups can be almost perfectly explained by the complexity of the subtests in an IQ battery. There is simply no support for cultural bias as an explanation of group differences.

S2: A Cross-Cultural Perspective on Individual Differences in Cognition
(Thursday, 1.30-3.00)

Symposium Chair**:** Professor Sergey Malykh (malykhsb@mail.ru)

Psychological Institute of Russian Academy of Education, Moscow, Russia

Symposium Summary

Cross-cultural studies bring a unique perspective on the origins of individual differences through identifying genetic and environmental factors contributing to differences between different cultures. The papers in this symposium present findings from four studies investigating different aspects of human intelligence, comparing samples from the UK, Russia, China, and Kyrgyzia at different stages of development. These studies highlight the need for such international comparisons in order to formulate new hypotheses about specific environmental factors involved in individual variation and to inform educational methods and cultural practices. The first study, presented by Maja Rodic from the University of London, describes an international comparison among 5 diverse populations of young children in their performance on a large battery of numerical cognition, mathematical knowledge, and general cognitive abilities. The study reports on different patterns of interrelationships among these early cognitive skills across the countries and discusses these findings in terms of potential mechanisms underlying these differences. The second study, presented by Elena Sabirova from the Kyrgyz-Russian Slavic University, reports on the cross-cultural study of the non-verbal intelligence comparing Russian and Kyrgyz 8-9 year old children's performance on the Raven's Progressive Matrices test. The study reveals striking differences in performance for these two cultures. The authors discuss these findings in terms of socio-demographic differences between the two populations. The third study, presented by Yulia Kovas from Goldsmiths, University of London, also investigates cross-cultural differences using Raven's Progressive Matrices in children, but applies a genetically-sensitive methodology. The study compares Russian and UK 12 year-old twins' performance, as well as aetiology of the individual differences, capitalizing on the well matched samples. Finally, the fourth paper, presented by Tatiana Tikhomirova from the Russian Academy of Sciences, describes a cross-cultural comparison of performance on tests of spatial memory and mathematical ability between two well matched samples of 16 year-old students in Russia and UK, using the same assessment instruments and protocols. The four papers uncover interesting patterns of cross-cultural similarities and differences, discussed throughout the symposium in terms of potential explanations for these patterns, as well as implications of these findings for understanding of individual differences in intelligence.

S2.1: What really counts?: A Cross-Cultural Perspective on Cognitive Underpinnings of Individual Differences in Mathematics

M. Rodic[*,1], T. Tikhomirova[2], X. Zhou[3], W. Wei, [3], S. Malykh[4], V. Ismatulina[5], E. Sabirova[5], M. Tosto[1],& Y. Kovas[1]

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Previous research on mathematical ability and number sense has shown that 8, 13 and 15-year old Asian children (e.g. from China, Korea, Singapore and Japan) outperform the rest of the world in mathematics. The present study tested 600 children in the first stage of their early education (5-7-year-olds) on the same computerized tasks using the same procedure in the UK, China, Russia, and Kyrgyzstan (Kyrgyz and Dungan populations). The seven tasks evaluated reaction time, number knowledge, intentional and unintentional (autonomous) processing of symbolic and non-symbolic numerical magnitude, as well as early mathematical ability (addition). The aim of this study was: (1) to reveal any cross-cultural differences in early numerical ability (that is presumably not transmitted through education) as well as in early mathematics; and (2) to identify whether the pattern of the relationships among the numerical and arithmetic abilities in children differ across the countries. The results showed that, in line with previous research, Chinese children outperformed the rest of the children in mathematical ability even at this early age. In our study, the Chinese children were the most accurate in all tasks of numerical cognition, but usually the slowest (with the exception of the 'physical comparison' task). With the exception of the Chinese sample, the best predictor of early mathematics in children was the number naming task, which assessed the knowledge of numbers. In the Chinese children, mathematics was best predicted by two tasks that assessed numerical magnitude ('magnitude comparison' and 'dot counting' tasks). The inclusion of the Dungan population allowed us to compare two ethnically similar, but culturally diverse populations (Dungan vs. Chinese). The results showed that that Chinese children significantly outperformed Dungan children in accuracy on all number-related tasks, but not on a numerically irrelevant task. We discuss the results in terms of potential influences of linguistic, socio-cultural, demographic, and genetic factors.

S2.2: A Cross-cultural study of nonverbal intelligence in children from Russia and Kyrgyzstan

E. Sabirova*,[1], V. Ismatullina[1], Y. Davydova[1], O. Muhordova[2], S. Malykh[3]

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Raven's Progressive Matrices is one of the most widely used non-verbal tests of intelligence. It comprises five sets (A to E) of 12 items each, with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyze information. Traditionally, the test is assumed to be free from the influence of cultural factors, although there exists some contradictory evidence. The aim of this study is a cross-cultural comparison of intellectual abilities of children from Russia and Kyrgyzstan. Participants were 290 children and adolescents, aged 8-9 years. The Russian sample (Group 1) included 190 children (94 boys, 96 girls), the Kyrgyz sample (Group 2) consisted of 100 children (48 boys, 52 girls).

	Group 1			Group 2			All
	M	F	Total	M	F	Total	
N	94	96	190	48	52	100	290
Mean	31.78	31.95	31.87	25.27	23.09	24.14	29.20
SD	11.22	11.01	11.08	9.64	8.40	9.04	11.04

Overall, the number of correct answers in the first group was 53% and 48% of the possible answers for Group 1 and Group 2 respectively. Analysis of variance (ANOVA) revealed significant differences in the studied groups ($F = 36.01$, $p < 0.01$). This finding is consistent with only a few studies and needs further investigation. In addition, analysis of variance (ANOVA) was conducted to study the effect of sex on the total score of intelligence. No significant sex differences were found in this study.

S2.3: Cross-Cultural Investigation of the genetic and environmental influences on fluid intelligence in 12 year-old twins

Y. Kovas[*,1,2], I. Voronin[3], S. Malykh[3]

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Introduction: Previous research suggested moderatre genetic infuences on general cognitive ability (*g*) in middle childhood, with both shared and non-shared environments also playing a role. Cross-cultural comparisons of well described samples can offer further insights into the mechanisms underlying individual differences in intelligence.
Method: We collected data on a well-known intelligence test – Raven's Progressive Matrices – in two samples of 12 year-old twins in the UK and in Russia. The Russian sample included 120 pairs (60 MZ and 60 DZ) of twins recruited from Mocow and greater Moscow region. The UK sample included a sub-sample of the Twins' Early Development Study (TEDS) for which Ravens Progressive Matrices data from 4381 pairs of twins were available age 12. The TEDS participants were matched to the Russian twins in terms of age, gender, and urban status (selected from London and greater London area). First, we conducted behavioural analyses, comparing the samples in terms of average and variance differences, as well as in terms of gender effects. We then applied standard Twin Model Fitting analyses in order to assess the relative contribution of genetic and environmental factors to individual differences in intelligence in the two samples, and to directly compare these parameters across the samples.
Results: Our results suggest strong behavioural similarities in performance on the Ravens Progressive Matrices for the Russian and British children, both in terms of averages and in terms of variances. No gender differences were found in either sample. In terms genetic and environmental aetiology, our results indicated some potential population differences in the degree to which shared environment affects this trait.
Conclusion: We discuss our results with refernce to educational and cultural practices in the two countries, and to potential mechanisms of gene-environment interface.

S2.4: Cross-Cultural Study of Individual Differences in Spatial Memory and Mathematical Achievement

T.N. Tikhomirova*[1,2], M.G. Tosto[2], M. Rodic[2], & Y. Kovas[2]

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Research into individual differences in mathematical abilities is hugely important for today's society. According to the latest estimations, even small improvements in mathematical achievement at the level of an individual can lead to large GDP increases. One way to gain more understanding about the origins of individual variation is through cross-cultural research. Clear cross-cultural differences exist in school mathematical achievement. The latest report by the OECD's Programme for International Student Assessment (www.pisa.oecd.org), which plots the comparative academic progress of 400,000 15-year-olds in 57 countries ranks Great Britain's (average score = 492, rank 23-31) and Russia's (average score = 468, rank 38-39) performance in mathematics well below average. The top results are consistently obtained from several Asian countries and Finland (e.g., China's score = 600, rank 1).

Multiple factors are likely to underlie these cross-cultural differences and at least some of them will also contribute to individual variation in mathematics within each culture. One factor that has been proposed to contribute to individual differences in mathematical achievement is variation in spatial memory. Here we report a cross-cultural study that aimed to investigate whether any differences exist between the groups of 16 year-old Russian and British school children in: (1) different aspects of mathematical ability; and (2) relationships between spatial memory and mathematics. We focus on these two countries for two reasons: (1) although similar according to the PISA, the countries show some meaningful differences in this rating; and (2) both countries have a centralized National Curriculum. A Russian- and English-language version of the same battery of tests was validated and implemented for on-line web administration in Russia and the UK. The battery included 2 measures of mathematics (math fluency and a general measure of mathematical achievement). The battery also included a test of spatial memory, among other measures. 250 Russian 16 year-olds completed the on-line battery in Russia (51% females). The students were recruited from a public secondary school in a greater Moscow region. 250 British participants were sampled from the large Twins Early Development Study, which includes several thousand children. The UK participants were matched to the Russian participants for sex, age, school type, school location (greater London region), and spatial memory.

First, the data were analyzed in terms of norms and distributions for each measure. These analyses revealed both, cross-cultural similarities and differences. Second, we investigated whether any differences exist in relationships among the spatial ability measures and mathematics measures. Here again, we observed both cross-cultural similarities and differences in the structure of the relationships among the measures. We discuss these fascinating results in terms of new hypotheses emerging from this study about potential involvement of curricula, and other socio-cultural factors in the development of spatial ability, mathematical achievement, and on the relationship between them.

T2: Talks, generally about population differences
(Thursday, 3.20-4.00)
T2.1: Sex differences in drawing a horizontal line increase with age: A meta-analysis

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Piaget's Water-Level Test has been developed in the late 1940s as a simple means to assess development of the concept of invariance of horizontality in children. Surprisingly, this simple test was subsequently observed to pose serious difficulties and yield incorrect answers even in adults. In this context, it is interesting to note that results in the Water Level Test have been shown to bear a moderate relationship with several intelligence domains, particularly spatial ability (e.g., associations from $r = .39 - .49$ between performance in the Water Level Test and Mental Rotations Tasks; Voyer & Sullivan, 2003). Moreover, sex differences ranging from $d = -0.01$ to 1.84, indicating almost invariably more accurate performance of men than women, have been reported over the past decades. Voyer, Voyer, and Bryden (1995) observed in a meta-analysis a significant reduction of these performance differences between sexes over time. Indeed, as a considerable number of studies have been published since this first meta-analysis which would allow a more in-depth analysis and consideration of potentially moderating variables, an update and extension of results of this investigation is warranted.

Based on preliminary results (Pavlovic, Voracek, & Formann, 2008), in the present study, we present evidence of the so far most comprehensive meta-analysis on this topic (>25,000 subjects, >150 independent samples) from 1948 to 2011. A highly significant overall sex difference of $d = 0.55$ was observed (equalling 35% of non-overlap of the sex distributions when assuming normality), thus indicating better performance of about half a standard deviation of healthy men than women on the Water-Level Test. There was no evidence for decreasing effects over time as observed by Voyer et al. (1995). Of note, multiple weighted meta-regression showed significantly more pronounced sex differences in older participants observable beginning in adolescence, thus pointing towards emerging effects of sex-specific hormones as possible explanations for these increasing effects. Additionally, sex differences were more pronounced when tasks were presented as multiple choice questions, whereas they appeared to be robust in respect to several other potentially moderating variables (group vs. individual testing, number of items, power only vs. speed & power test, published vs. unpublished study, publication year, reference line vs. no reference line in task, sex of first author of study, shape of vessel in task).

In all, we show conclusive evidence that men perform on average half a standard deviation better than women on the Water-Level Test. This effect appears to be pervasive, differentiated in regard to age and answer mode, but robust over time.

T2.2: Differentiation with respect to the *g* factor in the Hungarian standardization samples of the WISC-IV and WAIS-IV

Jelte M. Wicherts[*,1], Dylan Molenaar[1], Kristof Kovacs[2,3], Sandor Rozsa[4], & Natasa Ko[4]

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According to Spearman's Law of Diminishing Returns (SLODR), the strength of the *g* factor decreases across the *g* continuum. In a seminal study, Spearman (1927) found the inter-correlations between cognitive subtests to be smaller among normal children than among learning disabled children. Several later studies of SLODR have employed a host of statistical methods and grouping variables to study whether (standardized) *g* loadings are higher in the lower ranges of *g*, but the results of these studies are mixed. Here we apply two newly developed factor-analytic methods to study SLODR or differentiation with respect to the *g* factor in two representative standardization samples of adults and children from Hungary. In the first study, we employ moderated factor analysis (Molenaar, Dolan, Wicherts, & van der Maas, 2010) to study differentiation in the WISC-IV by using the Raven's Progressive Matrices as a proxy for *g*. In the second study we apply an internal factor analytic method (Molenaar, Dolan, & Verhelst, 2010) to study non-normality of the *g* factor and heteroscedastic residuals in the WAIS-IV. We also consider the issue of differentiation with respect to age. Results show clear signs of differentiation with respect to the *g* factor in both the adult and children samples, suggesting that the g factor has a negatively skewed distribution. We found little support for age differentiation but did find some heteroscedasticity of residuals.

POSTERS
(Thursday, 6.30-8.30)

(Poster presentations appear in the programme in alphabetical order)

P2: Weighting as Possible Alternative to Trimming in Response Time Data Analysis

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Studies on individual performance in elementary cognitive tasks and its relation to cognitive ability most commonly involve analysis of 'average' response time as a measure of individual processing speed. However, the problem of location of individual response time distribution itself invites special attention.

Indeed, a speed task normally includes a number of trials; therefore, several response times are registered for each participant. Distributions of these individual response times are most commonly positively skewed and are likely to include outliers. Thus, a measure of location of these individual distributions that is used to represent the level of individual performance in a speed task must be robust to skewness and presence of outliers. The simple mean evidently does not meet these criteria. To overcome this problem, several robust measures of central tendency that were based on data trimming, such as the trimmed mean, M-estimators and Winsorized mean, were developed in the last several decades.

Herein, we discuss another possible approach to analysis of location of response time distributions, which is based on data weighting. Two measures of central tendency based on data weighting are described in detail. Algorithms for calculating these measures in R are provided.

Conventional measures of central tendency (arithmetic mean, median, geometric mean and harmonic mean), the abovementioned measures that are based on data trimming and two measures that are based on data weighting are compared in a simulation study. Data were generated from an ex-Gaussian distribution with parameters that were plausible for empirically observed response times in simple tasks. Sample size in each generation was small (30 data points) to mimic the commonly used number of trials in a speeded task. Conditions with different numbers of outliers and without outliers were simulated. First, robustness of the measures of central tendency across these conditions is analyzed. Second, stability of each measure across 50000 generations of samples from the same underlying distribution in each condition is discussed as another important characteristic of a measure of central tendency in response time analysis.

In addition, changes in behaviour of each measure which depend on skewness of the underlying response time distribution are analyzed. The results for different sample sizes are also presented, and the issues that arise when a number of trials is especially small (e.g. 5 or 10 trials) are discussed. The discussion also covers advantages and disadvantages of each weighting and trimming as two alternative approaches to dealing with response time outliers.

P3: Does education mediates the effect of intelligence on religiosity?

Yoav Ganzach*

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A number of authors suggested that education mediates, or at least partially mediates, the relationship between intelligence and religiosity. Although there is no direct evidence in the literature for such a mediation effect, there is some indirect evidence. This evidence are, however, conflicting as some indicate that education mediates the relationship between intelligence and religiosity and some that it does not. The current study shows that education does not mediate this relationship, and suggest that conflicting conclusions about this mediation may be drawn if appropriate controls are not taken into account.

P4: General Mental Ability and Pay: Nonlinear Effects

Yoav Ganzach*[1], Asya Pazy[1] and Doron Greenberg[2]

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We suggest that intelligence has both a marginally decreasing (concave) and a marginally increasing (convex) effect on pay. The concave effect is associated with Spearman's law of diminishing returns and the concave effect is due to the fact that intelligent people are employed in more complex jobs, and the greater the complexity of the job, the higher the return on intelligence. We demonstrate these effects in two nationally representative American samples.

P5: The Chinese Advantage in Cognition: From Logographs to gf

Smaragda Kazi*,[1], Andreas Demetriou[2], George Spanoudis[3],
Xiang Kui Zhang[4], & Yuan Wang[4]

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This study investigated intellectual development in Greek and Chinese children, 4-7-yrs old, who were examined on speeded performance, working memory, reasoning, and self-awareness tasks, all expressed through quantitative, spatial, and categorical relations. Speeded performance tasks included character recognition of Latin, Arabic, and Chinese letters. Structural equation modeling showed that performance is organized in a four-fold universe involving domain-specific problem solving, representational capacity, inference, and consciousness in both cultures. Relations between constructs were closer among Chinese and this was associated with their logographic experience. Chinese outperformed Greeks in (1) reading-related but not culture-free processing efficiency tasks, (2) spatial but not verbal WM, (3) cognitive, and (4) the self-awareness tasks. Therefore, although the same at the start in fundamental processing capacity, Chinese are privileged by their logographic experience; this enhances general cognitive fluidity through enhanced visuospatial processing and representation early in age, gradually accumulating over the years in higher IQ scores.

P6: Cognitive strategies in visual search task used at different kinds and levels of intelligence

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There is some evidence that individuals at diverse IQ levels use different cognitive strategies for elementary cognitive tasks, mainly inspection time tasks. In the experiment participants (N=269, 60% female, mean age 14.9) performed a visual search task and their intelligence level was measured. In the visual search task sets of pictures of objects were presented to the participants on a computer screen. Each set contained from 1 to 6 pictures which were randomly arranged along an imaginary circle. The task was to identify as fast as possible if there was a certain picture (a tree) among others on a screen. Reaction time and accuracy of responses were registered. Data on correct responses of participants whose mean overall accuracy was higher than 70% were analyzed. To measure intelligence Raven's Advanced Progressive Matrices, Russian version of verbal subscale of Amthauer's IST and Mednick's Remote Associations Test were used. G-factor value and special factor loadings for each intelligence measure were computed. They were divided into three equal groups on the basis of 33 and 67 percentiles according to their level of special factor loading for each measure of intelligence.

The three-way repeated measures ANOVA was preformed with ln(RT) as DV. In all iterations of analysis number of objects (N^o, factor levels from 2 to 6) and type of response ("yes" vs. "no") were taken as within-subjects factors. Levels of special factor loading for different intelligence measures (APM^{spec}, verbal IST^{spec}, RAT^{spec}) were taken as between-subjects factors. The main factor effects of number of objects (RT was increasing for larger N^o) and response type (negative responses took longer than positive ones) were significant. N^o/response type interaction was also significant: RT of negative responses was increasing faster compared to RT of positive ones. As for specific intelligence measure factors, the only significant effect was revealed for the threefold APM^{spec}/ N^o/response type interaction. In low APM^{spec} group RT of negative responses was increasing faster for larger N^o, compared to RT of positive responses, meanwhile in high APM^{spec} group curves of RT increase for positive and negative responses were almost parallel, due to slower RT increase for negative responses. It is suggested that steeper slope of RT for negative responses is related to self-terminating sequential target search, while slow parallel increase of RT for both positive and negative responses – to exhaustive sequential search, which is more effective. Thus specific component related to performance on APM appeared to be positively associated with exhaustive search - an effective strategy of processing of multiple objects in the visual search task.

For verbal IST specific factor loading, the threefold interaction with response type and number of objects didn't reach acceptable significance level (p=0.15). But the pattern of results was opposite to that for APM^{spec}. Participants with low verbal intelligence have less divergence between RT curves for positive and negative responses than participants with high verbal intelligence because of the steeper slope for negative responses of the latter. Thus specific component related to performance on verbal IST tended to be negatively associated with exhaustive search in the visual search task. These findings may be interpreted in favor of existence of specific cognitive mechanisms underlying performance on different intelligence measures. Possible implications for further research are proposed.

P7: Can Fluid Intelligence Be Reduced To 'Simple' Short-Term Storage?

Kenia Martínez*[,1], Miguel Burgaleta[1], Francisco J. Román[1], Sergio Escorial[2], Pei Chun Shih[1], Mª Ángeles Quiroga[2], Roberto Colom[1]

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Much is written regarding the associations between human intelligence and cognition. However, it is unusual to find comprehensive studies. Here twenty four measures tapping eight cognitive abilities and skills are considered for assessing a sample of one hundred and eighty five young adults. The simultaneous relationships among fluid, crystallized, and spatial intelligence, along with short-term memory, working memory capacity, executive updating, attention, and processing speed are analyzed using a latent-variable approach. The key findings show that (a) short-term storage, working memory, and updating are hardly distinguishable, and (b) fluid intelligence is near-perfectly correlated with these three cognitive functions. It is concluded that this nuclear intelligence component can be largely identified with basic and general short-term storage processes, namely, encoding, maintenance, and retrieval.
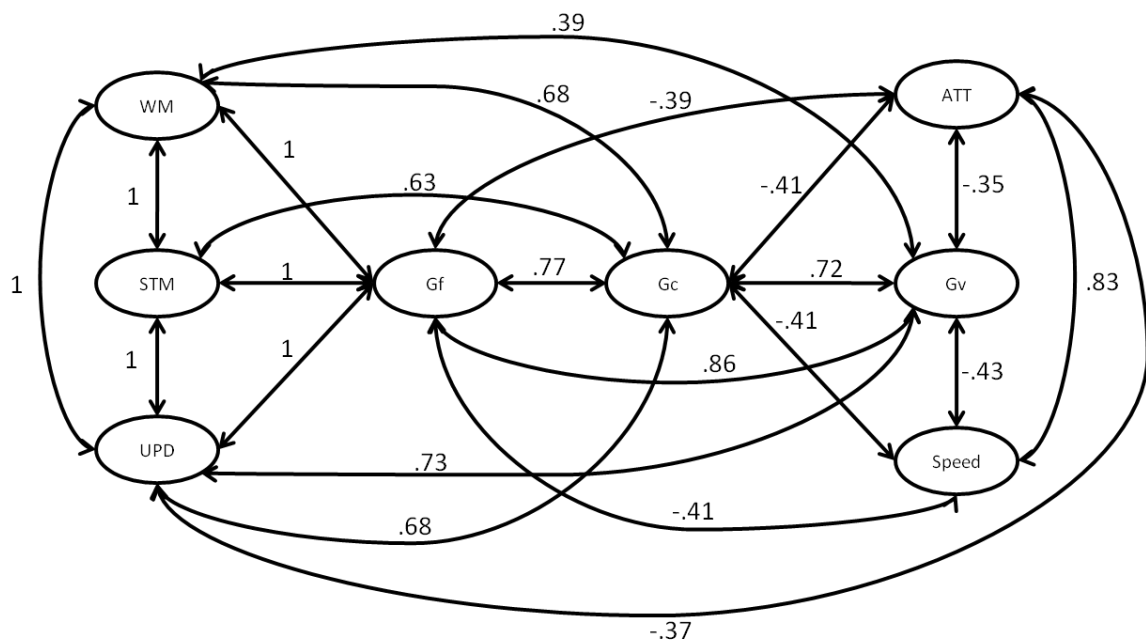
P8: IQ, school achievement, and economic growth

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A limited number of studies has predicted economic growth with either IQ (mainly from Lynn & Vanhanen, 2006) or school achievement (from international assessments of science, mathematics and other curricular subjects). In most of these studies, independent positive relationships between the cognitive indicator and economic growth were noted (Jones & Schneider, 2006; Weede & Kämpf, 2002), although negative results have been reported as well (Chen & Luoh, 2010).

The present study explores some further questions about the robustness and mechanisms of these effects. Important findings are:

1. In the 79 countries having both measures, both IQ and school achievement are independently related to economic growth between 1975 and 2009 when initial GDP, average educational level in the country, corruption, freedom/democracy, and history of communist rule are controlled, with t values for the cognitive measures in excess of 6.

2. In these 79 countries, IQ is a slightly better predictor of economic growth than is school achievement. In a larger sample of 144 countries, a measure of intelligence that is computed from IQ and school achievement is an equally strong predictor of growth.

3. When a median split is applied, high intelligence favors economic growth in both rich and poor countries.

4. 35% to 40% of the IQ effect in the poor countries is mediated by the total fertility rate (TFR). In these countries, high TFR is a powerful predictor of low economic growth. Technological competitiveness is another mediator of the intelligence effect.

5. In rich countries, neither TFR nor technological competitiveness mediate the growth-promoting effect of intelligence. These two variables do not have significant independent effects on economic growth in these countries.

6. Negative effects on economic growth are noted for corruption, freedom/democracy, and high consumption share in GDP. However, these variables do not mediate the effects of intelligence.

The results support the theory that rising IQ during the 20th century has been an important cause for the economic progress that has created our present prosperity.

P9: Relationships Between Emotional Intelligence And Individual Differences in Goals Achieving Self Regulation

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The study is aimed at discovery of intercorrelation between Emotional Intelligence (EI) and individual differences of Voluntary Activity Self-regulation (SR). EI is an ability to perceive, understand, control and regulate emotions of oneself and others (Gardner, 1993). SR is defined as a process of conscious organization of psychic activity that assures goals setting and corresponding to these goals achievement (Konopkin & Morossanova, 1989). Goal-oriented personal regulation is considered to be the main mechanism enabling constructive relationship between the subject and objective social reality (Morosanova, 2003). The phenomenon of individual Self-regulation manifests itself in the way people plan activity goals, model achievement conditions, applying different methods and algorithms to complete and to correct their activity, have different success criteria to evaluate the results.

Sample: 211 persons (aged 15–18, 108 girls, 103 boys). Methods: Self-regulation Profile Questionnaire (SPQM) (Morossanova V.I., 2003) – measures six regulatory profile components of individual regulatory processes: goal planning, conditions modeling, actions programming, results evaluation, regulation flexibility, independence and general level of self-regulation; Lyusin's Emotional Intelligence Questionnaire (EmIn-Q) – measures inter- and intrapersonal emotional intelligence (Lyusin, 2003).

The Pearson's correlation analysis reveals certain domains of EI has positive significant correlation with voluntary activity SR. Interpersonal EI correlates with Flexibility (ability to correct the accepted activity program) ($r=0,383$, $p<0,00$), Intrapersonal EI (understanding own's emotions) correlates with Significant Condition Modeling ($r=0,483$, $p<0,00$) and Results Evaluation ($r=0,346$, $p<0,00$) in the process of a goal achieving. The finding of the study indicates that different kinds of EI correlate with different components of SR. This research adds a new understanding of EI contribution in voluntary activity SR.

P10: A pilot study in 18-30 year old university students

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Omega-3 and omega-6 are unsaturated fatty acids sourced from the diet. Long chain forms of omega-3, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are derived mainly from cold water fatty fish and other seafood. The long chain form of omega-6, arachidonic acid (AA) is sourced mainly from meat, eggs and dairy and can be synthesized from linoleic acid. AA, EPA and DHA are essential for human cellular, neural and cardiovascular processes; however AA in excess relative to EPA and DHA has been shown to be pro-inflammatory and can lead to cardiovascular and neurological disease. A typical western diet contains a ratio of between 10:1-25:1 omega-6 to omega-3; this in comparison with a Palaeolithic diet that would have been in the range 1:1-2:1 (Simopoulos, 2002). The health benefits of long chain omega-3 EFAs were first highlighted in the 1970s by researchers studying the Greenland Inuit tribe. A diet high in fatty fish and seal meat was shown to be protective of cardiovascular and neurological disease despite a high consumption of tobacco in this cohort. There have been many other epidemiological studies as well as controlled prospective studies demonstrating the health benefits of a more balanced diet that includes long chain omega-3 EFAs. Very few studies have focussed on young healthy cohorts to investigate the importance of omega-6 and omega-3 on cognitive performance.

The aim of the current study was to investigate the association between EFA blood status and cognitive function in a group of university students. It was predicted that poor diet as reflected in a high omega-6 to omega-3 ratio would be associated with poorer spatial working memory (SWM) and cognitive function. SWM, a measure of fluid intelligence has been shown to index age-related cognitive decline and has been shown to improve following nutraceutical intervention.

A group of 34, 18-30 year old students participated in the study conducted at Swinburne University, Melbourne Australia. Blood plasma phospholipids were measured following overnight fasting. Cognitive performance was measured using the SUCCAB cognitive battery (Pipingas et al., 2010).

A number of cognitive measures correlated significantly with EFA blood status. Consistent with our hypothesis SWM was associated with a number of EFA domains including the omega-6 to omega-3 ratio, omega-3, EPA, omega-6, and AA/EPA. In all cases higher levels of omega-3 and lower levels of omega-6 were associated with better performance; omega-6 and the AA/EPA pro-inflammatory/anti-inflammatory index showed the largest correlations with SWM reaction time, $r=0.515$ (p<0.01) and $r=0.406$ (p<0.5) respectively.

Taken together these results suggest an association between diet as assessed by EFA levels and cognition. A larger study is warranted to confirm these relationships and these measures should be applied in an intervention trial to investigate the hypothesis that supplementation with long chain omega-3 in a group with a high omega-6 to omega-3 ratio will improve cognitive performance.

P11: Could Microcephalin have been a 'gateway mutation' for accelerated adaptive evolution involving intelligence?

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Despite the fact that Microcephalin and *ASPM* expression does not appear to be associated with individual differences in IQ, Rindermann (2007) reported a substantial ecological scale correlation between *Microcephalin* frequencies and national IQ for 24 countries (r(adjusted)=.79, $p<.05$). This correlation was furthermore highly robust to the effects of partialing out both educational level and Gross National Product (rp=.66, $p<.05$). In this study, the robustness of this ecological scale association is examined with respect to a sample comprised of the 59 populations used in both Evans et al's (2005) paper on *Microcephalin* and Mekel-Bobrov et al's (2005) paper on *ASPM,* for which population-specific IQ means were computed.

A correlation between *Microcephalin* and population IQ of r=.795 ($p<.01$) was found. No correlation was found with *ASPM*. Multiple regression in which national level HDI, DALY Infectious diseases, DALY Nutritional deficiencies and Würm glaciation temperature means were also used revealed that *Microcephalin* (but not *ASPM*) was a significant predictor of IQ (β=.271, $p<.05$). Stepwise regression in which the strongest predictor was removed in order to create three iterative models revealed substantive (but not significantly confounding) collinearity between DALY Infectious diseases and *Microcephalin*. Partial correlation analysis confirmed the presence of a significant impact from the latter on the *Microcephalin* x IQ correlation (rp=324, $p<.05$). Multiple regression revealed that both *Microcephalin* and *ASPM* were significant predictors of DALY infectious diseases (β=-.498, $p<.01$ and β=-.174, $p<.01$ respectively).

It is hypothesized that, as these genes express in the cortical tissues of the brain (Rimol et al., 2010), they might encode for hygiene enhancing behaviors, such as sensitivity to disgust, which, in a subsidiary study, was found to correlate with *Microcephalin* (r=.597, $p<.05$, N=12). Increased hygiene-enhancing behaviors may have advantaged both hunter-gatherer and agrarian societies coping with the heightened disease burden resulting from increased rates of population growth, making sustained growth viable. It is argued based on the 10,000 year explosion theory (Cochran & Harpending, 2009) that bigger populations would have contained more IQ enhancing mutations, which would have been subject to strong directional selection resulting from the increasing availability of cognitive niches associated with innovation and subsistence paradigm transitions. Hence, whilst not a 'gene for *g*' *Microcephalin* may nonetheless have functioned as a 'gateway mutation' favoring subsequent increases in IQ. This might account for the apparent robustness of the ecological scale correlation between *Microcephalin* and IQ.

Friday, December 9

T3: Talks, generally about cognition
(Friday, 8.30-10.10)

T3.1: The relationship between inspection time task and intelligence in young children

George Spanoudis*, Anna Tourva, and Christoforos Christoforou

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The aim of the present study was to examine the extent to which performance in inspection time tasks may reflect individual differences in attentional control and whether this relationship remains constant across age. Inspection time task (IT) is used as an index of individual differences in perceptual discrimination speed and it has been shown to be a reliable predictor of psychometric intelligence (Grudnick & Kranzler, 2001). However, the factors underlying the relationship between IT and intelligence are not clear, probably because no study to date has attempted to disentangle the effects of variables that are strongly related to both inspection time tasks and intelligence. A group of 148 children ranged in age from 7 through 18 years were tested in a visual inspection time task, a Go/No-Go reaction time task, a letter-matching task, and the Wechsler Abbreviated Scale of Intelligence (WASI).

Preliminary analyses showed that attentional control may account for the variance shared between IT and intelligence. Furthermore, after controlling for the potential effects of age on the relation between IT and attentional control measures, no significant relationship was observed between these two variables among children with high IQs.

T3.2: The interplay of intelligence and temperament in the course and effectiveness of cognitive processes

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So far, most of the studies aimed at exploring the borderline area between temperament and cognition focused either on relationships between intelligence and temperament or, more rarely, on the influence of temperamental traits on individual effectiveness in various cognitive tasks. However, little is still known about the interplay of intelligence and temperament in the performance in cognitive tasks. In the proposed paper, using the framework of Strelau's Regulative Theory of Temperament (RTT) we examine how temperamental traits complement, moderate and interact with intelligence in a number of different cognitive tasks. In two conducted studies (study 1: n=70; study 2: n=100), the participants completed Raven's Advanced Progressive Matrices (RAPM) and filled Formal Characteristics of Behavior –Temperament Inventory, before performing series of cognitive tasks engaging various cognitive process: working memory (operation span, MEMATT task), short-term memory (Sternberg task), and attention (Divided Attention task, Visual Selective Attention task). The results obtained indicate that:
a) temperament acts as a moderator of the relationship between intelligence and performance in cognitive tasks.
b) certain temperamental traits predict performance over and above intelligence
c) certain temperamental traits appear to influence the way in which data is processed, but not the final results of this processing
d) Sensory Sensitivity and Briskness proved to be the most important temperamental factors for the course and effectiveness of cognitive processes.

T3.3: Predictive Validity of SAT Non-*g* Variance: Results for Sex and Race

Thomas Coyle* and Jason Purcell

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This research is based on two findings related to general intelligence (*g*, variance common to cognitive tests) and the predictive validity of cognitive tests. The first is that a test's *g* loading is directly related to its predictive validity. The second is that removing *g* from a test typically neutralizes its predictive validity (Jensen, 1998). An exception concerns the SAT (Scholastic Aptitude Test). Although the SAT is highly *g*-loaded, its non-*g* variance predicts GPA almost as well as *g* (Coyle & Pillow, 2008). Moreover, non-*g* variance from its subtests shows a domain-specific pattern of predictive validity: Non-*g* variance from SAT math is positively related to math GPA but negatively to verbal GPA, whereas the opposite pattern is found for SAT verbal (Coyle, 2010). Prior research has examined the predictive validity of SAT non-*g* variance for undifferentiated samples. The present study examines this issue for four subgroups: males (M) and females (F), who have similar levels of *g*, and blacks (B) and whites (W), who have different levels of *g* (Jensen, 1998). SAT non-*g* variance was expected to predict GPA for all subgroups. Moreover, assuming that SAT non-*g* variance is a stronger predictor for high-ability groups (cf. Coyle et al., 2011), such variance might predict GPA better for whites than blacks.

Subjects were drawn from the National Longitudinal Survey of Youth (NLSY, N =8,989) and College Board SAT Validity Study (N = 192,467). The NLSY included first-year college GPAs, SAT (verbal + math) scores, and Armed Services Vocational Aptitude Battery (ASVAB) scores, which estimated *g*. The Validity Study included SAT subtest scores and subject-specific college GPAs. The predictive validity of SAT non-*g* variance for first-year college GPA was examined using the NLSY. The SAT predicted GPA for all subgroups (.38, .40, .45, .45, for B, W, M, F, respectively). The percentage of the SAT-GPA relationship attributable to SAT non-*g* (as opposed to *g*) variance was substantial for all subgroups (% = 49, 55, 41, 38, for B, W, M, F, respectively). The predictive validity of non-*g* variance from SAT subtests (math, reading, writing) was examined using the Validity Study. Non-*g* variance from each subtest was obtained after removing a *g* based on all subtests. This variance was used to predict a STEM GPA, based on math-loaded subjects, and a Humanities GPA, based on verbal-loaded subjects (e.g., English and history). For all subgroups, non-*g* variance from SAT math was positively related to STEM (.16, .12, .13, .14, for B, W, M, F, respectively), but negatively to Humanities (-.30, -.16, -.19, -.20, for B, W, M, F, respectively). Non-*g* variance from SAT reading was positively related to Humanities (.13, .06, .08, .09, for B, W, M, F), but negatively to STEM (-.13, -.10, -.09, -.08, for B, W, M, F). For all subgroups, the predictive validity of SAT non-*g* variance (for GPA) was substantial, sometimes equaling that of *g* (on a percentage basis). For all subgroups, subtest non-*g* variance was positively related to complementary GPAs (SAT math-STEM) and negatively related to non-complementary GPAs (SAT math-Humanities). A trend involving race was observed for one subtest, but not in the predicted direction: Non-*g* variance from SAT math predicted Humanities GPA slightly better (based on the magnitude of effects) for blacks than whites. The overall pattern of subtest results supports an "opportunity cost" theory: Developing non-*g* skills in one area (math) results in less time to develop such skills in competing areas (verbal), yielding negative relations between tests and non-complementary outcomes. Future research will examine whether the predictive validity of SAT non-*g* variance (a) varies with course choices for different subgroups, and (b) is related to non-cognitive factors (e.g., personality traits).

T3.4: Intelligence judgement and appraiser's intelligence

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The present research investigates intelligence (or 'cleverness' as would lay people say) judgement, based on what is known as implicit theories (or conceptions, or beliefs, or criteria). The highlight is if it has something to do with psychometric intelligence of both an appraiser and a target person. An accuracy of evaluation, implicit criteria of intelligence and their relation to appraisers' intelligence were taken into account. Two hypotheses were put forward:
- the higher an appraiser's intelligence is, the more accuracy his judgement of intelligence has;
- implicit criteria of intelligence differ for the people with different psychometric intelligence.

The feature of this study is that intelligence judgements were made on the ground of texts authored by target persons.

Participants (two samples of Moscow college students, N1=64, N2=27, aged 18-24) acted as judges, whose task was to evaluate the intelligence by reading texts, attributed to 9 targets (Moscow high-schoolers of high, medium and low IQ according to Raven's Matrixes and verbal section of Amthauer Structure of Intelligence test). The texts presented the equivalent sets of sentence completion performed by targets and designed to force inferences and its rationalization (for example: 'I consider,Because…'). The subject matters of these sentences were up to targets, the only requirement was to rationalize each of the completed sentences.

After reading these sentences the participants were to rate each target on a 'cleverness scale', similar to those used in a Dembo-Rubinstein self-evaluation test. They were also to answer a few questions about the reasons of their rating ('why have you placed the author on this very part of a scale?', 'what was it about this text that has drawn your attention while considering the target's cleverness?'). Scaling results were compared to actual scores on intelligence tests for getting an accuracy index. Written answers were subjected to analysis, aimed at revelation of some general criteria types and then to content analysis for getting quantitative differences between participants. Participants also took an intelligence test - TURV, created in Psychological Institute of RAE (M. Akimova et al., 2007).

We have found no evidence in support of the first hypothesis: participants didn't differ in judgement accuracy regarding their test scores.

Content analysis revealed four types of criteria: emotional attitude (things like agreement/disagreement, like/dislike afforded ground for intelligence judgement); personality features (which means emphasizing things about the author, not just the text – like traits, motivation, goals and so on); content criteria (accents on what is written, what an author meant to say, what kind of themes had he chosen); and finally formal text criteria (stressing structural features of the texts like grammar, vocabulary, logical reasoning and paralogisms). The extent of usage for this criteria types significantly correlated with participants (N=91) test scores: r=-0,29, p<0,05 for emotional attitude, r=-0,24, p<0,05 for personality features; r=0,2, p<0,05 for content criteria and r=0,29, p<0,05 for formal text criteria.

Thus, there are no links between intelligence and accuracy of judgement about intelligence of others, but people differ on preferable implicit criteria in respect of their own psychometric intelligence.

T3.5: Typical Intellectual Engagement and Cognition in the Ninth Decade of Life: the Lothian Birth Cohort 1921

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Abstract: Investment traits—the tendency to seek out and engage in cognitive activity—might affect intellectual growth across the lifespan, and specifically the development from fluid to crystallized intelligence. Here, we explore how childhood IQ at age 11 years, IQ at age 79 and the investment trait Typical Intellectual Engagement (TIE) at age 81 affect the mean level and change in verbal fluency scores, used as an indicator of crystallized intelligence, across the ages 79, 83, and 87 in the Lothian Birth Cohort 1921 (maximum N = 569).

A first latent growth model showed significant variance in the mean level of verbal fluency, and significant decline in verbal fluency from age 79 to age 87. The rate of change was invariant across study participants in the LBC 1921. A second model found that IQ at age 11 significantly predicted IQ at age 79 (β = .66; p < .001), which in turn predicted verbal fluency and TIE in the ninth decade of life with standardized path parameters of .46 and .15 (p < .001), respectively. TIE had a significant association with verbal fluency (β = .14, p = .002). Taken together, IQ at age 11, IQ age 79, and TIE accounted for 25.5% of the variance in verbal fluency. A final model identified the TIE sub-factor of intellectual curiosity as significant mediator of the effect of IQ at age 79 on verbal fluency; the TIE sub-factors abstract thinking; reading; and problem solving showed no significant associations with mean verbal fluency.

In summary, TIE—in particular, intellectual curiosity—significantly mediated the effects of childhood IQ and IQ at age 79 on crystallized intelligence across old age. The effect of TIE on verbal fluency from age 79 to 87 remained stable after adjusting for early and late life differences in general cognitive ability. Therefore, this study provides important evidence for the positive effect of investment traits for mean levels of crystallized intelligence. Because there was no significant between-subject variance in verbal fluency trajectories in the current study, neither TIE nor childhood IQ was associated with individual differences in cognitive decline.

S3: New insights from twin research into individual variation in intelligence, motivation, and achievement

(Friday, 10.30-12.00)

Symposium Chair: Yulia Kovas (y.kovas@gold.ac.uk)

Psychology Department, Goldsmiths College, London, UK

Symposium Summary

The current symposium brings together four studies that use twin methodology in different ways to address important questions concerning educationally relevant cognitive and motivational traits. The first study (**Tosto et al.**) uses multivariate twin methodology to examine the sources of the relationship between 'number sense' and mathematical ability. This is the first investigation of the genetic and environmental aetiology of this relationship, providing important new insights into mathematical development. The second study (**Tick et al.**) uses a unique aspect of the Twins Early Development study – the availability of data from two types of twinships: those attending the same class and those studying in different classes. The study examines the teacher and classroom effect through asking a question of whether studying together increases the twins' similarity in academic motivation (liking the subject and self-perceived ability). In addition, the study tests whether the teacher and classroom effect extends to motivation at later ages, or whether it can only observed contemporaneously. The third study (**Barsky et al.**) uses the classic twin design to examine genetic and environmental origins of verbal and non-verbal intelligence in Russian adolescent twins, suggesting different aetiology for the two factors. Finally, the fourth study (**Papageorgiou et al.**) uses data on different cognitive abilities from a large sample of twins at different ages to compare performance of different groups of children as a function of their gender and their sibling's gender. This analyses addresses the prenatal testosterone transmission hypothesis, according to which females with a male co-twin should show better performance in spatial and mathematical abilities. The study also tests the competing socialization hypotheses by adding data from non-twin siblings. Together these four studies demonstrate the potential of twin research to provide important insights into the origins and mechanisms through which individual differences in human intelligence and achievement emerge.

S3.1: Predictors of Individual Differences in Mathematics Achievement Beyond IQ: A Behavioral Genetic Investigation into the "Number Sense" and Mathematical Skills

Maria Grazia Tosto[*,1] , Yulia Kovas[1,2], & Robert Plomin[2]

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Introduction: Number Sense can be defined as a primitive mechanism that allows animals and humans to deal with basic numerical information. Babies show this numerical intuition in the ability to recognise and discriminate quantities/numerosities. Studies have shown that Number Sense abilities correlate with mathematical performance and achievement. However the nature of this relationship remains unclear. We present the first genetically sensitive investigation into this relationship as part of the longitudinal population-based Twins Early Development Study (TEDS).

Method: We created and validated an on-line battery of tests suited for 16 year-olds. The measures assessed the specific ability to approximate numerosity, numerical magnitude, non-verbal spatial memory, speed of processing, and a range of mathematical skills. These tests were administered as part of a larger battery of tests that included further cognitive measures such as verbal and non verbal IQ. The first cohort of twins, around 2,100 individuals, has already completed the tests when they were 16. The second cohorts of twins are in the process of completing the same battery while the third cohort will follow in the next months. TEDS have been regularly tested from birth on a variety of cognitive abilities, therefore we had available mathematical achievement, verbal, non verbal abilities, reading and language skills at the age of 7, 9, 10, 12 and 14.

Results: Univariate genetic analysis on the Number Sense measures was conducted on data collected from the first cohort. Although empirical evidence suggests that these abilities may have evolutionary origins, our data showed that individual differences in Number Sense are largely due to non-shared environmental factors (around .70 in both measures), small genetic influences (between .21 and .27 in the two measures) with the absence of shared environmental influences. The correlation between the two measures of Number Sense was only .22 suggesting that the Number Sense domain is heterogeneous. Number Sense measured at 16 correlated with current mathematical performance and retrospectively with mathematics at all time points. However this relationship showed to be weak and more importantly was not unique to mathematics. In addition to mathematics, Number Sense showed a consistent retrospective relationship with non verbal IQ, and to lesser extent with all other general cognitive abilities. Nevertheless, a preliminary bivariate genetic analysis examining the nature of the association between mathematics and number sense at 16 suggests some common genetic influences on the two abilities.

Conclusion: The result of this study confirmed the relationship between mathematics and Number Sense. In contrast with other findings, we found that this association extended to general cognitive abilities and specifically to non verbal IQ. The data collected on the second cohort will give us the increased power to examine the nature of the relationship between Number Sense and mathematics and with other cognitive abilities and intelligence.

S3.2: The effects of teachers on academic motivation, a longitudinal twin study.

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Research to date has shown the fundamental importance of motivation and its direct link to the levels of academic achievement at school. The importance of this relationship has been illustrated across every stage of education: elementary school (Spinath, & Spinath et al, 2006), secondary and high school (Hodis, Meyer et al, 2011), and university (Gadbois and Sturgeon, 2011). The common view is that motivation levels are dependent on the quality of the immediate environments, such as family and parental expectations, or school and teacher's feedback (Krapp, 2005). Liu, Kovas et al (in press) investigated the genetic and environmental origins of individual differences in motivation. They reported on the cross-lagged raltionship between motivation (self-perceived ability and liking) and National Curriculum mathematics achievement at ages 9 & 12. Using representative UK sample of twins, part of the Twins Early Development Study (TEDS), they found moderate heritability for self-evaluation of mathematical ability and interest at both ages (40% at 9 years and 43% at 12 years), with no input from shared environment but considerable non-shared environmental influences (59% and 57% at 9 and 12 respectively). The cross-lagged analyses revealed a genetic link from earlier motivation to later achievment. In the current study we report on motivation in the TEDS large representative longitudinal sample of monozygotic (MZ) and dizygotic (DZ) twins at ages 9, 12 and 16. At ages 9 and 12, twins' self-evaluation was measured by asking 'how much do you like?' (liking/interest) and 'how good do you think you are?' (perceived ability) on aspects of National Curriculum subjects. At age 16, three PISA (Programme for International Student Assessment) items measuring interest and eight PISA items assessing perceived self-efficacy were administered. Our study extends the previous research in that it puts to test the common view that teachers have a large impact on student motivation, so that when both twins share the same teacher/classroom, their motivational levels are more similar than those of twins in separate classrooms. We estimated the sources of individual differences in academic motivation for twin pairs taught at school in the same class and same teacher vs. pairs that are separated (attending different classes or schools). Additionally, we tested whether having the same teacher in childhood has any long-lasting motivational effects on adolescent and teenage twins. Our results replicated the findings by Liu, Kovas et al (in press) of significant heritability and the absence of shared environmental influences on motivation at all three ages, suggesting that observed similarity in motivation for twins is genetic in origin. We found no teacher or classroom effect, as motivational similarities between twins taught by the same vs. different teacher did not differ (for example, at age 9 the correlation for motivation composite was .55 for MZ twins taught by the same teacher and .54 for MZ twins taught by the different teacher). We also did not find any evidence for shared classroom environmental influences on motivational levels at later ages. We discuss these findings in terms of their educational implications.

S3.3: The heritability of verbal and nonverbal intelligence in Russian adolescents

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The aim of our study was to investigate genetic and environmental contributions to individual differences in verbal and nonverbal IQ in Russian adolescents. The intelligence quotient was measured with the Russian version of Wechsler's WISC-III test. The sample included 424 12-15 year old monozygotic and dizygotic twins (mean age = 13.3, SD = 0.5); 230 (54%) males and 194 (46%) females. The statistical genetic analyses were conducted using SPSS and MX software. The best fitting model for the verbal intelligence subscale was ACE (additive genetic factors, shared and nonshared environmental factors): a^2=0.28, c^2=0.51, e^2=0.21 - all significant. For the nonverbal intelligence subscale, the best fitting model was AE (additive genetic factors and nonshared environmental factors): a^2=0.64, e^2=0.36. The best fitting model for the general intelligence quotient was ACE: a^2=0.41, c^2=0.37, e^2=0.22. We consider the significance of shared environmental factors for the verbal intelligence in adolescence (with its insignificance for the verbal intelligence subscale) as the evidence for the differential etiology of verbal and nonverbal mental abilities.

S3.4: Gender Differences in Cognitive Abilities: testosterone vs. socialization

Tamara A. Yampolskaya[*,1], Kostas Papageorgiou[2], Maria Tosto[3], Hannah Frenken[3], & Yulia Kovas[3,4]

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The aims of the current study were to investigate gender differences in the development of spatial, mathematical and general cognitive ability, as well as the sources of individual variability in different cognitive domains. More specifically, using the large dataset containing measures of cognitive abilities at different ages from the Twins Early Development Study (TEDS), we tested the testosterone hypothesis (see Vuoksimaa et al., 2010). According to this hypothesis, intra-uterine testosterone can be transferred from males to their female co-twins, resulting in their enhanced cognitive abilities in domains traditionally associated with male advantage (e.g. spatial ability). We created four groups of children: males from dizygotic same-sex twin pairs, females from dizygotic same-sex twin pairs, males from opposite sex twin pairs, and females from opposite sex twin pairs. In respect to the testosterone hypothesis, we expected that females from opposite sex twin pairs would show enhanced mathematical ability in comparison to females from same sex twin pairs, due to testosterone transmission from their male co-twin. In order to further test the testosterone hypothesis, we collected additional data from adults with non–twin siblings to examine whether having a non-twin brother also leads to enhanced performance in females. If true, this would suggest alternative or additional explanations, for example the effect of socializing with a male sibling. We assessed participants' mental rotation ability, non-verbal intelligence, spatial memory, and mathematical fluency and analyzed the data in terms of gender by gender of sibling status. In addition, we examined the potential negative and positive effects of a gender stereotype on males and females. Our results suggest that: (1) gender differences in cognitive abilities are small and, in most cases, not statistically significant ($p<0.05$); (2) Testosterone transmission in the womb does not seem to affect females' cognitive abilities; (3) Females have a cognitive advantage in comparison to males up until the age of 7 years; (4) from 7 till 9 years of age males tend to score higher on mathematical and general cognitive ability tests; (5) from years 10 to 14, gender differences tend to be very small; (6) the gender of the sibling does not seem to influence the development of cognitive abilities; (7) Stereotype threat does not change significantly the performance of either males or females. This study contributes to the identification of developmental mechanisms of the mathematical, spatial, and general cognitive abilities, linking biological and social explanations of individual and group differences in human cognitive development.

S4: Annual Constance Holden Symposium: Rubbing Public Opinion the Wrong Way

(Friday, 1.30-2.20)

Organizer: Linda S. Gottfredson, University of Delaware, USA, (gottfred@udel.edu)

Featured speaker: Lone Frank, Author and Science Journalist, Copenhagen, Denmark,

Symposium Summary

Most science coverage is borne out of fascination with important new findings and the goings on in exciting research fields. It is news in a more traditional sense. With the media's general love of controversy, it seems striking that science journalism so rarely goes into those controversial topics where scientific findings clash with culturally accepted ideas and political winds. As a journalist, one is not only criticized for writing such stories - the stories themselves can also run into problems with getting published. I will present examples of my personal experiences with writing science stories that rub public opinion the wrong way. And I will discuss the responsibility of both media and scientists in relation to investigating and communicating findings that may run against conventional truths and social wishes.

T4: Talks, generally about neuroscience
(Friday, 2.20-3.20)

T4.1: Changes in gray and white matter after four weeks of videogame practice

Roberto Colom*[1,3], Mª Ángeles Quiroga[2], Miguel Burgaleta[1,5], Francisco Javier Román[1], Jesús Privado[2], Sergio Escorial[2], Juan Álvarez-Linera[3], Eva Alfayate[3], Félix García[3], Claude Lepage[4], Kenia Martínez[1], Ana Beatriz Solana[3], Juan Antonio Hernández-Tamames[3], Sherif Karama[4]

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Here gray and white matter changes after four weeks of videogame practice were analyzed using optimized voxel-based morphometry (VBM), cortical surface and cortical thickness indices, and white matter fractional anisotropy (FA) computed from several projection, commissural, and association tracts relevant to cognition. Beginning with a sample of one hundred young females, twenty right handed participants were recruited for the study and assigned to a practice or a control group carefully matched by their general cognitive ability scores. After the first scan, the practice group played '*Professor Layton and The Pandora's Box*' four hours per week during four weeks. A second scan was obtained at the end of practice. Image analyses revealed gray and white matter changes in the practice group. Gray matter increments were observed in right parieto-frontal areas, whereas gray matter decrements were more focused in temporal regions. White matter findings revealed decreased fractional anisotropy in several tracts, suggesting selective elimination of weak connections by synaptic pruning.

T4.2: Cortical thickness correlates of change in IQ in children and adolescents

Miguel Burgaleta*, Roberto Colom, Wendy Johnson, Alan Evans, Sherif Karama, and the
Brain Development Cooperative Group

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In recent years, IQ and general cognitive ability have been shown to be related to cortical thickness in cross-sectional studies (1) and specific patterns of cortical development in longitudinal studies (2). While generally viewed as stable, IQ is not perfectly stable over the lifespan. Whether changes in IQ reflect genuine changes in general cognitive performance or just measurement error remains a matter of controversy (3). The goal of the current work was to assess whether longitudinal changes in cortical thickness (CTh) are related to changes in IQ. In order to do so, we studied longitudinally 188 subjects (mean age = 11.59, SD = 3.46, 59% females) from the NIH MRI Study of Normal Brain Development (4). Participants were scanned (structural MRI scans were acquired on 1.5T scanners for all participants) two years apart, and completed the Wechsler Abbreviated Scale of Intelligence (WASI) (5). Measurement of regional cortical thickness was implemented via CIVET 1.1.9 (6-8). Changes in IQ scores (DiffIQ) within the two year period between the first and second scan visits were regressed against cortical thickness change. Effects of age, gender, scanner, IQ at visit 1, and mean cortical thickness were controlled for. Results show that changes in IQ were related to rate of cortical thinning in left frontal cortical areas (Figure 1) (FDR < 0.05). To better illustrate these results, we created three groups of subjects based on their DiffIQ scores: increase (zDiffIQ > .5), no change (-.5 < zDiffIQ < .5), and decrease (zDiffIQ < -.5) in IQ. In the left frontal and prefrontal areas, the 'increase' group showed a non-significant cortical thickening (t=-0.658, p=0.513), whereas subjects in the 'no change' group showed the standard well documented monotonic decline in cortical thickness (t=2.578, p=0.012). Importantly, subjects in the 'decrease' group displayed the steepest and most significant reductions in CTh (t=4.827, p=0.00001). Results are consistent with previous findings showing an association between IQ and cortical thickness developmental trajectories. However, here we move one step further by demonstrating that different cortical thinning patterns may also be related to changes in IQ. These results support the notion of a plastic brain and have important consequences for the current understanding of cognitive performance and its stability across development.

T4.3: The Relevance of Scoring for Finding Intelligence in The Brain

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The number of studies reporting brain correlates for intelligence is increasing quickly. The relevance of a parieto-frontal network is generally highlighted, but discrepancies are also present. Here we show how the way intelligence is estimated impacts over achieved findings. For pursuing this main goal, nine standardized intelligence measures tapping abstract-fluid (Gf), verbal-crystallized (Gc), and spatial (Gv) intelligence were administered to a sample of one hundred and four young adolescents. VBM analyses were computed for different levels within the intelligence hierarchy: (a) measures, (b) first-order factors (Gf, Gc, and Gv), and (c) the higher-order factor (*g*). Statistical Parametric Mappings (SPMs) for all these levels were systematically compared with respect to their overlap. These were the main findings: (1) SPMs were sharply distinguishable for the specific intelligence measures, but regularities became increasingly relevant for first and second-order factors, especially for Gf and *g* and (2) the Advanced Progressive Matrices (APM) test produced a closely similar SPM to that obtained for *g*. These results were confirmed using cortical surface indices --obtained from the Montreal Neurological Institute CIVET pipeline-- instead of volumetric measures.

T5: Talks, generally about intelligence and life outcomes
(Friday, 3.40-5.00)

T5.1: Associations between intelligence in adolescence and indicators of health and health behaviours in midlife in a cohort of Swedish women.

Karin Modig*[,1] & Lars R Bergman[2]

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Objectives: To investigate associations between intelligence and indicators of health and health behaviours in women.
Design: Population based longitudinal study.
Setting and participants: Örebro, Sweden. A school grade cohort of 682 Swedish women of which 369 were invited to a medical examination.
Main outcome measures: A number of indicators of health status and health behaviours in midlife.
Results: There were no significant correlations between intelligence and any of the health indicators (at 5% significance level). In unadjusted logistic regression models where the indicators were analysed as dichotomous dependent variables, with cut-off points based on risk levels, four out of sixteen indicators of health and health behaviour showed significant associations with low intelligence. After adjusting for educational level two remained statistically significant, being obese OR 1.46 (95% CI 1.03, 2.06) and having a high systolic blood pressure OR 1.41 (95% CI 1.00, 1.99). No associations were found between intelligence and health behaviours.
Conclusions: This study finds no support for a sizable association between intelligence in adolescence and indicators of health and health behaviour in midlife among Swedish women, measured by a range of indicators, with the exception for an association with low intelligence and the odds of being obese and having a high systolic blood pressure, which, however, were on the border to be statistically significant. Whether this is specific for women remains unknown. The proposed mediating effect of health behaviour on the IQ-mortality association is not supported by the results of this study, neither the idea of a general sizeable correlation of intelligence and health status among women.

T5.2: Intelligent children make happier adults

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Intelligence is one of the best predictors of success in life. Thus, as subjective well-being (SWB) is a key life outcome that people rank even ahead of money (Diener & Diener, 1996), a relation between those two concepts was expected. However previous research (e.g. DeNeve & Cooper, 1998) demonstrated the level of intelligence to have no significant impact on people's satisfaction with life (SL). This study, drawing on a multidimensional conceptualization of SWB (Diener, Suh, Lucas, & Smith, 1999), replicates and contributes to the literature by extending previous findings. Moreover, it explores the relations between childhood intelligence and other SWB components in adulthood (i.e., not only SL but also satisfaction with individual life domains, and the frequency of experiencing positive and negative affect). To tackle this issue, the authors drew on data gathered from a representative longitudinal study called MAGRIP, encompassing two waves of measurement over a 40 years time span. In 1968, detailed data were collected on intelligence, educational career and family background from about half of the Luxembourgish student population at the end of primary school in grade 6 (N = 2,824, M = 11.9 years, SD = 7.2 months; 50.1% male). In 2008, a random stratified representative subsample (N = 738, M = 51.8 years, SD = 6.6 months; 47.0% male) of the participants from 1968 took part in a second measurement, which encompassed a comprehensive interview on their educational and occupational careers and a broad SWB questionnaire. The results of SEM regression analyses confirmed previous research that childhood intelligence was not related to the level of SL. However, as expected, childhood intelligence had positive impact on the level to satisfaction with individual life domains that were related to achieving success in life (e.g. *health*, *finance* or *self-esteem*), and on the frequency of experiencing positive and negative affect. Of note, the predictive power of childhood intelligence remained even when controlling for other childhood characteristics, such as parental socioeconomic status or educational achievements.

T5.3: The Market Place for Intelligence: 2009 Version

Earl Hunt* & Tara M. Madhyastha

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The modern workplace depends upon the cognitive abilities of the workforce. We report a series of studies in which we treated cognitive ability as a commodity, and considered the demand for and supply of this commodity. Our primary data were ratings of the cognitive skills required by various occupations, as listed in the Department of Labor's O*NET database. We factor analyzed the 20 ratings O*NET, extracting to a three dimensional space. One of the dimensions of this space, which we identified as General Cognitive Ability (GCA), accounted for much more of the variability in the ratings of cognitive skills than did the other dimensions. Accordingly, we took the GCA factor score for an occupation as a measure of the GCA required by that occupation. The demand for GCA was determined by considering both the GCA score for occupations and the number of job holders within each occupation. The distribution of demand for GCA was positively skewed compared to a normal distribution, centered at a value slightly below the mean GCA factor score. From this, we concluded that the O*NET ratings represent an evaluation of adequate rather than typical performance. For a subset of the occupations we had available the scores that job applicants had obtained on the WONDERLIC PERSONNEL TEST, a cognitive test that is widely used in industrial hiring. The GCA factor scores for these occupations were linearly related to the WONDERLIC scores, across occupations. Finally we correlated the GCA factor scores with the median annual income associated with each occupation. The GCA factor score predicted approximately 60% of the variation in income across occupations. A small adjustment was required to account for the visual-perceptual abilities required in an occupation

T5.4: Genotype by Environment Interactions in Cognitive Ability Tested in 14 Different Studies

Dylan Molenaar*[,1], Sophie van der Sluis[2], Dorret I. Boomsma[3], & Conor V. Dolan[1]

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Cognitive ability is known to be considerably heritable. Researchers have tried to identify environmental variables that influence the heritability of cognitive ability, indicating a genotype by environment interaction. To date, environment variables that were found of interest include measured variables like income and socioeconomic status. The present paper focuses on genotype by environment interaction in cognitive ability where the environment variable is the unmeasured unique environmental factor, E, from the ACE-decomposition. We tested this in the GHCA-database (Haworth et al, 2010), which comprises data of 14 different cognition studies from 4 different countries including subjects of different ages. Results are considered on both the level of the aggregated data (i.e., collapsed over the individual studies) and on the level of the individual studies. Interestingly, substantial heterogeneity is observed between the individual studies with respect to environmental en genetic influences on cognitive ability. Possible sources of this heterogeneity are discussed.

FEATURED SPEAKER
(Friday, 5.30-6.30)

Dopaminergic Regulation of Selective Attention and the Expression of "Intelligence" in Genetically Heterogeneous Mice

Louis D. Matzel*

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A wide range of evidence suggests that the processing components of the human working memory system co-vary with individuals' performance on a wide range of cognitive tasks. The ubiquitous nature of this relationship as well as the reliance of most cognitive tasks on working memory has led to the hypothesis that variations in the efficacy of working memory processing may actually *regulate* (at least in part) individual differences in intelligence. Data from our laboratory indicates that genetically heterogeneous mice express a trait that is qualitatively and psychometrically analogous to "intelligence" (encompassing learning, attentional, and reasoning abilities), and that the expression of this cognitive trait varies across individuals. As in humans, the expression of general cognitive abilities in mice is strongly correlated with individual animal's performance on tests of working memory capacity and selective attention. Importantly, we have observed that intensive training on working memory capacity/selective attention tasks promotes an improvement in the general cognitive performance of both young and aged animals. In combination, these results support the possibility that working memory processing is the latent variable that regulates intelligence. From this behavioral foundation, we have begun to characterize gene expression profiles of mice that exhibit high or low general cognitive abilities. Consistent with a role for selective attention in the regulation of intelligence, we have observed that the principal genetic correlates of intelligence reside in the prefrontal cortex, and are primarily attributable to variations in the expression of a small cluster of genes that bias dopaminergic signaling toward the D1 receptor. Additional histological and immunochemical analyses indicate that D1 signaling and expression in both the medial and dorso-lateral prefrontal cortex is predictive of general cognitive performance. In combination with image-analyses and modeling data from other laboratories, our results have led us to (tentatively) conclude that dopaminergic modulation of selective attention by prefrontal cortical circuits may account for a large percentage of the variance in individual differences in "intelligence".

Saturday, December 10

T6: Talks, generally about intelligence and educational outcomes
(Saturday, 8.30-10.10)

T6.1: The VPR Model in Project Talent

Jason T. Major* & Wendy Johnson

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Project Talent is a longitudinal study of over 440,000 Americans high school students, which began in 1960, and which is now undergoing a limited 50-year follow-up. Despite the extensive research done with Project Talent, a systematic study into the factor structure of its ability tests has not been performed for several decades; in the meantime psychometric models of intelligence have evolved considerably. Our present study had two goals: first, to compare three prominent theories of ability structure in Project Talent, and second, in so doing to resolve this structure for the purposes of further study. We used confirmatory factor analysis to compare the fluid-crystallized model, the Cattell-Horn-Carroll Three Stratum model, and the verbal-perceptual-image rotation (VPR) model. We hypothesized that the VPR model would provide the best fit to the Project Talent tests. Preliminary results suggest that a verbal-perceptual model does outperform the other two, in both genders and all grade levels. The study provides further evidence in the ongoing debate about the structure of intelligence.

T6.2: Classification of students in two-year colleges: A latent class model approach

Heather Turner[*,1], A. Alexander Beaujean[2], Darrell Hull[1],

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The purpose of the present study was to discern variation in cognitive ability and personality factors common to students completing a two-year technological education program in order to identify which characteristics distinguish them from students in other less-technological education programs. *By better understanding the unique characteristics of students that pursue and persist in two-year technological education, the projects and centers under the National Science Foundation's Advanced Technological Education (ATE) program should be better equipped to develop curricula, instructional techniques, and recruitment activities. The present study is expected to contribute information to a substantial gap in the literature on personality and individual differences in two-year college students.*

Measures of cognitive ability, personality, and academic achievement were collected in a sample of students (N = 306) enrolled in one of five community/technical colleges in the United States. Participants completed subtests from the Shipley Institute of Living-Second Edition, Raven's Standard Progressive Matrices, spatial reaction time tasks based on the Shepard-Metzler (1971) Mental Rotation items, and the NEO-Five Factor Inventory. The results showed that there were two latent classes in the data, and 86a% of those attending a technical program were classified into the same class. This "technical" class showed large differences (i.e., Cohen's d values > 1) in scores on the Raven's, Shipley Block Patterns and Vocabulary subtests, and the standardized measure of math achievement. There were minimal between-class differences on the reaction time task or personality variables except for Openness to Experience, which showed a medium-sized difference (d = .56) .

The results from this support the hypothesis of career-environment fit as suggested by Gottfredson's (2002; 2005) circumscription and compromise theory, as the two classes (technical vs. non-technical two-year degree completers) were empirically differentiated based, mostly, on their cognitive abilities, especially within the quantitative, fluid, and spatial domains.

T6.3: Psychomotor ability is a more robust predictor of literacy than is cognitive performance during pre-school ages

Keith Widaman*[,1], Carmen Flores-Mendoza[2] & Renata Saldanha[2]

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This work investigates the influence of psychomotor ability and intelligence in the process of literacy through of Brazilian test named *Teste de Habilidades e Conhecimentos Pre-alfabetização* or THCP, developed by Laboratory of Individual Differences Assessment of Universidade Federal de Minas Gerais. This instrument is composed of five subscales, which evaluate five relevant skills to general learning, namely: perceptual-motor skills, language, quantitative thinking, memory, and focused attention. A sample of 304 children aged between four and six years, from public and private educational institutions located in the metropolitan region of Belo Horizonte-Brazil, participated in this study. Simultaneously to the administration of THCP, a subsample of children (n = 71) were cognitively assessed using the Brazilian intelligence test named Teste Não Verbal de Raciocinio Indutivo (Non Verbal Inductive Reasoning Test) or TNVRI. In addition, parents provided data regarding health and psychosocial aspects of their children and family. After six months, a school achievement test (TDE), involving reading, writing, and arithmetic, was administered to 69 children. The results indicated a correlation of 0.245 between intelligence test scores from the TNVRI and the literacy scales from the school achievement test (TDE), whereas the correlation between psychomotor skills score from THCP and the school achievement literacy scales (from the TDE) was 0.467. Thus psychomotor ability is a more robust predictor of school achievement during the very early years of schooling than is intelligence. Social economic status of parents was not significantly associated with school achievement (TDE). Implications for theories of intelligence and achievement will be discussed.

T6.4: Intelligence and Education: What Develops? For Whom?

Wendy Johnson*

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Department of Psychology, University of Edinburgh

Arthur Jensen's infamous 1969 *Harvard Educational Review* article, 'How Much Can We Boost IQ?', grew out of experiments he carried out during the mid-1960s comparing performance of young children from disadvantaged and relatively advantaged socioeconomic groups on various cognitive tasks. He had consistently observed that, matched for poor performance on tests like Raven's Matrices, children from disadvantaged groups showed markedly better performance on associative learning tasks than children from relatively advantaged groups. Moreover, Raven's performance was correlated with associative learning performance in the relatively advantaged groups but not the disadvantaged groups, and similarly correlated with school achievement in both. He concluded that some group difference in higher reasoning capacity assessed by Raven's was genetically determined, a conclusion that subsequent observation of dramatic Flynn Effects on Raven's performance has rendered at best premature.

In the furore surrounding Jensen's article, his fascinating data, and the very legitimate questions he raised about what happens when children with different backgrounds and abilities are exposed to education, have largely been forgotten. One person who did think along similar lines, however, was developmental psychologist Robbie Case. In the 1990s, he developed a series of theory-driven experiments to observe what changes in children's thought processes with exposure to education, in the process comparing socioeconomic and cultural groups and constructing mathematical models that could be used to test possible explanations for these changes. Like what may have been most important in Jensen's 1969 article, Case's work remains largely uncited. In this talk I integrate Jensen's observations with those of Case. I show how Case's models might be used to understand how children from different backgrounds might process the information presented in associative learning tasks very differently from that presented in Raven's matrices. I argue that understanding the origins of this difference is critical to determining how and to what degree we can improve cognitive function at any age.

T6.5: Aurorra Battery Intelligence Assessment Under TriarchicTheory

Ana M. Salgado* & Leandro S. Almeida

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Aurora Battery is a psychopedagogical assessment tool based on Robert Sternberg´s Triarchic Intelligence theory, which provides three dimensions for cognitive assessment: analytical, practical and creative. This battery is also proposed as a future contribution to the identification of gifted students, overcoming the limitations of the usually given IQ tests. It is an extensive tool such it consists in several instruments: teacher rating scale; parent interview, student self-scale, observation tasks and seventeen subtests. These are paper-pencil tasks with ecological validity and the content of the items ranges from figurative, verbal and numerical. The Portuguese version was collectively applied to a sample group of 123 portuguese students attending 5th, 6th and 7th grade in public schools. Preliminary statistical analyses on eleven subtests (analytical and practical dimension) suggest that some items needs to be hierarchical reorganized according difficulty level. By the other hand, others remain unclear and reveal poor adequacy for students in the age group of 10-12. Six subtests revealed high internal consistency and factor analyses showed three factors against item's organization according each dimension. However, maximum saturation in each factor point out that items are grouped according task's content. Future studies will focus on criteria for scoring open-ended items (creative intelligence).

S5: Studies on the neurotransmitter and biological basis of human intelligence
(Saturday, 10.30-12.20)

Symposium Chair: Prof C Stough (cstough@swin.edu.au)

Centre for Human Psychopharmacology, Swinburne University, Melbourne, Vic, Australia

Symposium Summary

In this symposium we present a series of studies and analyses concerned with the biological basis of cognition and intelligence. The studies use a pharmacological framework to provide some insights into the neurochemistry of human intelligence. All presentations involve data from studies collected at the Swinburne Centre for Psychopharmacology and represent either acute or chronic double blind placebo controlled trials in which cognition is the primary outcome variable. In the first presentation, Andrew Scholey presents the results of several studies in which glucose, caffeine or a combination of glucose and caffeine are administered to participants and cognition is assessed. In the second presentation Matt Pase presents an analysis of cognitive studies in which the Indian nootropic brahmi has been administered to humans. Of significant relevance to ISIR is the use of the Carroll cognitive ability framework in this and the following presentation to elucidate the specific cognitive abilities modulated by brahmi. In the following presentation by Natalie Grima, a similar analysis is undertaken for the effect of multivitamins on human cognition again using the Carroll ability framework. In the 5th presentation David Camfield the evidence for improvement in spatial working memory, a key component of human intelligence by nootropics using a novel and sophisticated brain imaging technique with high temporal resolution. In the last presentation Con Stough discusses the use of amphetamines and amphetamine-like substances to improve cognition reporting the results of several studies conducted at Swinburne University. Implications for the neurotransmitter and biological basis of intelligence as well as the ethical implications of smart drugs are discussed throughout the symposium.

S5.1: Synergistic effects of glucose and caffeine on mental performance

Andrew Scholey*

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Glucose and caffeine are two of the most widely researched nutraceutical cognitive enhancers in the world. However, there is still some controversy regarding the extent and pattern of their cognitive effects. In the case of glucose more effortful cognitive processing appears to be the most susceptible. Caffeine can improve several aspects of cognition and mood, particularly in fatigued individuals. In both cases behavioural responses are moderated by individual differences. In the case of glucose by physiology and in the case of caffeine by genotype. Despite this wealth of knowledge, the effects of caffeine and glucose alone on relatively under-loaded cognitive performance is unclear.
Here data are presented on the effects of caffeine and glucose loading both alone and in combination on a range of cognitive tasks ranging from simple processing to complex, higher-order multi-tasking platforms. In an initial randomised, double-blind, balanced, five-way crossover design, 20 participants ingested drinks containing various combinations of glucose or caffeine. Neither substance alone improved scores across a range of standardised cognitive tasks, whereas in combination glucose and caffeine improved memory performance. Later studies confirmed these effects including in a recent parallel groups study (N = 160) showing that a caffeine-glucose combination can significantly enhance multi-tasking performance, a result which may have ramifications for everyday cognitive processes.
The data demonstrate that the two substances act in an additive or possibly synergistic manner with glucose/caffeine combinations resulting in greater cognitive enhancement than would be predicted by the effects of either substance alone. These findings may offer a prototype for evaluating the cognitive enhancing effects of other nutraceutical combinations.

S5.2: The Indian nootropic *Bacopa monniera* and cognitive ability: A systematic review of randomized, controlled human clinical trials using the Carroll Cognitive Framework

Matthew P. Pase*[,1], James Kean[1], Jerome Sarris[1, 2], Chris Neale[1], Andrew B. Scholey[1], & Con Stough[1]

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Bacopa monniera is a sub-continental herb traditionally harvested for its purported cognitive enhancing effects. Despite a handful of recent randomized, controlled trials in the area, there is no review summarizing the cognitive enhancing effects of this herb. The current qualitative systematic review of randomized controlled trials aimed to examine the scientific evidence as to whether *Bacopa* can enhance cognitive performance in humans. Multiple databases were systematically searched by multiple authors with relevant trials objectively assessed for methodological quality. Articles were considered appropriate for review when *Bacopa,* or its isolated constituents, were administered chronically to adult humans without dementia or significant cognitive impairment. Any validated cognitive test, whether a primary or secondary outcome, was considered appropriate for review. All located cognitive tests were grouped into cognitive factors based on Carroll's extensive survey of factor analytic studies. Six trials were included in the final review. All trials were conducted over 12 weeks with *Bacopa* used at dosages of 300-450mg per day. All six studies examined the effects of *Bacopa* on memory while other cognitive domains were less well studied. There were no cognitive tests in the areas of auditory perceptual abilities or idea production and only a paucity of research in the domains of reasoning, number facility and language behaviour. Across studies, 9/17 tests in the domain of memory free recall were significant in favour of *Bacopa*. There was little evidence of enhancement in any other cognitive domains. In conclusion, there is some emerging evidence to suggest that *Bacopa* improves memory free recall with evidence for enhancement in other cognitive abilities currently lacking and understudied.

S5.3: The Effects of Multivitamins on Cognitive Ability: A Systematic Review and Meta- analysis using the Carroll Cognitive Framework

N.A. Grima*,[1], M.P. Pase[2], H. Macpherson[2] & A. Pipingas[2]

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Normal ageing is associated with cognitive change affecting multiple areas of cognitive functioning. Age related cognitive decline presents significant societal, economic and health consequences for the world as well as personal ramifications for older individuals to lead fulfilling lives. As society becomes more health conscious, complementary medicine use has become increasingly popular. Multivitamins, consisting of combined vitamin and mineral components, represents the most common form of vitamin supplements used by adults. Although, adequate dietary intake of vitamins and micronutrients is associated with neurological and cognitive health, randomised controlled trials (RCT) have not produced a clear consensus as to whether multivitamin use improves cognitive performance. This is largely because RCTs have produced heterogeneous results which are hard to interpret and compare, given the array of cognitive tasks used. By grouping the cognitive outcomes into true cognitive abilities defined through the extensive factor analytic work of Carroll, the aim of the current systematic review and meta-analysis was to quantify the effects of multivitamins on cognitive abilities. Online databases were searched by two independent researchers for randomized, placebo-controlled, double-blind clinical trials reporting on the chronic effects (>1 month) of oral multivitamin supplementation on any valid cognitive outcomes. The results revealed ten eligible studies with a pooled sample of 3,200 participants. Meta-analysis indicated that multivitamins were effective in improving number facility ($g= 0.34$ (95% CI: 0.01–0.67), $p < 0.05$) and memory ($g= 0.23$ (95% CI: 0.05–0.40, $p < .01$). Further analysis revealed that the beneficial effect of multivitamins on memory was in the domain of immediate free recall ($g= 0.24$ (95% CI: 0.06–0.43, $p < .01$) with no enhancement in delayed free recall, visual memory or any other cognitive domain. These findings suggest that multivitamin supplementation can modestly enhance immediate free recall memory and number facility with no evidence of enhancement to any other cognitive abilities.

S5.4: Enhancing Spatial Working Memory ability through the use of Nootropics

David A Camfield*, Con Stough, Andrew Scholey & Andrew Pipingas

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Spatial Working Memory (SWM) refers to the ability to maintain working representations of object locations in memory. SWM ability is a cognitive domain that has a high degree of sensitivity to pharmaceutical interventions and is also one of the first domains to be impacted by age-related cognitive decline. Previous neuro-imaging studies have highlighted the importance of the prefrontal cortex and the posterior parietal cortex in tasks requiring SWM ability. However, a deeper understanding of the second-by-second changes that occur in the brain during SWM tasks are difficult to gauge using conventional imaging techniques such as fMRI. Steady State Probe Topography (SST) is an electrophysiological technique that enables investigation into patterns of brain activity associated with SWM, using a superior temporal resolution of less than 80ms. The presentation will detail changes in steady state visually evoked potentials (SSVEPs) which have been found to occur during high-demand SWM tasks. Using data from a series of acute and chronic studies conducted in our laboratory, the effects of cognitive enhancing (nootropic) substances on neural activity during SWM task completion will be outlined. The substances that will be discussed are Cocoa Polyphenols, Panax quinquefolius Ginseng and B-Vitamins. Each of these studies used healthy adult samples from young adulthood up until late middle age, with a combined N of 200 people. Animations featuring brain maps in which real-time changes in SSVEP amplitude and phase during the completion of SWM tasks will be compared and contrasted for each of these substances versus placebo. The neural activity patterns that have been found to be associated with optimal 'peak' SWM performance will be delineated.

S5.5: The use of amphetamines to improve cognitive performance: implications for understanding the neurobiology of intelligence

Con Stough*,[1], Luke Downey[1], Beata Silber[1], Andrew Scholey[1] & Edward Ogden[1]

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The legal and illegal use of amphetamines and amphetamine like substances are on the rise in many countries despite negative health and accident data liking their use with poorer individual outcomes. Their use as a putative cognitive enhancer has for the most part led to this increased use. Several researchers have highlighted their use in improving cognitive performance across several applications including in improved examination performance for various IQ and cognitive tests. We report data on several studies conducted in our laboratory on acute and chronic dexamphetamine and methamphetamine consumption and cognitive performance. The acute administration studies represent randomized double blind placebo controlled within subject cross-over studies. The acute studies represent self-report drug use over an extended timeframe. All studies involve comprehensive cognitive assessments. Results suggest that dexamphetamine and methamphetamine, at least at doses administered acutely modulate cognitive performance differently with some evidence for improved functioning of lower level or simpler cognitive tasks and either no impairment or some impairment of higher order or more complex cognitive tasks. The data taken together raise important implications for the role of the neurotransmitter dopamine and human intelligence and may lead to interesting hypotheses linking genetic polymorphisms found in the dopaminergic system and human intelligence.

S6: Society, Intelligence and the Economy
(Saturday, 1.50-3.00)

Symposium Chair: Earl B. Hunt (ehunt@u.washington.edu)

Symposium Summary

Intelligence as one of the best-assessed constructs of psychology is and was always a hotbed of controversy. It is no longer of interest for psychologists and educators, but especially economists and other social scientist as well, got very interested in its implications for their area of research. The theoretical and practical importance of these discussions can now be researched and tested by rich quantitative data sets. PISA scores are highly related to intelligence as knowledge in terms of Ackerman's PPIK theory or to crystallized intelligence in the sense of Cattell and Horn.

Lubinski and Benbow continue the research of the highly gifted assessed via SAT initiated by Julian Stanley and have data available over several decades. Kell, Lubinski and Benbow will present results for accomplishments of such a highly gifted group and the importance of such a human capital for the economy and society. Heiner Rindermann has extensively published in the last years capitalizing on the international PISA, PIRLS and TIMSS data sets and their implications. In his presentation he will focus on the long-term prediction of the economic well-being of nations, integrating socio-demographic variables and the Flynn effect. Werner W. Wittmann demonstrates the role of tilted profiles especially the math-tilted ones for economic prosperity and the large differences between countries and gender on that component.

S6.1: Identifying and Tracking the Development of Exceptional Human Capital Requires Exceptional Measures: Educational, Occupational, and Creative Accomplishments of the Profoundly Gifted Over Three Decades

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Adolescents identified before age 13 (N = 320) as having exceptional mathematical or verbal reasoning abilities (top 1 in 10,000) were tracked over three decades. The last detailing of this special population focused on their educational experiences and the honors they received by their early 20s (Lubinski, Webb, Morelock, & Benbow, 2001). This study reports on their terminal graduate degrees, occupations and income, and their creative accomplishments in, for example, business, humanities and arts, law, social science, and science, technology, engineering, and mathematics (STEM). Their refereed publications (N = 477) and patents (N = 133) earned 25 years after their initial identification are also reported. Contrasting patterns of cognitive abilities portend distinctive developmental trajectories, but assessing multiple abilities and measures with high ceilings is required for studying truly exceptional human capital scientifically.

S6.2: Intelligence of the future and economic development

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"Cognitive capitalism" is a theory which postulates that cognitive ability is the cause of wealth. The average national intelligence level, and in particular the intelligence of the intellectual elite (top 5%) determine the general efficiency of society, the rate of technological innovation, the quality of institutions and of general administration, and the extent of economic freedom. By these means intelligence stimulates economic growth. This theory is supported by many studies using different research paradigms (human capital etc.).

Predicting the wealth of nations for the middle and end of this century involves trying to calculate the impact of contradictory trends with respect to national intelligence:

1. If the the secular rise of intelligence continues, then it may lead to higher cognitive ability levels in what are currently low ability countries, as well as boosting low ability groups within countries. However, the Flynn effect may be running out of steam, and it is not clear which groups, if any, may continue to benefit.

2. If brighter and better educated people continue to have fewer children, and delay those few births to later in life, then genetic and environmental factors may lead to an overall decrease in intelligence.

3. Large scale immigration of relatively low ability groups with high fertility into high ability countries may lead to a drop in intelligence in the host nation, while at the same time denuding the poorer countries of their brightest people, to the detriment of both societies. Assumptions about migration rates, ability levels and fertility rates are highly uncertain, and political responses such as restrictions on immigration, amnesties and affirmative action add further volatility to the picture.

Therefore, these different processes are likely to work together in a highly complex and intertwined way and will lead, depending on the assumption of the model and the quality of the data available for predictions, to very different forecasts of future intelligence and wealth.

To examine these issues in more detail we present detailed predictions for Germany, USA and Brazil, and more general predictions for 100 nations, for the years 2050 and 2100. The results may determine the life opportunities experienced by our children.

S6.3: Profile Differences in Intelligence as Knowledge and their Significance for the Economic Prosperity of Nations

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Since the publications of "Will we be smart enough? A cognitive analysis of the coming workforce" (Hunt,1995) and "IQ and the wealth of nations" (Lynn and Vanhanen, 2002) the impact of IQ and cognitive abilities for the economic and social consequences on society stirred a lot of interest, controversies and discussions among psychologists, economists and social scientists. The ubiquity of general intelligence (g) was demonstrated to play a central role at least from a correlational stance in its relationship to GDP/c. Robert Solow a Nobel prize winning economist calculated in the 1950 that about four-fifths of the growth in US output per worker was attributable to technical progress and even today a large share of the GDP is attributable to the science, technology, engineering and mathematics (STEM) dominated parts of the economy at least for the developed nations. These STEM areas need a workforce competent in math. O*NET data demonstrate that the highest availability of well-paid jobs is in the STEM area and that they demand math and figural skills. Using PISA data as proxies to intelligence as knowledge we differentiated the reading and math scales into a level (g-type) and a math/verbal tilt (scatter) factor. We postulated that countries with higher percentages of a high-level math-tilted incoming workforce will perform better in terms of GDP/c after controlling for the economic system (market versus socialist) and the availability of natural resources (oil). Using all the available OECD based PISA data sets for 2000, 2003, 2006 and 2009 we found large differences on the math/verbal-tilt factor between different nations and evidence that the math-tilt percentages of the workforce played a central role at least for the developed nations competing on the world market. Consequences for the status of education in different countries and their consequences for economic well-being in the future are discussed.

T7: Talks, generally about health
(Saturday, 3.20-4.20)

T7.1: Intelligent children become healthier adults: Findings from a 40 year longitudinal study in Luxembourg

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Cognitive epidemiology investigates the relationship between childhood intelligence and adult health. In the majority of studies, measures of childhood general intelligence (g) were employed to predict different adult health outcomes. Further, previous research focused on the medical dimension of health: Intelligent children were found to show lower risks of adult morbidity and mortality. The present paper contributes to this body of knowledge in several ways: First, we examine the relationship between childhood general intelligence and the medical, but also the functional (e.g., mobility) and subjective (e.g., satisfaction with health) dimensions of adult health. Second, we analyze whether these relationships hold when adjusting for children's socio-economic family background and gender. Third, we investigate if childhood fluid reasoning ability (Gf) and crystallized intelligence (Gc) exert a differential influence on adult health. Data were obtained from the longitudinal study MAGRIP, where a stratified random sample of 717 students (54% female) participated in two waves of measurement in 1968 (when aging on average 11 years) and 2008. Bivariate regression analyses showed positive relationships between childhood general intelligence and all three dimensions of adult health. These positive relationships remained for functional health and one indicator of the medical health dimension when adjusting for socio-economic family background and gender: Intelligent children experienced a better functional health and visited the doctor less frequently in adulthood. A separate investigation of childhood Gf and Gc in bivariate regression analyses yielded the same predictive pattern as general intelligence – Gf and Gc significantly predicted all three dimensions of adult health. The simultaneous investigation of Gf and Gc in a multiple regression model showed that Gf retained a significant influence on nearly all health outcomes, even when adjusting for socio-economic family background and gender. The effects of Gc were mostly attenuated to non-significance. Our results suggest that children's intellectual capacity should be considered when devising health care measures, and that it might be general reasoning, problem solving and logical thinking skills that are most important when it comes to dealing with health and health-related problems.

T7.2: Towards understanding the associations between health literacy and physical health

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Low levels of health literacy—low "capacity to obtain, process and understand basic health information and services needed to make appropriate health decisions"—constitute a risk factor for poor health. For example, low health literacy is associated with a failure to adopt preventive and early detection strategies, limited knowledge of particular health issues, poor ability to adhere to medication plans and, most importantly, with numerous manifestations of poor physical health itself. In order to lift the literacy-related barriers to health, it has been suggested to enhance people's levels of health literacy and/or to adjust health-services to recipients' literacy. For instance, interventions have been targeted at improving diabetes management or information access skills, and attention is being paid to simplifying patient-doctor communications and information given to patients. The success of these interventions has varied.

Whatever the strategy of responding to low health literacy, its effectiveness will depend on how well the antecedents of phenomenon and its pathways to physical health are understood. For one, it is necessary to understand how health literacy is associated with other, better-established psychological and social constructs. Theoretical models of health literacy introduce general cognitive ability as one of its underpinnings, along with other factors such as educational and occupational influences. There is indeed some evidence that scores on health literacy measures—which are in fact similar to cognitive ability test—are related to broader cognitive differences among people. This is also consistent with the literature showing associations between general cognitive ability and physical health. An obvious question that arises is to what degree general cognition accounts for the associations between health literacy and health outcomes. If it does so substantially, plans to raise heath standards by increasing health literacy can learn from the attempts to raise general cognitive ability. Likewise, prevention and health services should be adjusted to meet people's skills in a broader set of areas, not just in literacy alone.

Alternatively, rather than being related directly to general cognitive ability *per se*, health literacy may stem from other correlates such as educational attainment or occupational level. This would, then, suggest that health literacy is a domain-specific set of skills and knowledge that is relatively independent of general cognitive ability and that people develop in response to life-course opportunities.

The present study investigated whether three popular operationalizations of health literacy were predictive of a sample of nine indicators of physical health in older people at age around 73 years. The unique feature of the participants, the Lothian Birth Cohort 1936, is that all participants had been administered a well-validated general intelligence test at age 11 years. This made it possible to consider the influence of general cognitive ability before people absorb most of the life-course influences on health literacy and health, and before adult ill health affects cognitive ability. We first tested the degree to which general cognitive ability, observed concurrently with the health literacy assessments in old age, could account for the health literacy associations with health outcomes. We then investigated the earlier life-course roots of the health literacy-health associations by testing to which extent the associations could occur due to shared influences from childhood cognitive ability, educational level and adult occupational social class.

T7.3: What Explains the Association Between Low Cognitive Ability and Mortality Risk: Socio-economic Status, Health Behaviours, Cardiovascular Risk Factors, or Information Processing Speed? Evidence from the Third National Health and Nutrition Examination Survey (NHANES-III)

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Background. Although low cognitive ability has been associated with an elevated mortality risk, the mechanisms are unclear. In the most comprehensive analysis to date, we examined the role of indices of socio-economic status, health behaviours, other cardiovascular disease (CVD) risk factors (blood pressure, cholesterol, C-reactive protein, body mass index) and information processing speed.

Methods. The analytic sample comprised 5150 participants (2345 males) enrolled in the Third National Health and Nutrition Examination Survey (NHANES III; 1988-94) followed for mortality with data on cognitive ability (Symbol Digit Substitution Test, SDST; Serial Digit Learning Test, SDLT, r = .49, p < .001) and reaction time (a measure of information processing speed) data at baseline. Simple reaction time correlated .28 and .23 with SDST and SDLT, choice reaction time .26 and .20 (all ps <.001). Multiple imputation was used to reduce bias associated with missing data on covariates. Around 15 years later, 381 (7.4%) of the sample had died (117 CVD and 99 cancer deaths).

Results. In models adjusted for age, sex and ethnic group, 1 SD disadvantage performance on SDST (HR = 1.33, 95% CI 1.21, 1.47) and SDLT (HR = 1.56, 95% CI 1.33, 1.83) was associated with all-cause mortality. Corresponding hazard ratios for CVD mortality were 1.40 (95% CI 1.26, 1.56) and 1.92 (95% CI 1.55, 1.29). Simple reaction time (HR = 1.30, 95% CI 1.12, 1.51) and choice reaction time (HR = 1.39, 95% CI 1.19, 1.63) were associated independently with all-cause mortality and CVD-mortality (HR = 1.30, 95% CI 1.12, 1.51; HR = 1.39, 95% CI 1.19, 1.63). Reaction time attenuated SDST and SDLT associations with mortality by 10-15%, educational attainment by 23-31%, socio-economic status 8-16%, health behaviours 4-8%, and cardiovascular risk factors 14-19%.

Discussion. In a representative sample of U.S. adults, reaction time, educational attainment, socio-economic status, health behaviours and cardiovascular risk factors partially but not fully explained the association of low cognitive ability with all-cause or CVD-mortality.