Session C

Implicit spatial perspective taking: an fNIRS investigation into the role of the mirror neuron system

Natania Shuyi Ang[1], Birgit Brucker[2], Thomas Dresler[1,3], Ann-Christine Ehlis[1,3], Peter Gerjets[1,2]

[1]LEAD Graduate School & Research Network, University of Tubingen; [2]Knowledge Media Research Center, Tubingen; [3]Department of Psychiatry & Psychotherapy, University Hospital Tubingen

Spatial perspective taking is a high-level cognitive process that is crucial for various learning mechanisms, such as anticipating an opponent's move in a game of chess or soccer, or even navigating with landmarks. Spatial information can either be encoded from an egocentric or allocentric perspective. Previous research has established that human mirror neurons support the perception of actions performed by others; however, it is unclear how the mirror neuron system (MNS) might mediate perspective taking, particularly allocentrism, in spatial reasoning of static objects where action is implied. Using an established spatial perspective-taking paradigm together with functional near-infrared spectroscopy (fNIRS), we examined haemodynamic activity in the motor cortex and fronto-parietal regions of the mirror neuron network in 120 healthy, native German-speaking young adults. When presented with pictures of a person (as if sitting across from the participant) reaching for one object placed beside another on a table, participants chose between "left" or "right" in response to a query where one object is placed in relation to the other. Behavioural results indicate that most participants consistently adopted one perspective across all trials, with about two-thirds taking on an egocentric perspective. Neural data has yet to reveal whether and how levels of MNS activation is predictive of perspective-taking type. These results will be presented at the conference. The implications of our findings will contribute to a better understanding of the role and function of the MNS in embodied neurocognitive functions, especially in future studies of action-related learning processes in healthy and patient samples.

Enhancement of cognitive control in rewarding contexts in adolescence and adulthood

Lucía Magis-Weinberg[1], Ruud Custers[2], Iroise Dumontheil[3]

[1]University of California, Berkeley; [2]Utrecht University; [3]Birkbeck, University of London

Cognitive control may be sustained in anticipation of goal-relevant cues (proactive) or transient in response to the cues (reactive). Adolescents typically exhibit a more reactive pattern than adults in the absence of incentives. Here, we investigated how reward modulates cognitive control in a working memory task in 30 adolescents (12-16y) and 20 adults (23-30y). After a Baseline run without rewards, participants performed a Reward run in which they expected half the trials to be rewarded. A mixed blocked/event-related fMRI design enabled separation of transient and sustained neural activity associated with reactive and proactive cognitive control respectively. Participants' accuracy was greater in trials of the Reward run than the Baseline run, indicating engagement of proactive control. Overall accuracy increased with age. Across age groups, participants were faster for the No reward trials of the Reward run than of the Baseline run, indicating engagement of proactive control, and even faster for Reward trials, suggesting an additional reactive engagement of cognitive control. Increased sustained activity in the bilateral anterior insula, right dorsolateral prefrontal cortex and posterior parietal cortex was observed in adolescents and adults in the Reward run. Transient activation was observed in bilateral insula, lateral prefrontal cortex, posterior parietal cortex, and anterior cingulate cortex and putamen and caudate in response to reward. Some regions responded with both higher sustained and transient activity in rewarded blocks and trials. In the context of sporadic rewards, both adolescents and adults combine a proactive and a reactive strategy to maximise performance.

Commonalities and differences in brain activation associated with ordinal processing: Evidence from functional magnetic resonance imaging

Stephan E. Vogel[1], Sabrina Turker[1], Lena Schulz[1], Sonja Zeidler[1] Ian Lyons[2], Daniel Ansari[3], Roland H. Grabner[1]

[1]University of Graz; [2]University of Georgetown; [3]University of Western Ontario

Research into the cognitive mechanisms of ordinal processing (i.e., the order of elements within a set) has significantly increased over the past years. Findings from this research have indicated that the processing of numerical order relies on specific cognitive mechanisms that constitute unique and reliable predictors of arithmetic abilities. The brain mechanisms associated with ordinal processing remain, however, poorly understood. In the present study, we explored commonalities and differences in the neural architecture associated with the processing of different ordinal formats.
Functional imaging data from 30 adult participants were collected to investigate the neurocognitive mechanisms related to symbolic-numerical (Arabic-digits), symbolic-non-numerical (letters of the alphabet), non-symbolic-numerical (dot-arrays), and non-symbolic-non-numerical ordinal processing (patches of lines). In each condition, three stimuli were presented on a computer screen and participants had to indicate whether the stimuli were displayed in a correct order (e.g., 2 3 4) or incorrect order (e.g., 3 6 4). Arithmetic skills and working memory abilities were assessed in a separate session.
Results of the whole-brain analyses revealed common as well as distinct brain activation pattern. While Arabic digits and letters of the alphabet engaged regions of the frontal cortex (e.g., anterior cingulate gyrus, middle frontal gyrus), dot-arrays and patches of lines activated regions of the parietal cortex (e.g., intraparietal sulcus). This finding indicates a crucial distinction between the neurocognitive mechanisms associated with symbolic and non-symbolic ordinal processing. Correlation analyses will provide further insights about the functional relevance of these brain regions and their associations with behavioral measures.

Young children's responses to harm and injustice – an EEG study

Minkang Kim[1], Ling Wu[1]; Wendy Sae Me Lee[1], Jean Decety[2]

[1]The University of Sydney; [2]Child Neurosuite, The University of Chicago

Recent developmental research shows that preferences towards socially valued behaviours, including the ability to distinguish between valued and not valued behaviours in interpersonal interactions, emerge very early. Evidence suggests they are observable at an age of only three months. Moreover, there is evidence that children's interference in transgressions, in interpersonal contexts, emerges during early childhood and that many 4 to 11 year-old children intervene to prevent undesirable behaviour, even in the face of potentially negative consequences. The study reported in this presentation is being conducted at The University of Sydney, Australia in collaboration with Jean Decety at the Child Neurosuite at the University of Chicago, USA. Their research has provided EEG evidence regarding the brain processes involved when children discern socially valued and not-valued behaviours, but little is currently known about how this correlates with children's actual overt physical reactions, when engaging in real life settings with adults. For example, is a decision to help another or to prevent harm a relatively rapid and automatic emotional reaction, as some have argued, or is it directed by rather slow, effortful and deliberative appraisal of the situation? The current study is beginning to address these questions by investigating correlations between 3 to 5 year-old child's actual behaviours in live interactions with another person and temporal neurodynamics captured by electroencephalogram (EEG) when engaging with series of cartoons (Chicago Moral Sensitivity Task, CMST) that illustrate various interpersonal situations familiar to young children.

Neural and behavioral development of direct versus reflected self-evaluations in adolescence

Renske van der Cruijsen[1], Sabine Peters[1], Eveline A. Crone[1]

[1]Department of Developmental Psychology, Leiden University, the Netherlands

Adolescents are very preoccupied with the opinions of their peers, and reflected self-evaluations play a large role in the construction of the self-concept. Previous studies show that self-concept is strongly related to school achievement in adolescence. We investigated the developmental patterns of the neural correlates of direct and reflected self-evaluations in the academic, physical, and prosocial domain, across the whole age range of adolescence.
In this study, 150 adolescents (80 girls) between 11 and 21 years old participated in an fMRI study in which they performed direct and reflected self-evaluations. Participants evaluated trait sentences describing positive and negative traits in the three domains. They answered the question: 'does this trait describe me?' (direct) or 'do my peers think this trait describes me?' (reflected), on a scale of 1 (not at all) to 4 (completely).
Behavioral results showed that self-evaluations in the youngest adolescents (11-12 years) were more positive from their own perspective than from their peers' perspective. Contrasting brain activation for (1) direct- and (2) reflected self-evaluations versus a control task resulted in largely overlapping brain activations in mPFC, and bilateral TPJ. ROI analyses showed very strong correlations between activation for direct and reflected self-evaluations in these regions. Additionally, in accordance with the behavioral results, we found that the youngest adolescents (11-12 years) engaged stronger mPFC activation when evaluating their traits from a peers' perspective versus from their own perspective.
The results suggest that the perceived opinions of others about the self become adopted in one's self-concept during adolescence.

Neurocognitive processing of arithmetic complexity depends on math ability – An fNIRS study

Christina Artemenko[1,2], Mojtaba Soltanlou[1,2], Thomas Dresler[2,3], Ann-Christine Ehlis[2,3], Hans-Christoph Nuerk[1,2]

[1]Department of Psychology, University of Tuebingen, Germany; [2]LEAD Graduate School & Research Network, University of Tuebingen, Germany; [3]Department of Psychiatry and Psychotherapy, University Hospital of Tuebingen, Germany

Some individuals experience more difficulties in math than others. However, individual differences in math ability matter in particular when arithmetic problems get more complex. Therefore, this study aims at understanding the interaction of math ability and arithmetic complexity on behavioral and neural levels. Previously screened individuals with high and low math ability solved multiplication and division problems while brain activation was assessed by functional near-infrared spectroscopy (fNIRS). Arithmetic complexity was manipulated by using single-digit operands for simple multiplication problems and operands between 2 and 19 for complex multiplication problems and the corresponding division problems. On the behavioral level, individuals with low math ability needed more time for calculation and especially for complex arithmetic. On the neural level, these individuals showed less activation in the left supramarginal gyrus, superior temporal gyrus and inferior frontal gyrus than individuals with high math ability when solving complex compared to simple arithmetic. This indicates that individuals with low math ability fail to efficiently use the resources in the neural network of arithmetic processing and thus experience more difficulties when facing more complex arithmetic problems. We conclude that the consideration of individual differences is essential when investigating the neurocognitive processing of arithmetic. For improving arithmetic performance, strategies which rely on supportive brain areas might be used.

Data-driven subtyping of executive-function-related behavioural problems in children

Joe Bathelt[1], Joni Holmes[1], Duncan Astle[1]

[1]University of Cambridge

Introduction: Executive functions (EF) are cognitive skills important for regulating behavior and achieving goals. Executive function deficits are common in children who struggle in school and are associated with multiple neurodevelopmental disorders. However, there is also considerable heterogeneity across children, even within diagnostic categories. This study took a data-driven approach to identify distinct clusters of children with common profiles of EF-related difficulties, and then identified patterns of brain organisation that distinguish these data-driven groups.
Methods: The sample consisted of 442 children identified by health and educational professionals as having difficulties in attention, learning and/or memory. We applied community clustering, a data-driven clustering algorithm, to group children by similarities on a commonly used rating scale of EF-associated behavioral difficulties, the Conners-3 questionnaire. Furthermore, we then investigated whether the groups identified by the algorithm could be distinguished on white matter connectivity using a structural connectomics approach combined with partial least squares analysis.
Results: The data-driven clustering yielded three distinct groups of children with symptoms of either: (1) elevated inattention and hyperactivity/impulsivity, and poor executive function, (2) learning problems, and (3) aggressive behavior and problems with peer relationships. These groups were associated with significant inter-individual variation in white matter connectivity of the prefrontal and anterior cingulate cortices.
Conclusion: In sum, data-driven classification of EF-related behavioural difficulties identified stable groups of children, provided a good account of inter-individual differences, and aligned closely with underlying neurobiological substrates. These results highlight that data-driven methods provide a powerful tool to characterise heterogeneity of common cognitive difficulties in childhood.

Phasic heart rate changes associated with feedback and letter-speech sound learning in dyslexia

Gorka Fraga González[1], Dirk J.A. Smit[2], Melle J. W. van der Molen[3],Jurgen Tijms[4], Cornelis J. Stam[5], Eco J.C. de Geus[2,6], Maurits W. van der Molen[7]

[1]Rudolf Berlin Center, Amsterdam, Department of Psychology, University of Amsterdam; [2]Department of biological Psychology, VU University, Amsterdam; [3]Leiden Institute for Brain and Cognition, Leiden University; [4]IWAL Institute, Amsterdam, The Netherlands; [5]Department of Clinical Neuropsychology and MEG Center, VU University Medical Center, Amsterdam; [6]Neuroscience Campus Amsterdam, VU University, Amsterdam; [7]Department of Psychology, University of Amsterdam, Amsterdam Brain and Cognition, University of Amsterdam

Behavioral and neuroscientific evidence suggests that a failure to efficiently integrate letters and speech sounds may be a key deficit reading impairments in dyslexia. Besides a widely studied phonological component, the cognitive mechanisms related to associative learning may play a role in dyslexic's impairments. One of these mechanisms is performance monitoring. We used a probability learning task in which associations between new symbols and speech sounds pairs were learned by pressing a left or a right key followed by positive or negative feedback. The feedback could be either informative (consistent trials) or non-informative (inconsistent trials). Performance and heart rate measures were derived from 31 typical readers and 23 dyslexic young adults. Consistent with previous studies we observed anticipatory heart rate slowing to the feedback signal and added heart rate slowing associated with the processing of negative compared to positive feedback. The cardiac response discriminated between negative and positive feedback only on consistent and not inconsistent trials. Interestingly, the overall cardiac response was less pronounced in dyslectic relative to typical readers. Moreover, their response to negative feedback was more sluggish compared to the one exhibited by the typical readers. The current findings suggest that performance monitoring might be compromised in dyslexics.

Intervention on mathematics in students with ADHD

Beatriz Vargas Dorneles[1], Luciana Vellinho Corso[2], Jacqueline Raquel Bianchi Enricone[3], Yasmini Lais Spindler Sperafico[4]

[1]Universidade Federal do Rio Grande do Sul (UFRGS); [2]UFRGS, Nelba Maria Teixeira Pisacco, Universidade Estadual de Ponta Grossa; [3]Universidade Regional Integrada do Alto Uruguai; [4]UFRGS

School performance is often impaired in students with significant attention deficits. Studies indicate that many students with Attention Deficit Hyperactive Disorder (ADHD) have comorbid learning disorders, with rates ranging from 5 to 30% for the presence of ADHD and comorbid mathematics learning disability. Impaired performance among students with ADHD may be related to the core symptoms of the disorder, especially inattention and cognitive impairments in areas that are important for learning, such as the working memory (WM).

This study compared the effects of a combined intervention of working memory (WM) and arithmetic reasoning (AR) vs an intervention on WM alone, on the mathematics performance of students with ADHD. The disorder was clinically diagnosed by a multidisciplinary team of a university hospital linked to the University of the first two authors, according to DSM-IV criteria. Third- and fourth-grade elementary school students (n=46) completed measures for WM, AR, and mathematical calculations. Participants were randomized using a minimization approach taking age and IQ as variables of interest and assigned to one of two groups: G1 (n=24), combined WM/AR intervention; and G2 (n=22), WM intervention alone. The results indicated a significant group × time interaction (Wald χ^2=6.414; gl=2; p=0.04) in AR performance. G1 students showed significantly better performance in AR than G2 students immediately after intervention (pB=0.042). There was a time effect on mathematical calculations in the post-test (Wald χ^2=48.305; gl=2; $p<0.001$). A combined intervention of WM and AR seems to be more efficient in improving mathematics performance in ADHD students than a WM intervention alone.

The neural correlates of academic self-concept in adolescence and their relation to making future-oriented academic choices

Laura van der Aar[1], Sabine Peters[1], Eveline Crone[1],

[1]Leiden University

An important challenge for adolescents is to make future-oriented academic choices that fit with their identity, like choosing a major in higher education. Individual factors, such as how adolescents think about themselves in an academic context (i.e. academic self-concept) might play an important role in this complex decision-making process. In this study, we combined behavioral indices and neural correlates of academic self-concept and related these outcomes to a questionnaire measuring the motivation to make future oriented academic choices. We used a subsample of 48 adolescents that participated in the Leiden Self-Concept study. These participants were in the age-range of 14 – 20 years and indicated to be in one of the final years of secondary education. Academic self-concept was measured with an fMRI task in which participants were presented with 20 short sentences that described positively or negatively valenced traits or competencies in the domain of academics. They could indicate on a scale from 1(not at all) – 4 (completely) to what extent these traits applied to them. Behavioral results showed that academic self-concept, but not academic achievement (e.g. IQ and reading), was related to the motivation to choose a major in higher education. fMRI contrasts for academic self-concept versus a control task resulted in significant brain activations in precuneus and mPFC. Activation in the precuneus specifically, showed to mediate the relation between academic self-concept and the motivation to make future oriented academic choices. Together, these results demonstrate the importance of studying (the neural correlates of) academic self-concept in the educational decision-making process.

Executive functions explain the link between socioeconomic status and mathematical skills in preschoolers

Emma Blakey[1], Danielle Matthews[1], Lucy Cragg[2], Daniel Carroll[1]

[1]University of Sheffield; [2]University of Nottingham

There is a well-established connection between children's SES and their academic attainment, particularly in mathematics (Starkey & Klein, 2008). The gap in mathematical skills between children from higher SES backgrounds and children from lower SES backgrounds starts early and widens over time (Rathbun, West & Hausken, 2004). However, we still have a limited understanding of why this gap is there. We examined whether executive functions – the high-level skills involved in controlling and regulating behaviour – could explain early gaps that we see in mathematical skills before children start school. We tested: 1) whether gaps in mathematical skills between children from higher SES backgrounds and children from lower SES backgrounds exist prior to children starting formal schooling, and 2) whether any effect of SES on mathematical skills is mediated by differences in executive functions. One hundred and eighty-eight preschoolers were recruited from diverse areas of the U.K. Children completed measures of inhibitory control, working memory, mathematics and vocabulary. SES was measured by neighbourhood deprivation index (with almost half of children living in 20% of the most deprived areas of the U.K). SES explained significant variance in both preschoolers' mathematical skills and their executive functions. Furthermore, executive functions mediated the relation between SES and children's mathematical skills. The results suggest that differences in executive functions can explain the gap we see in early mathematical skills between children from advantaged backgrounds and children from disadvantaged backgrounds. The next step is to identify ways to ameliorate this gap early in development.

Theoretical model of arithmetic development and learning in children – evidence from empirical studies

Mojtaba Soltanlou[1], Christina Artemenko[1], Thomas Dresler[1], Hans-Christoph Nuerk[1]

[1]University of Tuebingen

Little is known about the neural correlates of arithmetic development and learning during childhood, the critical age of acquisition of this skill. Based on our own and other neurocognitive studies in children, we propose a theoretical model of arithmetic development, which contains two phases: (i) the neural efficacy (from slow effortful procedural processes to fast compacted procedural processes) and (ii) the neural efficiency (from fast compacted procedural processes to retrieval processes) phases. The model was developed based on two principles of brain function – optimum performance and energy consumption. According to these principles, the brain as a system tries to provide the optimal performance, while concurrently minimizing energy cost.

The model can explain the results of several empirical neurocognitive studies from our lab, which indicated that (i) arithmetic learning in children differs from adults, (ii) arithmetic achievement is not necessarily a shift from procedural to retrieval strategies in children, and (iii) mastering arithmetic complexity is related to domain-general cognitive processes in children.

Taken together, we provide a comprehensive framework for arithmetic development and learning in children. In particular, we suggest that learning and development in children may empirically and theoretically differ from learning in adults. The model might be helpful to develop educational instruction and therapeutic interventions and also a new measure of intervention outcomes in the frame of educational neuroscience. The theoretical model along with some of our empirical neurocognitive studies in children will be discussed.

A new theoretical framework that serves to improve inclusion of neuroscientific insights in school instruction

Nadja Marie Mariager[1]

[1]University of Southern Denmark, Department for the Study of Culture, Education

The scope is to present a new theoretical framework that has the potential to guide high school teachers towards including neuroscientific aspects on learning in their high school instruction.
The theoretical framework provides a new perspective on the interchange between neuroscientific findings and educational practice with a strong emphasis on developmental and behavioural aspects. This perspective enables educators to connect neuroscientific findings with current knowledge about learning in a scholastic context as well as with their experiences concerning the instructional reality of high school learning environments. The framework developed draws on Luhmann's systems theory, specifically emphasising the role of communication between teaching practice and different types of knowledge that serve to inspire high school teachers in their choice of instructional design.
Luhmann's systems theory is applied exploratively in order to describe the knowledge domain that revolves around neuroscientific insights on learning. This description involves different analyses and models of this knowledge domain based on reviews of scientific literature as well as interviews and observations of researchers involved in relevant research. The empirical insights have been conducted at UCSD, California as well as other research labs in the US, UK and Denmark. Lastly, main points from focus group interviews with Danish high school teachers will be highlighted with the purpose of shedding light on the potential usefulness of applying the theoretical framework in practice.

Brain space: Improving spatial thinking with instructional videos

Katie A. Gilligan[1], Michael S.C. Thomas[2], Emily K. Farran[1]

[1]UCL Institute of Education, University College London; [2]Birkbeck, University of London

This study investigates the effectiveness of instructional videos as a novel method of improving spatial skills and subsequently mathematics performance in children aged 6-8 years (N = 247). These instructional videos teach mental rotation and spatial scaling, spatial skills that have been identified as important predictors of mathematics for children (6-8 years). The use of instructional videos as a spatial training tool was compared to traditional spatial training (practice with feedback) and to control conditions (no spatial training). Participants completed a battery of spatial and mathematics measures both pre, and immediately post-training. These measures included: a spatial scaling task; a mental rotation task; and three mathematics tasks (a number-line estimation task; a geometry task, and a missing box calculation task).

Provisional findings show that spatial training using instructional videos leads to significant gains in spatial performance compared to control conditions, i.e. video training in rotation and scaling leads to significant gains in rotation and scaling accuracy respectively. Furthermore, following video training in spatial scaling, improvements in mental rotation accuracy and number-line estimation were also reported. No transfer effects were seen for video training in mental rotation. This suggests that transfer of spatial training gains may be specific to certain spatial skills. The findings suggest that instructional videos offer a fast, effective means of training spatial thinking, with knock on improvements for some mathematics outcomes. These results have extended implications for improving both mathematics, and Science, Technology, Engineering and Mathematics (STEM) outcomes more generally.

Effects of anodal tDCS on arithmetic performance and electrophysiological activity

Jochen A. Mosbacher[1], Clemens Brunner[1], Roland H. Grabner[1]

[1]University of Graz

Arithmetic abilities are among the most important school-taught skills and lay the basis for higher mathematical competencies. At the same time, their acquisition and application can be challenging. Hence, there is broad interest in methods to improve arithmetic abilities. One promising method is transcranial direct current stimulation (tDCS). In the present study, we compared two anodal tDCS protocols in their efficacy to improve arithmetic abilities and investigated stimulation-related electrophysiological changes. Three groups of participants solved arithmetic problems (additions and subtractions) before, during, and after receiving either frontal (N=24) or parietal (N=23) anodal tDCS (25 minutes; 1 mA) or sham stimulation (N=25). EEG was simultaneously recorded to assess stimulation effects on event-related (de-)synchronisation (ERD/ERS) in the theta and alpha bands.

In large subtractions, results showed an increased calculation speed in the persons receiving frontal stimulation, apparent during and after stimulation as compared to prior to stimulation. A comparable, but delayed (apparent only after stimulation) increase was found in the sham stimulation group, while it was absent in the group receiving parietal stimulation. Accompanying, preliminary results of ERD/ERS during large subtractions indicate a trend for a widespread increase in theta band ERS from prior to after the stimulation in the frontal and sham stimulation groups, but not for parietal stimulation. Analyses showed no effects for additions and small subtractions.

Taken together, tDCS did not improve arithmetic performance. However, frontal stimulation accelerated training gains, while parietal stimulation halted them. These location-based differences might emerge from the stimulations differentially influencing theta band ERS.

Improving teaching with research from the learning sciences

Tracey Tokuhama-Espinosa[1]

[1]Harvard University Extension School and the Latin American Faculty For Social Science Research in Ecuador

The changing teacher profile in the 21st century requires new skill sets, including knowledge of the brain and how it learns (Guerrero, 2017). The transdisciplinary field of Mind (psychology), Brain (neuroscience), and Education seeks to formalize a credible foundation for this new knowledge base. While many university teacher training programs are open to this idea, they are cautious as well-researched, evidence-based sources are scarce.

As new parameters for teacher education programs evolve, there are many open debates, which were used to establish six research questions. One-hundred and nine (109) invitations were sent to experts in the fields of neuroscience, psychology and education who were asked to reach consensus on answers these questions, 41 of whom complied. These experts came from 11 different countries (Argentina, Australia, Austria, Brazil, Canada, Chile, Germany, Holland, Slovenia, USA, and UK).

The modified Delphi technique and literature review identified contributions towards better teacher education, including specific content area knowledge about the brain and learning: Principles (n=6) or concepts that are true for all human learning ("well-established"); Tenets (n=21) or concepts that are true for human learning, but which have a high degree of human variation ("probably so"); and Neuromyths (n=70) ("false beliefs about the brain"). There was no agreement, however, on specific teaching guidelines and many calls for caution in sharing "sound bites" or brief summaries of the information, rather than teaching teachers how to understand the studies behind the recommendations.

More research is needed to determine mechanisms to integrate these findings into basic teacher education.

Value of a set of neuroscience concepts for lesson planning

Vicki Hinesley[1], Janet M Dubinsky[2], Zhengsi Chang[3], Marc Schwartz[1]

[1]University of TX Arlington; [2]Dept. Neuroscience, University of Minnesota, Minneapolis; [3]University of Texas at Dallas

In May 2016, fourteen teachers took part in a master's level course, Neuroscience for Educators, a course based on ten "educational neuroconcepts" (Dubinsky et al 2013 Educ Res 42(6):317-329). As a follow-up, we evaluated the impact of the neuroconcepts on the teacher's pedagogical decisions. Specifically, we were interested in which neuroconcepts influenced their practice and how. To assess both questions, all 14 teachers responded to a retrospective survey in the spring of 2017, requiring teachers to rate how often they applied each neuroconcept to their lessons prior to the course and currently and how often they envisioned applying them in the future. Retrospectively, teachers estimated that prior to the course the neuroconcepts played a role in their lessons 51 +/- 20% of the time. However the estimate of their role in future lessons increased significantly to 90 +/- 6.9%. A subset of 6 teachers took part in classroom observations in the spring of 2017. Before in-class observations, teachers provided the observer with a brief overview of those neuroconcept(s) applied to the observed lesson. Afterwards, teachers were interviewed to explain their rationale for the role(s) the neuroconcepts played in the observed pedagogy. The most cited neuroconcepts focused on synaptic plasticity, safe environments, and how salience, application, self-evaluation and rehearsal strengthen learning. This set of teachers represented a wide cross-section of K-12 ages and content specializations. Together these data indicate direct, lasting applicability and relevance of basic neuroscience knowledge to a broad spectrum of teaching practices.

More than number sense: Associations between cognitive control, metacognition and arithmetic in primary school

Elien Bellon[1], Wim Fias[2], Bert De Smedt[1]

[1]KU Leuven; [2]Ghent University

This longitudinal study jointly investigated two important domain-general predictors (i.e., cognitive control and metacognition) and one domain-specific predictor (i.e., numerical magnitude processing) of individual differences in arithmetic. To date, there is a lot of ambiguity about the specific and unique roles of these factors in addition to each other, as well as about their predictive roles. We investigated this issue in 127 typically developing 2nd graders and followed them up one year later (3rd grade). We used experimental task to investigate cognitive control (n-back task, WCST, Flanker task and animal Stroop task), metacognition (trial-by-trial confidence rating after the arithmetic items) and numerical magnitude processing (single digit comparison task). Both frequentist and Bayesian statistics were used to investigate how cognitive control, metacognition and numerical magnitude processing were (jointly) related to arithmetic. Our findings revealed that calibration of confidence and numerical magnitude processing were significantly related to arithmetic in both grades. Regression analyses revealed that calibration of confidence and numerical magnitude processing remained unique predictors of arithmetic in addition to each other in both grades. Inhibition was a unique predictor of addition in second, but not in third grade. Growth in response time in arithmetic was predicted by calibration of confidence in second grade. These data stress the importance of children's calibration of confidence, which should be considered as an important variable in studies on children's arithmetic performance and at the level of (mathematics) education, where children can be learned to identify their own errors and consequently learn from their mistakes.

The integration of science of learning into secondary initial teacher education

Paul Howard-Jones[1], Jayne Prior[1], Ruth Bailey[1], Konstantina Ioannou[1]

[1]University of Bristol

Teachers base daily decisions about practice on their understanding of how learning occurs, and their training can be considered as a foundational period during which their models of learning form. This paper explores the potential of Science of Learning (SoL) concepts to prompt insights in aspects that include planning, management and teaching strategies, differentiation and pastoral care. Specifically, the SoL concepts were introduced into the secondary PGCE course across eight subject areas. Interdisciplinary collaborative research resulted in the development and trialing of resources focused on supporting critical reflection, assessment and monitoring of practice amongst trainee teachers, as well as the scaffolding of talk and use of language around learning involving SoL concepts. An instrument was designed to evaluate the scientific understanding of learning amongst the student teachers, and this was administered twice (towards the beginning and end of the course) to monitor the development of SoL understanding. Based on the results of the project, possible characteristics for the successful implementation and integration of such perspective are proposed and discussed.

Enhancing human spatial skills: neurofeedback, machine learning and optimal performance - the case of upper alpha and mental rotation

Miriam Reiner[1]

[1]The Virtual Reality and Neurocognition lab, Technion, Israel

What is the mechanism that enables humans to identify a familiar object, when viewing from a variety of viewpoints, that they have never seen before? The projection on the retina –shape and colors-- changes with the spatial viewpoint. In spite of the different projections, humans identify the two as images of the same object. The underlying process is a mental mechanism of mental rotation, while preserving the perceived shape and features. The ability to rotate objects is fundamental in both everyday life and in academic learning, e.g. science/math/engineering. Indeed, many inventions are associated with mental manipulation, or 'seeing with the mind's eye'. Given the crucial fundamentality of mental rotation – can it be enhanced, beyond repetitive practice? Recent findings suggest a link between upper alpha brain oscillations and mental rotation. Here we used neurofeedback strategies to test the effect of elevated upper alpha (multiple sessions) on accuracy and speed of mental rotation. We then compared their performance with the controls. Results show that: the power of the upper alpha is positively correlated with the progression of training; that the experimental group achieved significantly higher speed and accuracy of mental rotation compared to the controls; low performers improved more; Using machine learning to further enhance controlling oscillations, showed further improvement in speed and accuracy of mental rotation both generally and in a physics 'right-hand-rule' problems, that require also mental rotation.