Neuroscience and education

2016 Meeting of the EARLI SIG 22

June 23-25, 2016
Royal Tropical Institute,
Amsterdam, the Netherlands
The 4th biennial meeting of

Neuroscience and Education

The Special Interest Group (SIG) 22 of the European Association for Research on Learning and Instruction (EARLI)

Hosted by
The Department of Educational Neuroscience, Faculty of Behavioural and Movement Sciences, Vrije Universiteit Amsterdam

23rd to the 25th of June 2016, Amsterdam, the Netherlands
Dear Participants,

We are very glad to welcome you to the 4th biennial meeting of the Special Interest Group (SIG) 22 Neuroscience and Education of the European Association for Research on Learning and Instruction (EARLI).

The aim of this conference is to bring together researchers from the fields of educational research, cognitive and developmental psychology, and cognitive neuroscience to discuss scientific research on human learning and development and the translation of research findings to the field of education. Within this conference, a wide range of topics in the field Neuroscience and Education is presented to you in the form of keynote lectures, oral presentations, and poster presentations. In addition, we present a symposium especially dedicated to discussing the use of neuroscience in the classroom.

Moreover, we are very pleased to announce that at this SIG22 conference the Dutch Research Agenda on Brain, Cognition, and Education will be presented. This agenda stimulates a new research approach that makes use of brain scan technology to investigate how learning processes take place at a deeper, more detailed level.

We hope you will have an inspiring, interesting, and fruitful Neuroscience and Education conference!

On behalf of the organization committee,

Nienke van Atteveldt,  
Vrije Universiteit Amsterdam, the Netherlands

Local organisation committee
Dr. Nienke van Atteveldt, Vrije Universiteit Amsterdam, the Netherlands  
Dr. Marlieke van Kesteren Vrije Universiteit Amsterdam, the Netherlands  
Dr. Iro Xenidou-Dervou, Loughborough University, UK  
Dr. Sandra van Aalderen-Smeets, University of Twente, the Netherlands  
Prof. Dr. Lydia Krabbendam, Vrije Universiteit Amsterdam, the Netherlands

Scientific Programme Committee
Dr. Roland H. Grabner, University of Graz, Austria  
Dr. Nienke van Atteveldt, Vrije Universiteit, Amsterdam, the Netherlands  
Dr. Bert de Smedt, University of Leuven, Belgium  
Dr. Iro Xenidou-Dervou, Loughborough University, UK  
Dr. Marlieke van Kesteren, Vrije Universiteit, Amsterdam, the Netherlands
By Prof.dr. Eveline Crone  
Chairman Brain, Cognition and Education Committee

At this conference we present the research agenda of the Brain, Cognition and Education Committee. It is an ambitious programme because we want to make an innovative contribution to education in the Netherlands, based on international developments in this emerging research area. In this research agenda, we call for a new research approach that makes use of brain scan technology to investigate how learning processes take place at a deeper, more detailed level.

We focus on four coherent research themes:

1. learning processes that focus on the knowledge and skills required in the 21st century
2. the education contexts that help children and adults achieve optimum success
3. the role of social interaction and collaborative learning in the learning process
4. optimising access to lifelong learning for all

This is the first research agenda to bridge and integrate formerly separate research themes concerning neural, cognitive and social aspects of learning processes in laboratory situations and classrooms. Our aim is to research what works for which individual, but in particular under which conditions an optimum learning process is achieved for which individual, the added benefit of social interactions during learning and how to achieve access and inclusion for all.

These questions are also the focus of the Dutch National Research Agenda (Nationale Wetenschapsagenda), which confirms the urgency of the research to society in particular. Combining brain research with other modern research methods such as big data, longitudinal approaches, design-based research and complex visualisations can also offer interesting opportunities for the further investigation of these questions. However, we are convinced that the cross-sectoral research themes named in this agenda can provide answers to these questions; answers that will contribute to personal, inspiring education for every individual and that will give the next generation the best possible foundation for the future.

This research agenda is a joint publication of the National Initiative Brain and Cognition and the Netherlands Initiative for Education Research.
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Thursday June 23rd

13.30 Walk-in with coffee/tea

14.00 Welcome address by Nienke van Atteveldt, VU University Amsterdam, the Netherlands

14.30 Presentation of the Research Agenda on Brain, Cognition, and Education by Prof.dr. Eveline Crone, Leiden University, the Netherlands

14.45 Keynote lecture 1: Stimulating the human brain to enhance learning and cognition: The parts are larger than the sum
Roi Cohen Kadosh, Oxford University, UK

15.45 Coffee break

16.15 Oral session 1. Chair: Bert de Smedt, KU Leuven, Belgium
   16.15 Comparison of ratios: The role of congruity and salience
       Babai Reuven, Tel Aviv University, Israel
   16.40 Specialization of the right intraparietal sulcus for processing mathematics during development
       Margot Schel, Karolinska Institute, Sweden
   17.05 Looking into the mind through the eyes: Children solve analogies differently than adults
       Rosa Alberto, Leiden University, the Netherlands
   17.30 The Seductive Allure of Educational Neuroscience
       Soo-hyun Im, University of Minnesota- Twin Cities, USA

18.00 End of the day
Friday June 24th

08.30 Walk-in with coffee/tea
09.00 Keynote lecture 2: **Social cognition in the classroom**
   *Lydia Krabbendam, Vrije Universiteit Amsterdam, Netherlands*

10.00 Poster session A and coffee break

11.15 Symposium: Neuroscience in the classroom. *Chair: Ido Davidesco, New York University, USA*
   11.15 **Introduction by Ido Davidesco**
   11.20 **Brain-to-brain synchrony in the classroom: utilizing portable EEG in schools to integrate research and education**
   *Suzanne Dikker & Ido Davidesco, Utrecht University & New York University*
   11.50 **Translating neuroscientific research on memory formation to meet classroom practice: an approach to empower teachers and students to innovate and improve their teaching and learning**
   *Efrat Furst, NeuroEducation practitioner, Boston, USA*
   12.15 **The effects of neuro-education on students' implicit beliefs about intelligence, their STEM-related belief-system and STEM performance**
   *Sandra van Aalderen, Twente University, the Netherlands*
   12.40 Chaired open discussion with all presenters

13.00 Lunch break (on your own)

14.30 Keynote lecture 3
   **The brain basis of knowledge and knowledge acquisition**
   *Guillén Fernández, Donders Institute, Nijmegen, Netherlands*

15.30 Poster session B and coffee break
16.45  Oral session 2. Chair: Daniel Ansari, The University of Western Ontario, Canada

16.45  **Reading Modifies the Auditory Cortical Representation of Speech**
Milene Bonte, Maastricht University, The Netherlands

17.10  **Form similarity between new and existing words influences learning**
Gabriela Meade, San Diego State University & University of California, USA; Radboud University Nijmegen, the Netherlands

17.35  **Stress-associated brain activation and its association to stress coping strategies in adolescents**
Sabrina Golde, Charité - Universitätsmedizin Berlin, Germany

18.00  **Core knowledge of geometry develops independently from vision**
Benedetta Heimler, Hebrew University of Jerusalem, Israel

18.30  End of the day

19.30  Conference dinner (pick up near conference venue)
Saturday June 25th

8.45  Walk in with coffee/tea

9.15  Keynote lecture 4: **Is cognitive control development in childhood and adolescence relevant to education?**  
      *Iroise Dumontheil, Birkbeck, University of London, UK*

10.15 Poster session C and coffee break

11.30 Keynote lecture 5: **Adapting brains for visual symbolic processing in reading and math**  
       *Bruce McCandliss, Stanford University, USA*

12.30 Closing Address (including the announcement of the Poster Award),  
       *by Roland Grabner, University of Graz, Austria*

13.00 End of the conference
The Royal Tropical Institute (KIT) was founded in 1910 as the ‘Colonial Institute’ to study the tropics and to promote trade and industry in the (at that time) colonial territories of the Netherlands. It was founded on the initiative of a number of large companies, with government support, making it an early example of a public-private partnership.

Since 1926, KIT has been housed in a historic building at the edge of the Oosterpark specially designed by the architect J.J. van Nieukerken and his sons. The building is richly adorned with decorative features and symbols referring to different cultures of the world and the colonial history of the Netherlands.

KIT aims to improve health and ensure equitable social-economic development as much as promote intercultural cooperation with our partners worldwide. As we focus on results and empowering people our research, advice, training and education are creative, context specific and evidence-based. We are an innovative organisation with more than 100 years of experience all over the world. A global host in our very own international knowledge hub in Amsterdam.

For more information see www.kit.nl.

The Royal Tropical Institute is part of a large building complex, which also houses the Tropical Museum. Please note that the entrance to the conference is the one on Mauritskade 63, and NOT the Museum entrance (Linnaeusstraat 2). The museum is definitely worth a visit though.

**Visiting address conference venue**
Mauritskade 63
1092 AD Amsterdam

**Central reception & information:**
T + 31 (0)20 568 8711
F + 31 (0)20 668 4579
In case of emergency
In case of serious injury or fire call the Dutch emergency number: 112

Getting around
The address of the Royal Tropical Institute is: Mauritskade 63, 1092 AD, Amsterdam. The Institute is part of a large building complex, which also houses the Tropical Museum. Please note that the entrance to the conference is the one on Mauritskade 63, and not the Museum entrance (Linnaeusstraat 2).

By public transport
From Amsterdam Central Station there are many public transportation options to reach the conference venue (please see www.9292.nl/en). The fastest option is taking tram 9 and getting off at Alexanderplein. You can purchase single tickets on the tram. If you plan to use public transport more often, then it would be better to opt for a re-chargeable chip-card (this can be used at trams, metro and the trains: www.ov-chipkaart.nl/apply-1/which-card-is-right-for-you/tourists.htm).

By bike
The best way to get around in Amsterdam is by bike! You can find bike rental shops all around the city but you can find some recommendations to get you started at www.iamsterdam.com/en/visiting/plan-your-trip/getting-around/rental/bike-hire.

By car
Leave the ring road A10 via the exit Watergraafsmeer/ Diemen (S113): follow the Middenweg (direction Centrum/ Watergraafsmeer), which turns into the Linnaeusstraat. The Royal Tropical Institute is at the corner of the Mauritskade.

Parking
Parking space at the conference venue (Tropen Hotel’s parking, Linnaeusstraat 2C, Amsterdam) must be booked via Moby Park: https://www.mobypark.com/carpark/276/show
There are also on-street parking areas near the Royal Tropical Institute. Please note that all parking in the center of Amsterdam is metered from Monday through Saturday, 09:00 to 24:00 hrs (EUR4/hour) and on Sunday from 12:00 to 24:00. For rates and other parking information, please visit http://www.bereikbaaramsterdam.nl. Parking meters take pin (maestro) and credit cards.

Conference Dinner
The conference dinner will be held on Friday, June 24th, on a luxurious private boat, which will take us on a wonderful canal cruise in Amsterdam. When you have registered for the conference dinner, you will be picked-up by the boat from the wharf near the conference location at 19.30. The conference dinner will end around 21.30, and we will be dropped off again at the wharf near the venue.
Crew
Our crew of students will be present to assist you with any problems of questions regarding the conference or practical issues. They are recognizable by their blue SIG22 t-shirts.

Information for oral presenters
Oral sessions and the symposium are in the Grote Zaal (main lecture hall). We have a Windows 10 laptop (PowerPoint 2016) available, please upload your presentation 30 min. before your session (during the break). Crew members (blue SIG22 shirts) will be available to assist.

Information for poster presenters
Poster sessions are at the upstairs balcony (the “Rotonde”). Authors are asked to present their posters during the assigned session. A jury will be scoring the posters during the presentations; the winner of the award will be announced during the closing address. The following criteria will be used by the jury: 1) scientific quality, 2) on-site performance and 3) how well your poster bridges neuroscience and education.

For presenters in session A (Friday June 24th, 10.00 -11.15): please put up your poster between 8.30 – 9.00 AM (on Friday 24th), and take it down either at the end of session A or at the beginning of the lunch break.
For presenters in session B (Friday June 24th, 15.30-16.45), please put up your poster during the lunch break, and take it down either at the end of session B or at the end of the day.
For presenters in session C (Saturday June 25th, 10.15 -11.30): please put up your poster between 8.45-9.15 AM (Saturday) and take it down at the end of the session.

Location of the sessions
All keynote lectures, oral presentations, and the symposium will be held in the main lecture room (“Grote Zaal”) at the KIT. The posters are presented on the upstairs balcony (“Rotonde”). The registration desk will be located in the reception area (“Marble hall”), this is also where coffee and tea will be served. See http://www.kitmeetingsandevenets.nl/en

Lunch locations
Lunch is not included in the conference. There is a range of different lunch options nearby the conference venue (also see map on page 13):
• Grand Café De Tropen (http://amsterdamdetropen.nl/?lang=en): the cafe of the Tropenmuseum, around the corner from the conference venue.
• Pata negra 2 (http://patanegra2.nl/) Authentic tapas-bar/restaurant.
• De Biertuin (http://www.debiertuin.nl/). Beer garden. Famous for their chicken wings and all other stuff that goes well with beer
• Louie louie (http://www.louielouie.nl/menu.html)
• Spargo (http://www.cafespargo.nl/)
• Café Milo (http://www.caffemilo.com/over-ons) - Italian-American cuisine
• Elkaar (http://www.etenbijelkaar.nl/en). Mediterranean-French cuisine
• For more lunch options, we recommend the following website: http://en.iens.nl/restaurant/amsterdam/oost
Twitter
Twittering? Follow @EarliSig22 and use the hashtag #EarliSIG22 for conference related tweets.

WIFI
Network: Meetings & Events
Password: Welcomebyevents
Surroundings of the KIT
Stimulating the Human Brain to Enhance Learning and Cognition: The Parts are Larger than the Sum

Roi Cohen Kadosh, 
Oxford University, UK

Thursday June 23rd, 14.45 - 15.45

Fluid cognitive skills, such as working memory, reasoning, and mathematics, are critical in most academic settings. Current attempts to improve cognitive skills in children and adults have yielded mixed results and limited evidence of transfer beyond the immediate cognitive training materials. These failures have led some to suggest that cognitive skills are fixed. Another suggestion is that these failures are due to suboptimal approaches to exploit neuroplasticity. An innovative method to modulate neuroplasticity is using brain stimulation, with the assumption that concurrent brain stimulation and cognitive intervention interact synergistically, enhancing the benefits derived from the intervention. However, researchers have questioned the utility of brain stimulation for these purposes, leading to the imperative question: can brain stimulation produce genuine cognitive enhancement? By discussing the putative mechanisms of brain stimulation application, in this case random noise stimulation, during training of arithmetic and executive functions, I will demonstrate that a between-groups comparison such as active stimulation versus sham stimulation can produce misleading results. Instead, integrating relevant neurophysiological and psychological measures at the interindividual-level can substantially increase the precision of conclusions about the efficacy of brain stimulation. These results lead to the idea that a consideration of the parts, (e.g., the neurocognitive factors characterising the individuals in the experiment) can lead to a much clearer understanding of effects than considering only the sum, (e.g., the group they belong to). This approach yields basic and translational benefits. It would enable the improvement and individualisation of interventions, and produce a better understanding of the underlying neurocognitive mechanisms.
Adolescence is a developmental phase characterized by risks and opportunities. Navigating the increasingly complex social world is a challenge, and at the same time offers rich opportunities to learn new social skills. Understanding the cognitive and neural mechanisms underlying social development in adolescence may aid the fostering of social competence. An important social developmental goal is learning whom to trust. Trusting others can be risky, and therefore requires a sensitivity to the other person’s perspective. There is evidence that perspective-taking skills are still developing during adolescence. How does this impact on their disposition to trust and cooperate? In my presentation, I will draw on behavioural and neuroimaging studies investigating trust and cooperation during the adolescent years. In the first behavioural study, trusting behaviour and perspective-taking were assessed in 200 adolescents. Trust was experimentally assessed using a trust game, in which the first player can express trust in the second player by investing money. The results suggest that increased perspective-taking ability was negatively related to expression of trust, but only in adolescents with a proself orientation. In the second study, better perspective-taking was associated with a stronger decline in trust in response to unfair behaviour from the other player in the trust game. In the third study, we used two trust games with a trustworthy and an unfair partner to explore the neural mechanisms underlying trust in subjects ranging from adolescence to mid-adulthood. Increasing age was associated with higher trust at the onset of social interactions, increased levels of trust during interactions with a trustworthy partner and a stronger decline in trust during interactions with an unfair partner. The findings demonstrate a behavioural shift towards higher trust and an age-related increase in the sensitivity to others’ negative social signals. Increased brain activation in mentalising regions, i.e. temporo-parietal junction and precuneus, supported the behavioural change. Together, the results suggest that sensitivity to the other person’s perspective is crucially involved in decisions to trust or not trust in adolescence. I will discuss these findings in view of their relevance to education.
The brain basis of knowledge and knowledge acquisition

Guillén Fernández
Donders Institute for Brain, Cognition and Behavior, Radboud University Medical Center, Nijmegen, The Netherlands

Friday June 24th, 14.30 - 15.30

The acquisition, integration and use of our entire knowledge represent a massive mnemonic operation including memory formation, consolidation and retrieval. Although neuroscientific research over the past 60 years has provided substantial insight in these operations we are far from understanding the brain basis of knowledge. Functional neuroimaging has delineated and characterized a set of mnemonic operations underlying formation, consolidation and retrieval, but those appear most relevant for episodic memory, the kind of memory that enables us to remember specific events of our past. It is, however, unclear whether such episodic memories represent the basis of knowledge which is typically thought to be devoid of specific episodic detail. There are currently two models discussed how episodic memory and knowledge may interact. One kind of models proposes that episodic memories are decontextualized by consolidation leading to generalized knowledge and other models suggest that an a-contextual memory is augmented by episodic detail during memory formation. Here I will provide relevant empirical evidence for a third option, in which two memory systems, one optimized for structured knowledge and one for salient information relevant for survival are working in parallel though balanced dynamically. As I will show there is initial support for a model in which hippocampal and medial prefrontal contributions to memory formation are dynamically balanced depending on the ease by which new information can be integrated into existing knowledge structures (i.e., schemas). I will present functional neuroimaging studies probing schema-related memory formation and retrieval at the level of local activity, multi-voxel activity pattern and network properties. Results suggest that the medial prefrontal cortex links, during schema encoding, consolidation and retrieval, representations in posterior brain areas, potentially forming the brain-basis of knowledge. I will conclude with presenting initial empirical data that is educationally relevant and discuss how this insight might stimulate educational research.
Is cognitive control development in childhood and adolescence relevant to education?

Dr. Iroise Dumontheil
Department of Psychological Sciences, Birkbeck, University of London, UK

Saturday June 25th, 9.15 – 10.15

Cognitive control refers broadly to the mechanisms underlying the regulation, coordination and sequencing of thoughts and actions in goal-directed behaviour. Cognitive control is supported by a broad fronto-parietal network of brain regions, where both grey and white matter show prolonged maturation into adolescence and early adulthood. Particular aspects of cognitive control, or executive functions, have been the focus of developmental psychology and developmental cognitive neuroscience research. This research has demonstrated extensive improvements in working memory, inhibitory control and task switching during childhood and adolescence, as well as changes in the structural and functional neural correlates of these functions. Further, individual differences in executive function tasks performance have been associated with brain structural and functional differences. More complex cognitive control skills, such as strategy use, error monitoring and reasoning, have not been studied as extensively but also show prolonged development during childhood and adolescence. In a second section, I will discuss observed associations between individual differences in cognitive control and academic performance, focusing in particular on the domain of mathematics. I will highlight the different approaches used to investigate these associations, from correlational studies to dual task paradigms, the need to develop more complex models relating individual executive functions to components of mathematical knowledge, and the proposed implications of this research. I will end by investigating whether executive function skills, and their underlying brain networks, can be trained with an aim to improve academic performance. Computerised training games are thought to enhance the functioning of the fronto-parietal executive functions network and its influence on posterior cortical regions by repeatedly recruiting these networks and strengthening their functional connectivity. I will review additional strands of research assessing whether executive function skills can be trained with approaches that are not computerised and/or focus on metacognition and strategy, such as mindfulness meditation or a strategic use of inhibitory control.
Adapting brains for visual symbolic processing in reading and math.

Prof. Bruce McCandliss,
Department of Psychology, Graduate School of Education, Stanford Neurosciences Institute, Stanford University, U.S.A.

Saturday June 25th, 11.30 – 12.30
Educational experiences in early elementary school, when successful, drive dramatic cognitive transformations in cognitive abilities, such as the emergence of literacy and mathematical skills. Both of these emerging abilities rests on changes within brain systems that allow visual symbols to be fluently and precisely integrated with other functional brain systems. Thus the initial mastery of visual symbols within education creates fruitful ground for research that links changes in brain systems with educational experiences. This talk will review recent advances in understanding the changes that occur over the first years of elementary school education that enable the emergence of visual symbolic processing in reading and mathematics. By imaging the changes in brain circuitry that occur over the early years of elementary school when visual symbolic processing emerges, we gain insights into questions about how learning experiences lead to changes in these neural circuits, questions about why some children face challenges in making these changes, and questions about why some teachers and educational technologies might be particularly effective in addressing these challenges. By contrasting these changes across the visual symbol domains of reading and mathematics we gain insights into generalities across these different neural pathways, as well as insights into domain specific processes that are unique to each. An emerging theme across these studies centers on the importance of top-down, goal directed attentional processes that drive activation within specific neural systems within a given moment, across a series of learning epochs, and across a child’s early education. Better understanding such processes may open a new form of collaboration between cognitive neuroscience constructs that seek to find mechanisms of change within neural systems and pedagogical techniques that aim to overcome challenges in developing robust visual symbolic skills in a wide range of children.
Oral Session 1 –
Thursday June 23rd, 16.15-17.55
Chair: Bert de Smedt, KU Leuven, Belgium

Comparison of ratios: The role of congruity and salience
16.15-16.40
Babai Reuven¹, Arava Y Kallai², Ruth Stavy¹
1. Tel Aviv University, Israel, 2. Emek Yezreel College, Israel

Proportional reasoning (comparison of ratios) is widely used in science, mathematics, and in everyday life and is difficult for children and adults. We studied the role of salience, congruity and their interaction in comparison of ratios using reaction time and fMRI. Participants were asked to decide which of two mixtures of red and white paint drops was darker (i.e., larger ratio between the number of red and white paint drops). Numbers of red and white paint drops were presented by Arabic numerals (without mathematical symbols). In congruent trials the mixture with the larger number of red drops was darker and in incongruent trials it was lighter. In each condition, half of the trials were red salience (more red than white drops in both mixtures; ratio>1) and half of them were white salience (ratio<1). High-school students were testedbehaviorally and showed an interaction between congruity and salience: Accuracy was higher and RT was shorter in congruent red salience and incongruent white salience conditions as compared to congruent white salience and incongruent red salience. Brain imaging of skilled adults also showed this interaction. Higher activation in a fronto-parietal numerical network was observed in congruent red salience and in incongruent white salience conditions as compared to the other two conditions. This suggests that the automatic processing of natural numbers of the salient color supports or suppress the comparison of ratios as a function of congruity.

Specialization of the right intraparietal sulcus for processing mathematics during development
16.40-17.05
Margot Schel¹, Torkel Klingberg¹
1. Karolinska Institute, Stockholm, Sweden

Mathematical abilities, especially the perception of numbers and performance of arithmetic, are associated with both structure and function of the intraparietal sulcus (IPS). Nonverbal reasoning and visuospatial working memory, two abilities highly related to mathematics, are also associated with IPS. However, because of the use of group averages and the large individual variation in IPS anatomy, most studies confound the anatomical specificity when localizing these cognitive functions. In the current study, we used individually defined IPS subregions based on the pattern of structural connectivity with frontal, parietal, and occipital cortex. In a sample of 44 6-year-old children, cortical thickness in the right anterior IPS, as defined by its connections to the frontal cortex, was associated with both mathematics and visuospatial working memory. In an independent sample of 66 participants, aged 6-25, who were scanned 1-3 times at a 2-year interval, we next found that this right anterior IPS region specialized during childhood to be specifically related to mathematics and not visuospatial working memory in participants older than 12 years of age. This could be an example of interactive specialization, where interacting with the environment in combination with interactions between cortical regions leads from a more general role of right anterior IPS in spatial processing in childhood, to a specialization of this region for processing mathematics during development.
Looking into the mind through the eyes: Children solve analogies differently than adults

17.05-17.30
Rosa Alberto¹, Claire Stevenson¹, Jean-Pierre Thibaut²
1. Leiden University, the Netherlands, 2. Université Bourgogne Franche-Comté, France

Analogical reasoning is central to children's learning; analogies are pervasive in education and used as a tool to teach and transfer knowledge. Knowing how this learning mechanism works is key. Eye tracking techniques are used to understand cognitive processes and as such provide insight into how and which information is captured. Research has, although sparsely, shown that children and adults differ in their analogy solving approach; they focus on different information and use disparate search strategies. However, conclusions about strategy use are almost exclusively based on static eye movements, thereby limiting insight into the temporal dynamics of strategy use. Therefore we compared 37 children and 31 adults who solved five analogies using three increasingly detailed eye-movement analyses with: (1) information that was generally extracted (static), (2) information extracted in the beginning, middle and end of the search (phasic), and (3) the temporal order in which information was extracted (scanpaths). The three approaches indicated that children focused throughout their search mainly on the answer options, whereas adults' main focus was on the analogy itself. These findings point to strategic differences; children tend to use a superficial (error-prone) strategy, whereas adults used a thorough problem-model strategy. An important implication is that expert/adult strategies may be used as a basis to train children's analogical reasoning and knowledge transfer.

The Seductive Allure of Educational Neuroscience

17.30-17.55
Soo-hyun Im¹, Keisha Varma¹, Sashank Varma¹
1. University of Minnesota-Twin Cities, USA

The seductive allure of neuroscience (SAN) effect is that people overweight psychological arguments when they are framed in terms of neuroscience findings. The current study extended this finding to the evaluation of educational articles. We developed eight educational articles that orthogonally varied two topics (learning vs. development) with two approaches (cognitive vs. affective). Four versions of each article were created that progressively increased the level of neuroscience framing: 1) psychological finding alone, 2) with an extraneous neuroscience finding, 3) with an extraneous neuroscience finding and graph (bar or line), and 4) with an extraneous neuroscience finding and brain image. We recruited 320 participants through Amazon MTurk and randomly assigned them to one of the four levels of neuroscience framing. They rated the credibility of each article's argument on a Likert scale. There was a SAN effect, with participants rating educational articles as more credible when 4) they were accompanied with both an extraneous neuroscience finding and brain image. This effect remained significant after controlling for familiarity with education, attitudes towards psychology, and knowledge of neuroscience. As well, participants rated as more credible educational article about learning vs. developmental topics. The implications of this seductive allure of educational neuroscience effect, especially for learning topics and in the face of prior knowledge, are discussed.
Reading Modifies the Auditory Cortical Representation of Speech

Efficient neural associations between written and spoken language representations are important for fluent reading skills and may be compromised in dyslexic readers. Experimental paradigms used to study these associations typically require stimulus congruency manipulations or higher-order tasks. Here we use a newly-developed ‘text-based recalibration’ paradigm that takes advantage of the finding that visual presentation of text induces an illusory shift in the perception of ambiguous speech. We have recently demonstrated this effect at the behavioral level using speech sound /a?a/, where ‘?’ is an ambiguous phoneme midway between /b/ and /d/. To investigate the neural effects of text-based recalibration we analyzed functional MRI data of 15 typically reading adults using univariate and multivariate decoding techniques. Ambiguous speech sounds evoked BOLD responses across the superior temporal cortex extending towards the posterior middle temporal cortex, as well as in frontal and parietal regions. Most interestingly, fMRI decoding results indicate that it is possible to extract the text-induced perceptual interpretation of ambiguous speech sounds from brain activity patterns in the left posterior superior temporal cortex. The text-based recalibration paradigm thus provides a promising tool to study neural mechanisms underlying (lack of) audiovisual plasticity during typical and dyslexic reading development.

Form similarity between new and existing words influences learning

This study examined how novel words from another language (L2) are integrated into the established lexicon of beginning adult learners and whether or not native language (L1) neighborhood density affects that process. Native speakers of English learned to associate 80 L2 (pseudo)words with pictures depicting their meanings over the course of four days. Half of the L2 words belonged to high-density L1 neighborhoods (i.e., looked like many English words), whereas the other half belonged to low-density L1 neighborhoods (i.e., looked distinct from English). Preliminary results indicate that accuracy in a typing task is higher for L2 words that belong to high-density L1 neighborhoods, especially in the earliest stages of learning. Participant reports further suggest that this high-density advantage might result from the use of real English neighbors to scaffold learning (e.g., associating ‘big sink’ with the L2 word bink, meaning ‘pool’). Finally, event-related potential data recorded during a language decision task before and after learning show differences in N400 amplitude as a function of language membership and L1 neighborhood density. Results will be discussed in the context of competing theories of L2 word acquisition.
Stress-associated brain activation and its association to stress coping strategies in adolescents

17.35 – 18.00

Sabrina Golde1, Tobias Gleich1, Lydia Romund1, Patricia Pelz1, Diana Raufelder2, Robert C. Lorenz3, Andreas Heinz1, Anne Beck1

1. Charité - Universitätsmedizin Berlin, Germany, 2. Ernst-Moritz-Arndt-Universität, Germany, 3. Max-Planck-Institut für Bildungsforschung, Germany

Coping with stress in an efficient and productive way is an essential factor for successful education and development in achievement-oriented societies. At the same time, vulnerability to stress is heightened during adolescence. In the presented study, we combined psychosocial stress induction during fMRI with salivary cortisol and verbal stress evaluations in a sample of 47 adolescents. In addition, we measured adolescents’ stress coping strategies using the German Coping Questionnaire for Children and Adolescents (Stressverarbeitungsfragebogen für Kinder und Jugendliche, SVF-KJ) by Hampel et al. (2001). Results revealed increased prefrontal, ‘social brain’ (insula and TPJ) as well as hippocampal, and reduced orbitofrontal activation during stress. Interestingly, solely ‘social brain’ activation was related to subjective stress experience. Moreover, prefrontal brain activity during stress was positively related to adaptive stress coping strategies. This is the first study to observe neuro-functional aspects of acute stress in adolescence. Consequences for emotional and physiological functioning during adolescence are analyzed and discussed.

Core knowledge of geometry develops independently from vision

18.00-18.25

Benedetta Heimler1, Tomer Behor1, Stanislas Dehaene2, Amir Amedi1

1. Hebrew University of Jerusalem, Israel, 2. University Paris-Sud, France

Geometric intuitions have been shown to spontaneously drive visuo-spatial reasoning. Is their emergence intrinsically linked to visual experience, or does it reflect a core property of spatial cognition shared among sensory modalities? To unravel this issue, we tested sensitivity to geometric invariants in congenitally blind and sighted (blindfolded) adults using a tactile deviant-detection task. Blind participants spontaneously used geometric concepts such as parallelism, right angles, geometrical shapes and distances among elements to detect intruders in the tactile displays. However, they failed in detecting complex spatial transformations such as symmetry and mental rotations. Such properties were the least detectable also among sighted participants. In addition, the performance of blind adults did not correlate neither with their level of education in geometry nor with their explicit knowledge of geometric terms. Intriguingly, we also observed a remarkable similarity between previously documented performance of pre-school children in vision and congenitally blind adults in touch. The present results provide first evidence towards the existence of a core-system of geometry that arises independently of visual experience and that is shared across sensory modalities. Furthermore, they suggest important implications for geometry education of blind pupils, hopefully improving the available guidelines and methods in this area.
Symposium – Neuroscience in the classroom
Friday June 24th, 11.15-13.00
Chair: Ido Davidesco, New York University, USA

11.15 – 11.20 Introduction to the symposium aims by Ido Davidesco

Brain-to-brain synchrony in the classroom: utilizing portable EEG in schools to integrate research and education
11.20-11.50
Suzanne Dikker¹, Ido Davidesco²
1. Utrecht University, the Netherlands, 2. New York University, USA

How does the human brain support the complex dynamic interactions in a classroom? We used portable EEG to simultaneously record brain activity from a class of high school students throughout one semester as they engaged in regular classroom activities (following lectures, watching instructional videos, engaging in group discussions). A novel analysis technique to assess group neural coherence (total interdependence) demonstrated that both student engagement and social cohesion predict the extent to which brain activity is synchronized across students. Our findings reveal the role of brain-to-brain synchrony as a novel biomarker for dynamic social interactions. As part of this crowd-sourcing neuroscience study, we developed an interactive neuroscience education program for schools. In this program the students became the researchers: they developed an EEG experiment, collected and analyzed data and finally presented their results. This program can serve as a model for hands-on neuroscience teaching in high schools and colleges.

Translating neuroscientific research on memory formation to meet classroom practice: an approach to empower teachers and students to innovate and improve their teaching and learning
11.50-12.15
Efrat Furst¹
1. NeuroEducation practitioner, Boston, USA

Findings from neuroscientific and cognitive research increasingly influence educational programs. Nevertheless, the importance of explaining the neuroscience behind the suggested practice to the students and teachers themselves is rarely considered. I describe a ‘practical neuroeducation’ approach, designed to present the science behind memory formation processes in the brain and to connect it directly to common teaching and learning practices. This novel understanding of the scientific principles in the basis of practice supports and empowers teachers and learners: encouraging some to hold to their effective teaching and learning styles, and motivating others to improve and innovate in their own working-context (self, classroom or school).
The effects of neuro-education on students' implicit beliefs about intelligence, their STEM-related belief-system and STEM performance

12.15-12.40

Sandra van Aalderen¹, Juliette Walma van der Molen¹, Lydia Krabbendam², Nienke van Atteveldt²

1. Universiteit Twente, the Netherlands, 2. Vrije Universiteit Amsterdam, the Netherlands

There is an increasing worldwide need for workers educated in Science, Technology, Engineering, and Mathematics (STEM)-fields. Much effort is put into stimulating STEM education and STEM career-choices. Research shows that a growth mindset, i.e. believing that intelligence and abilities are incremental with time and effort, has a positive effect on students’ belief-system, such as self-efficacy, motivational and stereotypical beliefs, especially within the STEM domains. We hypothesize that stimulating students’ growth mindset positively influences their STEM belief-systems and coping strategies, and STEM career-intentions. We compare the effectiveness of two high school interventions: a brief priming message vs. a 3-hour lesson. Both interventions focus on neuroscientific knowledge about brain plasticity. For the priming intervention, we found a positive effect on domain-specific (STEM) mindset, but not on general measures of mindset (n = 222, age= 15.2). There was no effect on the use of positive coping-strategies, self-efficacy beliefs, and motivation. These data will be compared to the effects of a 3-hour lesson on students’ domain-specific and general mindset, self-efficacy beliefs, motivation and STEM career-intentions. Together, our data increase insight in whether we can stimulate students’ STEM specific mindsets, and in the essential characteristics (time, duration, content) of interventions aiming to stimulate students’ growth mindsets within a STEM context.

Chaired open discussion with all presenters

12.40-13.00
1. Adjusting Learning Protocols to Aid Learning in Developmental Disorders

Esther Adi-Japha¹
1. Bar-Ilan University, Israel

Procedural memory is integral to the learning of cognitive, perceptual, motor, and linguistic skills that contribute to school achievements. The learning of motor skills can be viewed as a model for procedural learning. Atypical learning and consolidation of motor skills was reported in several developmental disorders, including attention deficit hyperactivity disorder (ADHD) and specific language impairment (SLI). The evidence suggests that individuals with ADHD tend to perform inaccurately, and their inaccuracy is even enhanced 24-h post-training, in a training protocol adjusted for typical development. Children with SLI display an initial learning rate that is slower than that displayed by their peers without the impairment. Furthermore, these children do not retain their learning well between sessions. It has been suggested that adjustments in the learning protocols can improve learning and consolidation in individuals with developmental disorders. Here I show that shortening of the learning protocol can aid individuals with ADHD, while those with SLI may require additional task repetitions to fully display their skills. Implications regarding individualized learning will be discussed.

2. Confusions of Mirror Letters in Dyslexia: The Indirect Cause

Emmanuel Ahr¹, Margot Roell¹, Axelle Martinez Teruel¹, Olivier Houdé¹, Grégoire Borst¹
1. LaPsyDE - Paris Descartes University, France

A common misconception is that dyslexia provokes mirror errors, such as confusions of mirror letters b and d, or p and q. Naama Friedmann identified more than 10 types of dyslexia, resulting from specific impairments and causing specific types of errors (Friedmann & Haddad-Hanna, 2014). None of these types of dyslexia specifically causes mirror errors. Educational and psychological studies agree on this absence of a direct causal link between dyslexia and mirror errors (e.g. Lachmann & Geyer, 2003). Mirror errors are likely due to the neuronal recycling of part of the visual associative neuronal networks of the ventral stream that are recycled to process letter and word stimuli (Dehaene, 2004). Reading consequently inherits some of the neuronal properties of the recycled area, and notably mirror generalization, a property that allows one to recognize a face, an animal or an object regardless of the side from which it is perceived, but which is no more adapted to the discrimination of mirror letters such as b and d. We demonstrated that dyslexic children manage -but with more effort than non-dyslexic children- to inhibit this inherited neuronal property of mirror generalization to discriminate mirror letters, a result supporting recent psychological data revealing a small deficit of inhibitory control on literacy tasks in dyslexics (Wang et al, 2012), and neuroscience findings about the impairment of their visual reading network (Monzalvo et al, 2012).
3. Is the (Under-) activation of Inhibitory Control Mechanisms Associated with the Difficulty to Evaluate Scientific Answers
Genevieve Allaire-Duquette¹, Michel Bélanger², Roland H. Grabner³, Steve Masson¹
1. Université du Québec a Montréal, Canada, 2. Université du Québec a Rimouski, Canada, 3. University of Graz, Austria

Students hold misconceptions about how nature works that can challenge science learning partly because they rely on spontaneously activated intuitions which often leads to scientifically correct explanations, but not always. Therefore giving a scientifically valid answer can sometimes require inhibiting these intuitions. Studies show that experts in science activate (more than novices) brain areas related to inhibition in order to overcome misconceptions. However, no study has yet explored whether the activation of inhibition could be associated with the difficulties some students are facing when asked to provide scientifically valid answers. An ongoing study recruited fifth grade secondary students and formed two groups controlled for age, socio-economic status, reading abilities and scientific training. One group having difficulties to evaluate scientific answers while second group easily evaluates scientific answers. Students took part in a functional magnetic resonance imaging (fMRI) session where they were asked to determine if verbal statements, either intuitive (e.g. Heart pumps blood), or counterintuitive (e.g. Heart manufactures blood) if they involved a common misconception, were scientifically correct or incorrect. Preliminary results will be presented and educational implications will also be discussed as (fMRI) provides complementary data to understand how learning science concepts might be difficult for some students.

4. A Computer Based Screening Tool for Dyscalculia: Lessons Learnt
Arif Altun¹, Sinan Olkun², Galip Kaya³
1. Hacettepe University College of Education, Turkey, 2. TED University, Turkey, 3. HAVELSAN, Turkey

This proposal reports the design, development, and validity results of an in-house developed dyscalculia screening tool for 6-11 year old age groups. The computer based screening tool included tests designed to test the basic number processing (BNP) performance of children. These are canonic dot counting (CDC), Symbolic Number Comparison (SNC), and Mental Number Line (MNL) tests. Apart from these tests, two paper and pencil tests were used to assess students’ math achievement.Mathematics Achievement Test (MAT) was a curriculum based test that has open ended questions. Arithmetic Performance Test (APT) on the other hand was consisted of five columns of symbolic operations ordered from very simple to complex. The design and development process has been informative in various reasons. First of all, the age groups, their background characteristics were found to be an informative process when designing such tools for these specific age groups. Secondly, the choice of programming environment was determinant on data collection process in that some software development frameworks were observed to handle the timing issues differently depending on the hardware. Finally, some user experience issues were observed during administering the tasks with users. Therefore, this presentation will address these issues from both pedagogical and user experience perspectives when designing computer-based neuropsychological tests and/or screening tools.
5. All Children Are Not Equal: Different Impact of Multiplying Fact Learning Methods
Juan Antonio lvarez-Montesinos¹, Javier García-Orza¹, Adam Sánchez Urbano¹
1. Universidad de Málaga, Spain
Methods in the classroom for multiplication fact learning usually do not consider individual differences. In this research we explored the effect of two methods on the learning of children with different math skills levels. One method emphasized the use of rules and memory (R&M method) to reduce the set of multiplication facts to memorize. The other (traditional) method emphasized memory.
One hundred and sixty two 2nd grade children (aged 7–8) were divided in two groups that received the traditional method or the R&M method during 6 months. A global math score (that excluded multiplication tasks) obtained at the end of the academic year was employed to identify children with high, medium and low math skills in each method group. As expected skill groups differed according to the global math score, more importantly a comparison of the math skills between method groups in each math skill group did not show differences in global math score. An ANOVA was run with math level (low, medium, high) and teaching program (R&M, traditional) as independent factors and scores in a multiplication fluency task as dependent variable.
Results showed clear differences between skill groups in the R&M group whereas no (or slight) differences were observed in the traditional group. Low skill participants in the R&M group scored significantly worse than their counterparts in the traditional group. A non-significant advantage was observed for the R&M group in the high level group.

6. Quantitative Measurement of Learning Using Electroencephalography (EEG) in Anatomy Education
Sarah Anderson¹, Heather Jamniczky¹, Olav Krigolson², Kent Hecker¹
1. University of Calgary, Canada, 2. University of Victoria, Canada
Quantitative measurement of the learning process through direct monitoring of neural processes offers an alternative means of assessment. Event-related brain potential (ERP) measurement by EEG has been used to examine changes in signals associated with reinforcement learning. Reward-related positivity (RewP), a positive deflection of the ERP wave associated with positive feedback during learning is thought to scale like a prediction error- as a subject learns there will be a diminished amplitude in response to positive feedback. This study examined changes in RewP in an applied setting (anatomy education), during a task where 11 participants learned to identify 12 anatomical structures based on feedback. As learners progressed in the module, we measured RewP and further corroborated this neural correlate as a measure of learning by comparison to behavioural learning curves. Mean ERPs were compared 260-300ms following feedback. RewP was 4.27 μV greater (p<.05) on correct compared to incorrect trials; signal was maximal over the medial frontal cortex. RewP decreased by 6.25 μV (p<.05) in response to positive feedback in late vs. early trials. This study translates and confirms findings from the neuroscientific literature in an applied educational realm. Validation of quantitative neurophysiological variables that measure learning will enable a direct measure of knowledge acquisition that can be used to assess and optimize new forms of teaching, learning, and evaluation.
7. Working Memory Training Improves Reasoning Skills in Secondary Social Studies Education: Evidence from an Experimental Study

Roel Ariës
1. Maastricht University, the Netherlands

Evidence suggests that working memory (WM) abilities and (content-based) WM training correlate with (school-based) deductive reasoning achievements. In this study, a combined WM-capacity and WM-reasoning strategy training is incorporated in secondary school social studies curricula to investigate its effects on reasoning achievements. Four secondary classes in three schools in the Netherlands participated in the experiment with a total of 81 general education medium track 16 year old students. N-back and odd-one-out training batteries, as well as a strategy training method, were used to train experimental groups during 90 minutes per week. Reasoning questions in regulatory school tests have been used to test the students’ reasoning skills. WM-capacity and reasoning achievements improved significantly after 4 and 8 weeks of training and remained significant 8 weeks after training ended compared to control group outcomes. The (significant) gain in reasoning abilities is demonstrated in both experimental subgroups, while control group results did not improve. The study supports the notion that WM-training can transfer into deductive (school-based) reasoning gains when WM-capacity training is supported by strategy-training and both components are provided in a content-based context. Furthermore, it provides preliminary evidence of accelerated learning following WM-training.

8. The Implication of Short-Term Memory in Numerical Magnitude Processing: Evidence from Turner Syndrome

Lucie Attout1, Marie-Pascale Noël2, Laurence Rousselle1
1. University of Liège, Belgium, 2. Catholic University of Louvain, Belgium

Most studies on early magnitude representation focused on the visual modality with no possibility to disentangle the influence of visuo-spatial skills and short-term memory (STM) abilities on visual quantification processes. In order to specify the influence of visuo-spatial and STM processing on numerical abilities, a series of magnitudes comparison tasks differing on visuo-spatial processing requirement (no/high), on the nature of the magnitude to be processed (continuous/discrete/symbolic magnitude) and on WM demands (simultaneous/sequential presentation) were administred to twenty patients with Turner syndrome (TS), a genetic condition characterized by poor mathematical achievement, low spatial skills and reduced STM abilities. Our results showed a lower acuity than a control group matched on verbal IQ when participants with TS compared the numerical magnitudes of stimuli presented sequentially (low visuo-spatial processing and high STM load: Dot sequence and Sound sequence). No difference was observed in the numerical comparison of sets presented simultaneously or when comparing continuous and symbolic magnitude stimuli. Besides, the group difference in sequential tasks disappeared when controlling for STM abilities. These results highlight the importance of STM abilities to extract numerosity through a sequential presentation and underline the importance of considering the impact of format presentation on magnitude judgments.
Jessica E. Bartley¹, Michael C. Riedel¹, Karina Falcone¹, Kailey MacNamara¹, Shannon Pruden¹, Eric Brewe¹, Matthew T. Sutherland¹, Angela R. Laird¹
Florida International University, USA
Modelling student thinking in physics is often measured by observing physics problem solving (PPS); this then informs education research on effective teaching strategies. However, no neuroeducation study has characterized the neurobiological processes underlying PPS or skill development via classroom instruction. We used functional magnetic resonance imaging (fMRI) to delineate PPS brain networks and probe differences resulting from a semester of college physics instruction. 15 students (age 18-24; 9 male) underwent pre- and identical post-instruction fMRI sessions wherein they solved physics problems. We assessed brain activity and identified regions more engaged post- relative to pre-instruction (P<0.05). FMRI data revealed consistently left lateralized fronto-parietal networks contributing to PPS. Moreover, significant increased activity in dorsal posterior cingulate (dPCC) and retrosplenial cortices (RSC), accompanied by improved PPS scores, following instruction implicate this region’s critical role in physics learning. As RSC/dPCC likely supports spatial memory and attentional focus [1,2], pre- vs. post-instruction activation shifts suggest educational experience augments brain activity which, in turn, contributes to enhanced PPS skills. These novel neurobiological observations provide insight into how classroom learning may drive large-scale brain network reorganization in physics students. 1 Leech et al. 2014 Brain 137 2 Vann et al. 2009 Nat Rev Neurosci 10

Tomer Behor¹, Menahem Kerem¹, Amir Amedi¹
Hebrew University of Jerusalem, Israel
Given their intrinsic visual properties, teaching graphs to Visually Impaired Pupils (VIPs) still remains a huge challenge. Here, we present a novel platform called the MathMusic, which aims to significantly facilitate this issue. The MathMusic conveys the shape properties of the graph through visual-to-auditory sensory substitution, namely transforming visual information into auditory soundscapes. These soundscapes are combined with an innovative spatial text-to-speech algorithm conveying the content of text items together with their spatial position in the graph. To test the efficiency of the MathMusic, we presented different types of graph exercises to congenitally blind participants. Already after a short training and despite their previous little experience with graphs, participants successfully solved those exercises. Moreover, congenitally blind participants showed great enthusiasm towards our approach and encouraged its inclusion in educational settings. These initial promising results further strengthens the efficiency of sensory substitution in conveying visual-related information within rehabilitation settings. Moreover, they suggest that the MathMusic can become an incredibly useful tool in the education of VIPs, hopefully breaking the barriers towards the integration of this population in science, technology and mathematics fields.
11. Are Individual Differences in Arithmetic Fact Retrieval in Children Related to Inhibition?
Elien Bellon¹, Wim Fias², Bert De Smedt¹
1. Katholieke Universiteit Leuven, Belgium, 2. University of Gent, Belgium

Executive functions (e.g., inhibition) play an important role in scholastic learning, such as mathematics. Although it has been proposed that inhibition is related to individual differences in mathematical achievement, it is not clear how it is related to specific aspects of mathematical skills, such as arithmetic fact retrieval. However, such association can be theoretically postulated, as incorrect but competing answers have to be inhibited during fact retrieval, since arithmetic facts are stored in an associative network in semantic memory. The present study therefore investigated the association between inhibition and arithmetic fact retrieval and further examined the unique role of inhibition in individual differences in arithmetic fact retrieval, in addition to numerical magnitude processing. We administered measures of cognitive and behavioural inhibition, as well as numerical magnitude processing and arithmetic fact retrieval in 86 typically developing third graders. We used correlational, regression and Bayesian analyses. This study failed to observe a significant association between inhibition and arithmetic fact retrieval. Consequently, our results did not reveal a unique contribution of inhibition to arithmetic fact retrieval in addition to numerical magnitude processing. On the other hand, symbolic numerical magnitude processing turned out to be a very powerful predictor of arithmetic fact retrieval, as indicated by both frequentist and Bayesian approaches.

12. The Effect of Training on Children's Visual Search Strategies During Analogical Reasoning: An Eye-tracking Study
Marjolein Boots¹, Claire Stevenson¹
1. University of Amsterdam, the Netherlands

Children’s analogical reasoning, the process by which novel situations can be understood using the relational similarities with familiar situations develops with great variability. Analogical reasoning performance can be improved with training; the use of scaffolds has been shown to have an additional positive effect. The most efficient analogy solving strategy that has been identified with eye–tracking is constructive matching in which the focus centers around analogy components before it shifts towards the answer components. Adults tend to use constructive matching whereas children’s visual search patterns are less structured and focus more on the answers. In this study we investigate whether training can improve the efficiency of analogy solving strategies, leading to usage of constructive matching. During a pretest-training-posttest control group design, 40 children (M = 7.00, SD = 1.00) will be trained while eye movements are recorded. Accuracy is expected to improve after receiving training. The accuracy is expected to be higher at the post-test due to applying increasingly efficient visual search strategies during training, leading to an improvement of children’s analogical reasoning skills. If analogical reasoning skills improve then the training can be translated into learning materials to help enhance children’s reasoning abilities.
13. Neural Correlates of Two Different Teaching Interventions in Reading Words for Preschoolers

Lorie-Marlène Brault Foisy¹, Stanislas Dehaene², Riopel Martin¹, Julie Myre-Bisaillo³, Steve Masson¹

1. Universite du Quebec a Montreal, Canada, 2. Unité de neuroimagerie cognitive Inserm-CEA, France, 3. Université de Sherbrooke, Canada

During early reading acquisition, children must learn to link visual word forms to spoken words. To do so, reading instructions can direct the learners’ attention on different unit sizes. Research conducted with adult participants have shown that directing the attention at a grapheme-phoneme (G-P) level while learning to read words induce a stronger cerebral activity in the occipito-temporal cortex (OTC) than directing the attention of participants at a whole-word (W-W) level. To our knowledge, no research compares the effect of different reading instructions in children who have not formally started learning to read. Can different reading instructions provided to novice readers impact differently the activity in the OTC? To answer this question, 48 non-reader preschoolers were equally and randomly assigned to two experimental groups: instructions in group A directed the attention at the G-P level, while instructions in group B directed the attention at the W-W level. Both interventions focused on learning the same 25 words and were implemented for 5 weeks at a frequency of 4 sessions of 20 minutes per week. Functional magnetic resonance imaging (fMRI) was used to acquire brain images during two tasks in reading, before and after the interventions. The first task, a reading verification task, was assessing the activity in the OTC, and the second task was assessing the organization of the visual ventral pathway. First results will be discussed at this conference.

14. Science and Maths Reasoning in Adolescence is Associated with Semantic and Response Inhibition

Annie Brookman¹, Andy Tolmie², Denis Mareschal¹, Iroise Dumontheil¹

1. University of London, UK, 2. UCL, UK

Science and maths reasoning requires the integration of new evidence about the world into one’s existing theories. While the traditional view holds that naïve theories are replaced in the face of new evidence, neuroimaging research with adults suggests that old theories are still present even when new ones are learnt. When solving counterintuitive scientific problems, experts recruit areas of the brain associated with conflict monitoring, error detection and inhibitory control: lateral prefrontal cortex, and anterior cingulate cortex. This suggests that inhibitory control enables the suppression of naïve beliefs and misleading perceptual cues in the processing of counterintuitive material. The current project investigated the relationship between inhibitory control and a novel science and maths counterintuitive reasoning task in adolescence. Ninety 11- to 15-year-olds observed counterintuitive science and maths statements, pictures, and equations, and judged whether they were correct or not. Regression analyses found that across ages, individual differences in performance on the counterintuitive reasoning task were associated with individual differences in performance on both semantic (Stroop) and response (Go/No-Go) inhibition tasks. This work suggests that inhibitory control training may be helpful within the context of science and maths curricula.
15. Source-based Connectivity During Arithmetic Problem Solving

Clemens Brunner, Martin Billinger, Bert De Smedt, Roland Grabner

1. University of Graz, Austria, 2. Hannover Medical School, Germany, 3. Katholieke Universiteit Leuven, Belgium

There is an increasing body of evidence revealing neurophysiological differences between problem solving strategies in mental arithmetic. In particular, it was found that problem solving by means of fact retrieval from memory is associated with different oscillatory activity patterns in the electroencephalogram (EEG) as opposed to problem solving by means of calculation procedures.

The goal of the present study was to extend this line of research by investigating potential strategy-related differences in source-based EEG connectivity patterns during arithmetic problem solving. A sample of 19 participants performed mental additions and subtractions of small and large problem size. We used a variant of independent component analysis (ICA) to estimate cortical sources from the EEG channel data. We then fitted a vector autoregressive model to the source activations. Using the fitted model coefficients, we derived various connectivity measures that capture not only the strength, but also the direction of connectivity.

Our analyses are currently in progress, and preliminary results based on a subset of the available subjects indicate that (1) our methods are able to discover suitable cortical sources related to arithmetic problem solving, (2) there is a reasonable connectivity structure between specific cortical sources, and (3) strategy-specific differences can be found that are characteristic for fact retrieval or calculation procedures, respectively.


Alice Cancer, Silvia Bonacina, Maria Luisa Lorusso, Alessandro Antonietti

1. Università Cattolica del Sacro Cuore, Italy, 2. IRCCS Eugenio Medea, Bosisio Parini (LC), Italy

Developmental Dyslexia (DD) is a specific learning disorder of neurobiological origin that causes a reading impairment. One of the deficits underlying DD has been identified in difficulties in dynamic and rapidly changing auditory information processing. Since music and language share common mechanisms, a computer-assisted intervention method, called Rhythmic Reading Training (RRT), which combines sublexical reading exercises with rhythm processing training, was implemented. A test-training-retest study showed the efficacy of RRT intervention on reading abilities of fourteen junior high school students with DD, compared to a matched control group that received no intervention. A second study compared reading improvements after RRT to a visual hemispheric-specific stimulation, also known as Bakker method (VHSS), and an innovative treatment involving action video games training (AVG) in a group of 22 children with DD aged 8-12. Results showed no significant differences between the efficacy of the two treatments, which therefore are comparable in improving reading skills in children with DE. Furthermore, findings suggested that RRT is slightly more effective in enhancing reading speed, whereas VHSS and AVG in improving reading accuracy.

Danilka Castro-Cañizares¹, Vivian Reigosa-Crepsø²
1. University of Chile, Chile, 2. Cuban Neuroscience Center, Cuba

The aim of this study was to evaluate if children with Developmental Dyscalculia (DD) (N=30) exhibit a general deficit in magnitude representations or a specific deficit in connection of symbolic numerical representations with the corresponding analogous magnitudes. The magnitude comparison tasks were presented in non-symbolic and symbolic formats. Also, two estimation tasks, one of them with symbolic inductor (an Arabic number presented simultaneously with the corresponding set of dots) were administered. The results showed that DD and typically developing (TD) children exhibit similar numerical distance and size effects. However, DD children performed significantly slower in symbolic comparison tasks. There were not significant differences between DD and TD children in the estimation task without inductor. However, only in TD group the Weber fraction improved significantly in estimation task with inductor, respect to the other estimation task. Therefore, in DD children the approximate system of quantities processing seems to be preserved but a failure occurs in the interface between approximated and verbal systems. These results are consistent with the access deficit hypothesis, according to which DD children’s deficits are caused by difficulties accessing magnitude information from numerical symbols rather than in processing numerosities per se.

18. Longitudinal ERP Evidence for Inter-Individual Stability and Variability During Memory Retrieval and Cognitive Control

Daniela Czernochowski¹, André Haese¹
1. University of Kaiserslautern, Germany

The development of episodic memory retrieval in children is far from understood. To further complicate matters, comparable behavioral performance might be based on distinct cognitive processes, as indexed by ERPs. Developmental progress might be based on the maturation of critical brain structures, on the gradual use of adult-like retrieval strategies or both. Notably, larger variability in the cognitive processes gathered to support task performance in developmental populations might mask ERP correlates of memory processing. In addition, cognitive control abilities play a large role for guiding efficient memory search, and selecting between competing response alternatives. We investigated the interplay between memory and cognitive control longitudinally in children aged 8 and 10 years compared to a group of young adults, by repeating episodic memory and cognitive control paradigms after two years. Few age differences were observed with respect to general memory performance, whereas age was associated with a decrease in both reaction times and error rates for the cognitive control task, specifically for the most demanding conditions. While the age groups used distinct routes to support task performance, individual ERP waveforms were relatively stable across time. The role of neural maturation for inter-individual stability and change in neural signatures and related performance will be discussed with respect to strategy choice as well as an age-related modulation of attention.
19. Students’ Beliefs About Gender Differences in Classroom Behaviour, Learning and Intelligence: A Mixed Methods Study.

Emmy de Krak-Pauw¹, Floryt van Wesel², Nienke van Atteveldt¹, Lydia Krabbendam¹

¹. VU University, the Netherlands, 2. Utrecht University, the Netherlands

While gender differences in school behaviour and performance have been studied extensively, students’ views on these topics are largely unexplored. As students are central to the complex system of teaching and learning, this study explored the views of students aged 13-15 years, on gender differences in classroom behaviour, learning and intelligence. The study had a mixed methods design: it involved the collection and analysis of both quantitative (questionnaires) and qualitative data (focus groups). Results demonstrated that boys and girls mostly share the same gender-stereotypical views. Regarding self-reported beliefs about intelligence: more than half of the students believed that their intelligence is static (“fixed mindset”), that abilities and characteristics are mostly unchangeable. Less than a third believed that intelligence is incremental (“growth mindset”) and can be changed through effort and persistence. The others showed an in-between mindset. During the focus groups, girls more often than boys gave examples of their teachers’ statements regarding alleged abilities. Girls also seemed to be less confident about their beliefs, and expressed lower self-esteem. Some participants thought that gender differences in behaviour can be explained by brain differences. In conclusion, a study about students’ views provides valuable starting points to teacher interventions with regard to incremental intelligence beliefs, for example through neuro-education.

20. The Interference Effect in Arithmetic Fact Solving: An fMRI study

Alice De Visscher¹, Sam C. Berens², James L. Keidel², Marie-Pascale Noël¹, Chris M. Bird²

¹. UCL, Belgium, 2. University of Sussex, UK

Some multiplication facts share common digits with other, previously learned facts, and as a result, different problems are associated with different levels of interference. The detrimental effect of interference in arithmetic facts knowledge has been recently highlighted in behavioral studies, in children as well as in adults, both in typical and atypical development. The present study investigated the brain regions involved in the interference effect when solving multiplication problems. Twenty healthy adults carried out a multiplication task in an MRI scanner. The event-related design comprised problems whose interference level and problem size were manipulated in a $2 \times 2$ factorial design. After each trial, individuals were requested to indicate whether they solved the trial by retrieving the answer from long-term memory.

The results highlighted two specific regions: the left angular gyrus was more activated for low interfering than for high interfering problems, supporting the idea of an automatic mapping in this region, and the right intraparietal sulcus was more activated for large problems than for small problems, supporting the idea of magnitude representation activation in this region. In both regions, brain activity was not modulated by the other effect. Importantly, neither effects can be reduced to a strategy effect since they were present when analyzing only retrieval trials.
21. Number Cruncher or Memory Athlete - What Brain Rhythms Tell Us About Sources of Mathematical Abilities

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Mathematical abilities play a crucial role in our society, where high fluid intelligence allows for superior performance on math problems. We were interested in the cognitive processes and neural mechanisms in mental arithmetic and algebra that are facilitated by high fluid intelligence. Grade-10 students (N = 60) were presented with arithmetic and algebraic problems that varied in complexity. Based on earlier studies in this field, we analyzed the event-related (de-)synchronization (ERD/ERS) in the alpha and theta frequency range in order to differentiate three cognitive processes required by the problems: fact retrieval, memory/executive processes, and magnitude processing. We then evaluated the impact of fluid intelligence on the different ERD/ERS measures revealing the following results concerning related cognitive processes: (1) students with average compared to high fluid intelligence experience greater memory storage demands and (2) students with high compared to average fluid intelligence maintain and retrieve interim results for the most complex problems more successfully. Correlations between the ERD/ERS measures and additional measures on participants’ working memory abilities and their number sense support these findings. Further, they underpin that the alpha and theta ERD/ERS constitutes a reliable indicator of cognitive processes during complex mathematical problem-solving and thus is a useful tool in research at the interface of neuroscience and education.

22. Parietal activation during exact calculation tasks in left- and right-handed students assessed with functional near-infrared spectroscopy (fNIRS)

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Nowadays the interest to the neuropsychology of left-handedness has increased significantly. Left-handed participants have been recently included as a separate target group along with right-handers in some studies, because of differences in functional brain organization. However, most comparative studies examined language associated differences in brain activation. Differences between left- and right-handers in arithmetic processing of basic operations were not systematically investigated for varying complexity levels within participants.

The purpose of the present research project was to detect the differences in brain activation in left- and right-handed adults during arithmetic processing by means of functional near-infrared spectroscopy (fNIRS). 36 left-handed native German-speaking students performed exact calculation tasks including such operations as addition and subtraction with simple and complex difficulty levels (without and with carry/borrow operation, respectively) and were compared to 33 right-handed students from an earlier study. Handedness was accessed with the help of preference (Edinburgh Handedness Inventory) and performance (Dot-filling, Spiral tracing, moving beads) tests.

The results showed bilateral activation for easy subtraction, and stronger hemispheric laterality regarding complex addition and subtraction (with carry and borrow effect) in both left and right-handers. However, increased activity in right parietal areas in left-handers and in left parietal areas in right-handers was observed for complex addition and subtraction. No significant differences in brain activation were found in simple addition and subtraction without carry and borrow effects.

We conclude that there are no general differences between left- and right-handers in any calculation task. Only more complex tasks associated with stronger verbal mental recoding seem to reveal brain lateralization differences in left- and right-handers with larger activation.
in contralateral parietal areas.

23. The Neural Correlates of Mental Arithmetic in Children: A Longitudinal fNIRS Study

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The fronto-parietal network associated with arithmetic processing has been intensively studied in adults. However, although developmental processes are associated with neural changes, studies in children are scarce. In particular, longitudinal studies systematically examining the different basic arithmetic operations are lacking. Moreover, existing studies use experimental procedures adjusted to constraints of fMRI, but do not reflect natural school settings.

The current study aimed at identifying the neural correlates of the four basic arithmetic operations in a longitudinal sample of 6th grade children across one year. In order to realize a natural setting, children had to calculate in a written production paradigm during a functional near-infrared spectroscopy (fNIRS) measurement.

Neural activation in the left parietal cortex was found to be similar in all four basic arithmetic operations, fostering the assumption of a core common region of symbolic arithmetic processing. Moreover, a trend for a developmental shift from left frontal activation in grade 6 to bilateral parietal processing in grade 7 was obtained in the absence of significant behavioral improvement. This suggests a neural network for arithmetic processing similar to adults, which seems to underlie developmental changes from domain-general to more domain-specific numerical processing even within one school year and even without explicit instruction of respective operations.

24. Prevalence of Neuromyths Among Student Teachers in Chile: What to Do Next?

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The present study investigated the prevalence of neuromyths and knowledge of neuroscience among student teachers in Chile. We surveyed 186 student teachers from three different universities, each enrolled in 5-year teacher-training programmes. The participants were asked to complete an online survey based on Dekker et al. (2012)’s study, which consisted of responding yes, no or do not know to a list of 20 assertions about the brain and its functioning, and 12 neuromyths. The results showed that on average student teachers failed to identify 50.7% of the neuromyths and responded correctly to roughly 60% of the assertions. We also found that students who had a high interest in neuroscience and those who had taken at least 1 neuroscience course performed the best, both at identifying neuromyths and responding to assertions. Overall, these results suggest that beliefs in neuromyths and knowledge of neuroscience among student teachers is very similar to that found across working teachers in different countries, and that interest in neuroscience and training seem to diminish the prevalence of neuromyths and improve neuroscientific knowledge. We call for the need to include neuroscience courses in the curriculum of all teacher-training programmes in order to avoid misconceptions about the brain, which are both costly and detrimental to education.
25. The Effect of Social Exclusion on Working Memory in Adolescence

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Adolescence may be a sensitive period of brain and cognitive development. As such, the rapid social changes in adolescence, as well as the associated stresses, may have amplified effects during this period of life. Here, we investigated how social stress affects cognitive functions relevant to academic performance by simulating social exclusion in the laboratory and comparing its effects on working memory in young adolescents (aged 10-14, N=23), mid-adolescents (aged 15-17, N=22) and adults (aged 18-39, N=18). Participants in all age groups completed n-back working memory tests three times: once at baseline, once after social inclusion, and once after social exclusion by virtual peers in the ball-tossing game, Cyberball. The effects of social exclusion on working memory did not differ between age groups for accuracy ($X^2(4)=3.94, \text{ns}$), but did for reaction times ($X^2(4)=14.65, p=.005$). Young adolescents responded more slowly after exclusion while adults responded more quickly ($z=2.84, p=.012$). Mid-adolescents’ reaction times did not differ significantly from those of the other age groups. This indicates that younger adolescents and adults may respond qualitatively different to social exclusion. Younger adolescents’ working memory performance may be reduced under social stress while adults may over-compensate for exclusion with improved performance.

26. Can the Intuitive Sense of Magnitude Help Solving Arithmetic Problems?

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Current works on numerical cognition have emphasized the intuitive sense of magnitude as the basis for math knowledge. However, math activities in school usually focus on solving math problems with algorithmic procedures, and devote little attention to the use of the intuitive sense of magnitude. The following series of studies demonstrate the recruitment of this sense of magnitude to solve multi-digit multiplication problems using computation estimation (Ganor-Stern, 2015a, 2015b; Ganor-Stern & Weiss, 2015). In this estimation task, participants were presented with multi-digit multiplication problems accompanied by reference numbers and they indicated whether their estimated answer for each problem is larger or smaller than the reference number. Research on adults diagnosed with dyscalculia or ADHD showed that although they face difficulties in exact calculation, their performance in the estimation task was close to that of controls. A current developmental study has shown that children already in 4th grade reached adults level of accuracy. Furthermore, strategy analysis has shown that young children as well as adults with DD and with ADHD rely on an intuitive sense of magnitude when solving this task. Thus, the present research suggests that computation estimation which recruits the intuitive sense of magnitude may help individuals that experience difficulties in arithmetic.
27. Training Approximate Number System Acuity with Haptic or Visual Modality

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The approximate number system (ANS) allows to process nonsymbolic quantities in visual, auditory, and haptic modalities. ANS acuity increases with development, and its relation with maths achievement is currently debated. Very few studies showed an ANS practice effect on ANS acuity or on symbolic maths (e.g., DeWindt & Brannon, 2012; Hyde, Khanum, & Spelke, 2014). Our study asked three questions: (1) Can ANS be enhanced by haptic or visual trainings? (2) Is there a possible transfer between haptic and visual ANS abilities? (3) Does improving ANS acuity lead to improve symbolic arithmetic abilities? In pre- and post-tests, 69 5-year-old children were evaluated in symbolic arithmetic, visual- and haptic-nonsymbolic comparisons. Then, they received one of the three trainings: visual or haptic nonsymbolic approximate additions, or control. Results revealed no improvement with the visual training, whereas the haptic one was benefit. Children improved across training sessions, and those with low initial ANS acuity had a better progression between pre- and post-test in haptic ANS acuity than children from the control group. No transfer from haptic to visual performance and no transfer from ANS to symbolic arithmetic abilities were observed. Improving ANS acuity in children is possible, although limited, and no transfer to symbolic arithmetic was evidenced in this study.

28. Neuronal Correlates of the Self-Concept in Adolescence: A focus on the Significance of Friends

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Few imaging studies concentrated on self-referential processing during adolescence. From existing studies the distinction between neural structures involved in self-reflection and reflections of familiar others are not clear. To investigate those processes more detailed, here, we investigated 41 adolescents with functional magnetic resonance imaging (fMRI). Participants made judgments about trait adjectives and indicated whether the traits describe themselves, their friends, their teachers or politicians. The results showed greater similarities in neural responses to self- and friend-related judgments compared to teachers and politicians; typical self-reference related structures such as the ventromedial prefrontal cortex and medial posterior parietal cortex exhibited higher activation to judgments about friends compared to the other conditions. In contrast, neural responses towards judgments of teachers (familiar others) and politicians (unfamiliar others) did not differ significantly. The present results are in accordance with behavioural findings of a greater relevance of friends for the development of a self-concept during adolescence in terms of the underlying functional brain processes.
29. Latin American (LA) Teachers' Perception of Brain Function

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Exploring how neuroscience can inform education is a worldwide interest. This project is set in LA, where educational contexts vary greatly and neuroeducation may have to adapt to fit them. It aims to provide a basis for future attempts to improve the LA teachers’ critical understanding of the role of neuroscience in their practice by exploring their understanding of brain knowledge, the mind-brain relationship and their attitude towards neuroeducational research. A mixed-methods design was used to emphasize dialogue by interviewing 19 teachers and administering an online questionnaire to 314 teachers from LA countries. Popular themes were that emotions play an important role in brain functioning and learning and that dopamine can be activated by being in a pleasant environment or brain gym. In a region where some countries have more than 50% of their population living in poverty, 24.2% of the teachers (and 12.4% who did not know) disagreed that poverty can impact the brain. That ‘learning styles make learning easier’ remains one of the most popular neuromyths in LA and other nations. LA teachers’ interest in neuroscience was positively correlated with both neuroscience literacy and neuromyth scores suggesting that they obtain information from valid and unscientific sources. Results highlight the need to promote LA teachers’ critical approach to neuroscience research through dialogue to better understand how context can inform future neuroeducational questions.
1. The Automaticity of Conceptual and Physical Magnitudes in Dyscalculia and Dyslexia
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Conceptual magnitudes is the internal representation of an object's size. Physical magnitudes is the perceived size of an object. Recently, we found that both magnitudes are processed automatically. This study examined automatic processing of conceptual magnitude in developmental dyscalculia (DC) and developmental dyslexia (DL). In a set of experiments, conceptual and physical magnitudes were manipulated orthogonally to create congruent (e.g., a physically small apple compared to a physically large violin) and incongruent (e.g., a physically large apple compared to a physically small violin) conditions. The results revealed that in the conceptual comparison, all participants responded in a similar manner and presented automatic processing of physical magnitude. In contrast, in the physical comparison, control and DL subjects presented automatic processing of conceptual magnitude. DC subjects, however, presented a lack of automaticity of conceptual magnitude. Our results fit with previous findings of weaker magnitude representation in DC subjects; and support theories of a shared neural substrate for different types of magnitude.

2. Does Adding Cue-Directed Action Improve the Learning of Prime Numbers in Adults? An Exploratory Study on Action Video Games for Learning Based in Neuroscience Research
Carolina Gordillo¹
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This is an exploratory study of the influence action video games are claimed to have in learning in order to inform the possibility of a further bridging study at the interface of neuroscience and education.

Participants (N=32) were tested in their learning of mathematical facts (prime numbers) after playing two versions of a computer game, which differed only in a cue-directed action feature added. Learning was compared by recording the difference between pre-test and post-test response time and accuracy. These behavioural measures were complemented by self-reported perceptions of enjoyment, engagement and learning. There was a significant increase in speed and accuracy for recognising prime numbers as measured by difference between pre- and post-test, and even retention post-test. However, there were no conclusive findings on the difference between a video game containing a cue-directed action and one without.

Notwithstanding, other findings arising from measures in accuracy and speed as well as from the self-reported perception might be of interest in the design of further research in this area and for future researchers wanting to explore novel educational ways to improve human learning based on neuroscience research.
3. Culture Moderates How Bicultural Adolescents' Interoceptive Sensitivity Impacts their Empathy for Triumph Over Adversity

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The extent to which we can feel our body states, our interoceptive sensitivity, affects our ability to feel empathy. Does cultural variability in the entwinement of bodily and psychological states impact how we interpret our body states to empathize with others? We evaluated empathy in participants’ oral interview responses to stories of triumph over adversity. In empathic responses a participant described imagining himself as the protagonist or imagining the protagonist’s thoughts and feelings. Participants’ heart rate was monitored while they indicated with a button press when they believed each fifth heart beat occurred. Interoceptive sensitivity was measured as heartbeat detection accuracy. 31 adolescents (age 14-18; 17 female) from low-SES immigrant families, 13 East-Asian American and 18 Latino/a American, participated. Ethnic groups did not differ in empathy or interoceptive sensitivity. Interoceptive sensitivity impacted empathy, but this effect was moderated by cultural group, F(1, 24)= 6.86, P=0.02, η²p = 0.22. For East-Asians, higher interoceptive sensitivity was associated with higher empathy; the opposite held for Latino/as. Interoceptive sensitivity may impact empathy, but among bicultural youth this relationship differs due to cultural ways of feeling and expressing emotions. Educators interested in promoting empathy in adolescence should consider varied ways in which cultural experiences can organize the effect of bodily awareness on empathy.

4. What Promotes Analogy Between Arithmetic Word Problems?

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Learning to transfer a solving strategy from one problem to another is one of the most crucial issues of education. Yet, doing so requires making the analogy between the mathematical structures of source and target problems, which necessitates seeing beyond the superficial traits of the problems. We assume that the ability to make such an analogy depends on the semantic congruence between the representations abstracted from the problems rather than on the shared common traits, would they be structural or superficial. We created isomorphic problems that elicit 2 distinct strategies depending on the representation abstracted from their wording. Cardinal representations lead to a 3-steps strategy, and ordinal representations lead to a 1-step strategy (Gros, Thibaut & Sander, 2015). In order to test the impact of semantic congruence on the solver’s ability to make analogies between problems, we designed a task in which 191 participants (m=27.1 years, sd=11.3) had to decide whether 2 given problems could be solved using the same strategy. As hypothesized, analogy rate was higher between semantically congruent problems (83.8%) than between semantically incongruent ones (61.8%), F(1,187)=69.61, p<0.001. This confirmed the influence of the abstracted representations on the ability to detect the similarities between problems. These results suggest that the semantic congruence between the problems representations should be a central issue to develop transfer in education.
5. The Investigation of the Effect of the Number Size of the Primary School Pre-Service Mathematics Teachers Having Different Cognitive Style

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This paper is a part of ongoing project supported by a state university. The purpose of this study is to analyze the behavioral data that are obtained in the addition process conducted with large and small numbers of the pre-service mathematics teachers categorized into groups according to the field dependent-field independent cognitive styles. The participants of the research are composed of 30 primary school pre-service mathematics teachers including 15 field-dependent and 15 field-independent who are studying in a state university. In the determination of the sample, the purposive sampling method is used. For this purpose, Group Embedded Figure Test developed by Witkin, Oltman, Raskin and Karp (1971) is used. In this study, as a data collection tool the addition operations (stimuli) will be used. With E-Prime Software, the addition operations will be presented to the participants on a computer screen. In addition, single-digit numbers will be used. The problems will be presented randomly within blocks. Finally, the answers of the participants will be recorded by E-Prime program and the obtained data will be evaluated by taking their cognitive styles into consideration in terms of the correct answer rate and correct response times of the operations. The obtained results will be discussed.

6. Instructing Flexible Representations in Arithmetic Problem Solving

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Even after instruction children use situation-based, intuitive strategies to solve arithmetic word problems (Brissiaud & Sander, 2010). Students have a very high success rate on problems whose description is easy to simulate (e.g. Luc is playing with his 42 marbles at recess. He loses 3 marbles. How many marbles does he have now?) - Si-problems, while their performance is low when the problem requires arithmetic knowledge (e.g. Luc is playing with his 42 marbles at recess. He loses 39 marbles. How many marbles does he have now?) - MA-problems. A pedagogical design was put in place in first grade classes that used techniques of comparing intuitive and formal procedures in order to induce a representational change and to facilitate the use of conceptual arithmetic knowledge. Students from the 6 experimental and 6 control classes were tested at the end of the school year on different categories of problems, each presented in their Si- and MA-version. The results revealed that students in the experimental classes had higher performance than students in control classes on all the presented problems. Moreover, performance on MA-problems was as high as Si-problems on most problem categories only in the experimental classes. These results put forward that the pedagogical design induced a flexible representation of the situation and allowed students to overcome their intuitive strategies and apply arithmetic knowledge when relevant for providing a solution.
7. Language-Dependent Knowledge Acquisition in Bilingual Learners: Mechanisms Underlying Language-Switching Costs in Fact and Procedure Learning

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Given the increasing number of bilingual education programs, the question if knowledge is represented in a language-dependent way has gained high practical importance. First studies have revealed that content learned in one language will be retrieved and applied more slowly and less accurate when participants have to switch the language from instruction to testing (i.e., language-switching costs, LSCs). In two experiments, we investigated to what extent LSCs are a function of the arithmetic operation as well as the kind of knowledge, and what are the underlying cognitive mechanisms. In experiment A (n=40), students learned arithmetic facts of three different operations over a period of four days. In experiment B (n=35), students acquired procedures and facts in a novel arithmetic task. Participants of both experiments were tested in the trained and untrained language while measuring RT and accuracy as well as collecting strategy reports. The results a) replicate LSCs using auditory stimuli, b) show that the number of trials for which participants reported to translate numbers before responding, significantly predicted the size of the individual LSCs, c) find LSCs mainly for pure arithmetic fact retrieval, not for trained procedures, and d) find that individual differences in language-proficiency, intelligence profile, and math fluency were unrelated to the size of LSCs. The implications of these findings for (bilingual) mathematics learning and cognition will be discussed.

9. Children's Ability to Acquire and Consolidate a Motor Skill Is Related to Handwriting and Reading Proficiency

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Procedural learning is a core skill that has not been studied yet in the context of academic achievements. In a longitudinal study, procedural learning of 56 children in kindergarten and grade two was assessed using the invented letter task (ILT). The ILT is a simple grapho-motor letter like task, typical of children’s activities performed on a digitizing tablet. Speed and accuracy of performance were measured at four time points: pre-training (baseline), post-training, 24 hours post-training (consolidation) and two weeks post-training (retention). The acquisition of the ILT demonstrated learning and consolidation enhancement. Writing speed and writing legibility were tested concomitantly and the following year. Reading was also assessed the following year. Beyond age and socioeconomic status, averaged ILT performance-accuracy was associated with contemporaneous handwriting speed and legibility. Following-year reading-speed mediated the association between task-performance-speed and following year handwriting-speed. Initial performance-speed was associated with contemporaneous handwriting-speed, and with following-year handwriting- and reading-speed. Importantly, 24 hours post-practice gains in performance-speed, underscore consolidation abilities, further contributed to predictability. Our findings suggest that procedural learning, specifically the consolidation performance assessed using the ILT, may be used in early school years to predict later academic achievements.
10. Uncertainty Drives Exploration Behavior in 10-year-old Children
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Exploration is a key mechanism through which children learn about their environment. We investigated whether children select options that yield a known source of reward (i.e., exploitation) or whether they explore unknown options for a potentially better outcome (i.e., exploration) when there is uncertainty about the action outcomes. Additionally, we fit a mathematical model to children’s responses to investigate whether uncertainty about the expected value of options drives exploration behavior. Forty-five 10-year-olds played a computer game in which they stopped a clock arm in order to win points before it made a full round in five seconds. Participants needed to respond at different times (e.g., responding quickly in some conditions, and slowly in other conditions) in order to learn how to get the most points. The experiment consisted of four conditions with 50 trials each that had separate reward distributions. Behavioral results show that children learned to adjust their behavior when they had to respond fast to maximize their reward. Moreover, results derived from the model reveal that relative uncertainty over the reward space correlated with the trial-by-trial reaction time adjustments among explorers. These results provide novel insights into the underlying factors that derive children’s exploration behavior, which are fundamental for learning in home and school settings.

11. Differences in Cerebrovascular Hemodynamics in Children with Normal and Below-Average IQ
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Vascular-associated pathologies have been associated with lower cognitive performance in adults. Specifically, patients with vascular dementia and Alzheimer disease score lower on intelligence quotient (IQ) tests compared to scores obtained before disease onset. Although, the relation between cerebrovascular hemodynamics and cognitive functions has been examined in older adults, little is known how these indices vary in adolescents with and without cognitive deficits. For instance we know that adolescents with cognitive deficits score lower on IQ measures, than their peers, and show heterochrony in development of cognitive functions. However, the relation between cerebrovascular hemodynamics and cognitive performance remains unclear. We investigated the association of parameters of cerebrovascular hemodynamics and cognition adolescents, aged 14 to 17 years. We measured parameters of cerebral blood flow in 31 participants with mild intellectual disability (IQ 50-69) and in 79 participants with normal IQ. Results show a significant difference between peak systolic and end diastolic blood flow velocities of two groups. Findings are discussed in terms of neurocognitive development and the potential of ultrasonography as a tool for research and clinical diagnosis.
12. Plasticity of Cognitive Skills in Adolescence
Lisa Knoll1, Delia Fuhrmann1, Ashok Sakhardande1, Maarten Speekenbrink1, Sarah-Jayne Blakemore1
1. UCL, UK

The brain’s ability to adapt in response to experience, environmental and physiological change – remains high in adolescence. Little is known whether this window of prolonged plasticity provides an opportunity to acquire certain cognitive skills more efficiently than at other ages. In this study, we investigated the impact of numerosity discrimination and relational reasoning training during adolescence, with face processing as a control training task. We were specifically interested in whether the learning trajectory of these cognitive skills changes during adolescence. 633 participants aged 11-33 years, were divided into 4 age groups and 3 training groups and underwent up to 20 days of online training on one of the cognitive skills. Participants were tested before training, after completing training and again six months later. There were different patterns of learning between the three trained cognitive skills. Training on numerosity discrimination yielded improved performance only in the late-adolescent and adult groups. In contrast, all age groups improved their performance when trained in reasoning but benefit from reasoning training increased from mid to late adolescence, and then no further benefit into adulthood. Training on face processing did not result in any performance differences between age groups. These findings provide a better understanding of the effectiveness of cognitive training in adolescence and may have implications for education.

13. Differential Diagnosis Between Primary and Secondary Mathematical Learning Disability - Indications from the Dyscalculia Test Basis-Math 4-8
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Studies in children with AD(H)D without mathematical learning disability (MLD) and studies on the effects of methylphenidate on arithmetic have shown that most deficits in mathematics and most error types which are commonly described as specific for developmental dyscalculia (e.g., finger counting, fact retrieval deficit, complex counting, difficulties with carry/borrow-procedures, self-corrections) cannot be seen as such and thus not be used for the differential diagnosis between primary dyscalculia and secondary MLD. Here, the overall score in the dyscalculia test Basis-Math 4-8 (Moser-Opitz et al., 2010) as well as the number of self-corrections made during the test are proposed as cognitive markers for this diagnostic question.
Hierarchical cluster analyses were calculated in a sample of 43 clinically referred children with normal IQ and suspicion of MLD, including these two pieces of information. The results revealed definite cut-offs in these two markers differentiating between a subgroup with primary dyscalculia, a subgroup with secondary MLD due to attention deficits, and a comorbid subgroup.
In conclusion, the Basis-Math 4-8 (Moser-Opitz et al., 2010) can offer substantial information for the differential diagnosis between dyscalculia and secondary deficits in mathematics due to attention problems in order to optimize treatment decisions for the different groups.
14. Development of a Possible General Magnitude System for Number and Space

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There is strong evidence for a link between numerical and spatial processing. However, whether this association is based on a common general magnitude system is far from conclusive and the impact of development is not yet known. Hence, the present study aimed to investigate the association between discrete non-symbolic number processing (comparison of dot arrays) and continuous spatial processing (comparison of angle sizes) in children between the third and sixth grade (N = 367). Present findings suggest that discrete numerical and continuous spatial magnitude processing are related to each other, but with continuous spatial representations developing earlier and being more easily comparable than discrete number representations for children of this age range. Accordingly, results favour the existence of a more complex underlying magnitude system consisting of dissociated but closely interacting representations for continuous and discrete magnitudes. Finally, future studies are challenged to investigate number-space interactions in a more differentiated way on both the behavioural and neuronal levels, taking differences in developmental courses into account.

15. Using Neuropsychological Heterogeneity to Understand Adolescent Educational Attainment

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Due to the high demands the school environment places on social, cognitive and emotional skills during adolescence, it’s probable that difficulties in these areas will influence academic achievement. Examination of individual differences in adolescent developmental trajectories is essential to understand the effects of these changing behaviours, but often the heterogeneity within samples is ignored. In this study we used graph theory and community analysis to examine individual differences between adolescents who differed in their educational attainment, namely those who were delayed (i.e. had repeated a school year) or on-track in their progression through school. 392 adolescents (Mage= 13.3 yrs, SD=.8) completed questionnaires and a battery of neuropsychological tasks. These measures were used to identify two data-driven neuropsychological profiles that co-occurred in both the delayed and on-track groups: a subtype characterised by cognitive and socio-emotional difficulties and a subtype with fewer impairments. While standard group comparisons of the delayed and on-track groups showed no differences, comparison of the subtypes across groups demonstrated greater impairments in behavioural regulation, externalizing problems and peer interactions in the delayed compared to the on-track students. Thus, by examining the heterogeneity within these groups we were able to draw more detailed conclusions about the influence of developmental differences on educational attainment.
16. Do Adolescents with Developmental Dyscalculia Have a Generalised Magnitude Deficit? Processing of Discrete and Continuous Magnitudes

_Ursina McCaskey¹, Michael von Aster², Ruth O’Gorman³, Karin Kucian³,
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The link between number and space has been widely discussed in the literature, resulting in the theory that number, space and time are part of a generalised magnitude system. This leads to the question how children with developmental dyscalculia (DD), known for deficits in numerical abilities, process magnitudes. By means of behavioural tests and fMRI we examined the relationship between number and space in typical and atypical development. Participants were 16 adolescents with DD and 14 typically developing (TD) peers. In the fMRI paradigm participants had to perform discrete and continuous magnitude comparisons as well as a mental rotation task.

A conjunction analysis revealed commonly activated visual and parietal magnitude areas over all three tasks. No differences were found when contrasting the discrete and continuous magnitude conditions. In the behavioural tests dyscalculics performed significantly worse in numerical and complex spatial tasks, but showed similar results when making magnitude decisions. FMRI results further revealed that DD subjects showed increased activation in domain general regions.

In conclusion, our results point to the existence of a generalised magnitude system in the occipito-parietal stream. Moreover, adolescents with DD seem to have preserved abilities to process discrete and continuous magnitudes. However, neuroimaging findings hint towards the use of compensatory mechanisms in DD.

17. A Common Neural Substrate for Processing Symbolic and Non-symbolic proportions

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Recent neuroimaging research indicates that fraction processing is associated with activation in the intraparietal sulcus (IPS), irrespective of fraction notation (i.e., symbolic fractions vs. number words: ¼ vs. one-fourth). Yet, to teach fraction knowledge in school, non-symbolic proportions such as pie charts are commonly employed. We investigated whether the processing of symbolic fractions (i.e., fractions and decimals) and non-symbolic proportions (i.e., pie charts and dot patterns) draws on the same underlying neural substrate. Participants had to complete magnitude comparison tasks with fractions, decimals, pie charts, and dot patterns, respectively, while lying in the fMRI scanner.

We observed significant joint activation for the four notation conditions in the bilateral IPS – suggesting a notation-independent neural substrate for processing fraction and proportion magnitude. However, an additional Representational Similarity Analysis (RSA) revealed specific representational similarity between the processing of fractions, pie charts and dot patterns only.

The latter indicated that decimals are represented differently in the IPS as compared to the other notations. This may reflect that decimals do not require the computation of a proportional relation (e.g., ¼) but actually describe the outcome of this computation (0.25). Thus, employing non-symbolic proportions seems an appropriate way to teach the relational information of fractions.
18. Using the Assessment Process to Improve Evidence-Based Information Gathering Skills of Doctoral Students
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In today’s world of Wikipedia and Google Scholar citations, how can we teach students what are, and where to find good sources of evidence? Quality control of a student’s information gathering skill by looking at their citations is suboptimal because the evaluation happens after the student has invested the time with unreliable sources. The purpose of this study is to measure changes in student information gathering ability before and after a training session in evidence-based information gathering strategies. 23 first-year Audiology doctoral students (Au.D.) enrolled in Auditory Neuroscience were given surveys before and after a two-hour information literacy training on how to find and evaluate resources during the evidence-based information gathering process. The assessments contained questions on confidence (CNF), knowledge (KNW), and current student information usage and behavior (USE). Wilcoxon signed-rank tests were used to compare the rank ordered median of responses. Results show that understanding evidence-based practice (EBP) early in the first year of doctoral education allows the learner to gain confidence in information gathering and produce higher quality scholarly output. Our study suggests a method for learning assessment may be used to guide life science education practices. As such, programs themselves may become “evidence-based” in regards to education, resulting not only in improved awareness, but also in the rigor of the students’ scholarly output.

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The relationship between teachers and students is crucial in education. Particularly, the teaching techniques of hinting and advising are distinctive aspects. This has been researched through conventional approaches, such as protocol analysis, behavioral analysis, and so forth. Recently, we have been able to apply the neuroscientific approach to measure brain activity effortlessly because of the development of a device for measurement. Analysis of the brain activity data would provide a new perspective for education, presenting a new possibility to identify additional characteristics of the teachers’ techniques in giving hints or advice by measuring brain activity in the setting of a teacher-student interaction. The current study aimed to examine the brain activity of pairs of student-role and teacher-role subjects during a tangram puzzle task, which required forming a shape using seven pieces. In the student-teacher pairs, the student-role subjects were required to construct the puzzle while the teacher-role subjects observed the solving process and provided necessary hints. A hint was showing the position of a piece. There were two types of timing in hint giving. They were: (a) when the teacher-role subjects wanted to propose the hint, and (b) when the student-role subjects requested for it. In order to obtain brain activity data of both the student-role and teacher-role subjects, we used near-infrared spectroscopy.
20. Number Processing Performance of Patients with Math Learning Disabilities (Dyscalculia) and Healthy Subjects

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Problems in perceptions of number may be associated with dyscalculia. 1944 3rd graders selected from 13 primary schools, were screened by a curriculum based math achievement tests, calculations performance test, and RAVEN test to obtain data about their math performance and general abilities. Children were grouped into mathematics learning difficulties and healthy individuals. Number processing performance of patients with mathematics learning difficulties was compared to healthy individuals to examine the differences in these two groups. Number sense is evaluated by visuospatial stimuli in behavioral task. Dot comparison, symbolic number comparison and mental number line tests were applied. Children were evaluated in terms of level of intelligence and for other psychiatric disorders. When compared math skills of dyscalculia group with healthy controls, there was a significant difference between these two groups. However, there was no significant difference in terms of reaction times and accuracy in computer implemented basic number processing tests. The results are partly in conflict with the literature. The reasons for this conflict might be the differences in the paradigm used, age and intelligence mismatch, handedness criteria when creating the patient and control groups. However, this will allow testing of brain function differences in an appropriate manner between dyscalculia patients and healthy controls in further imaging studies.

21. Reading Books: The Best Cure Against Believing in Neuromyths

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There is growing concern about the prevalence of neuromyths among teachers. We surveyed 531 (498 females; mean age = 20.56 years, SD = 4.55) undergraduate and postgraduate students enrolled in Pedagogical Departments in the University of Thessaly and the University of Athens. We used a 70-item questionnaire to assess general knowledge on the brain, neuromyths, as well as reading habits (frequency of reading popular science literature and number of books of any kind read per month). To examine factors predicting neuromyths, a linear regression was performed for neuromyth error scores; sex, student status, university, reading of popular science, number of books read, and the error score of general assertions about the brain were the predictors. The model was significant, R² = .07, F (6, 531) = 6.75, p < .001; the general knowledge error score was the only significant predictor of neuromyth error score (β = .37). A second regression was performed for the error score of the general assertions; sex, student status, university, reading of popular science and number of books read were the predictors, R² = .021, F (5, 531) = 2.26, p = .04. The error scores on general knowledge about the brain was significantly predicted only by the number of books read monthly (β = .63). Findings indicate that prospective teachers that read more books tend to have better general knowledge about the brain. In turn, general knowledge is the best safeguard against believing in neuromyths.
22. A Novel Saccade-Contingent Visual Enumeration Procedure Provides a More Parsimonious Measure of Subitizing Capacity

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It is not known whether eye movements play a functional role in enabling exact enumeration of small sets of objects ("subitizing"), and ipso facto underlie the computation of visual numerosity. Given individual differences in subitizing capacity predict maths problem solving abilities, resolving this question would shed light on the utility of eye movements as an unobtrusive measure of numerical cognition in children and adults alike. Most studies determine subitizing capacity (largest set size enumerated without error) using very brief, fixed stimulus durations. Here we examined the possibility that eye movements improve perceptual resolution and correspond to discrete increments in numerical decisions for small sets. Adolescents enumerated random dot arrays under three conditions (1) fixed-duration displays of 250ms, 500ms and 1000ms; (2) saccade-contingent displays that remained visible until one, two or four fixations occurred; or (3) displays that remained visible until an enumeration response. Subitizing capacity was typically one to two elements larger for the fixed-duration and saccade-terminated trials, than for the response-initiated trials. Moreover, subitizing thresholds were less variable in the saccade-contingent compared to fixed-duration trials. The findings indicate a functional role of saccades in enumeration within the subitizing range and validate a novel saccade-contingent procedure for investigating individual differences in numerical cognition.

24. The Neural Differences and Similarities Between Children with and Without Learning Disorders During Arithmetic

Lien Peters¹, Hans Op de Beeck¹, Bert de Smedt¹

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Children with specific learning disorders (dyslexia, dyscalculia) often have problems with basic arithmetic. Different hypotheses have been proposed on the neural origin of these disorders (number processing deficits in dyscalculia, phonological deficits in dyslexia) but these have never been contrasted in one study. Therefore, we compared the brain activity of children with learning disorders in a design that allowed us to unravel processes (e.g., fact retrieval, procedure use) that might be associated with the specific or common neural origins of these learning disorders. Sixty children aged 9 to 12 took part, comprising children with dyslexia-only (DL), children with dyscalculia-only (DC), children with comorbid dyslexia and dyscalculia (DLDC), and healthy controls (HC), that were carefully matched. All underwent fMRI scanning during which they had to subtract numbers up to 10 presented as dots, digits or number words. As expected, DL children performed poorly on symbolic formats (digits, words) whereas DC and DLDC children showed poor performance on all formats. However, on a neural level, preliminary analyses show very few differences between children with learning disorders: HC children show higher activation levels than the three groups of children with learning disorders, regardless of the disorder. These data suggest that, despite behavioral differences, the neural profiles of children with different learning disorders may be more similar than initially thought.
Joanna Plewko
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Learning letter-speech sound association is the first and critical step for reading development. Previous studies showed reduced responses to letters and speech sounds as well as no congruency effects in dyslexic subjects. Little is known however if such deficits are already present in children with familial risk for dyslexia (FHD+).
55 FHD+ and 41 FHD- children (mean age = 7 years) underwent fMRI scanning during which four experimental conditions were presented (letters, speech sounds, congruent and incongruent letter-speech sound associations).
FHD+ children showed weaker activity for processing speech sounds in the left superior and inferior temporal gyri and in the left fusiform gyrus, while they had higher activity than FHD-children in the right intraparietal lobe and interior frontal gyrus. FHD+ children had also reduced activity for letters in the anterior temporal lobes bilaterally.
Interestingly, in multisensory conditions, incongruent vs. congruent letter-speech sound association produced higher activation, observed for less transparent orthographies. In this condition FHD+ compared to FHD- children had significantly reduced activity mainly in the left tempo-parietal cortex.
Our results suggest that some brain activity differences observed in dyslexic children and adults are already visible in beginning readers at risk of dyslexia.

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Arithmetic processing is complex. Arithmetic operation, strategy use, and problem size modulate activity in the brain network that supports arithmetic processing. Prior behavioral research has shown that arithmetic fact retrieval is related to phonological processing ability and elicits brain activity in left lateralized brain regions that support phonological processing. However, whether common brain regions support both arithmetic and phonological processing is unclear. This study used neuroimaging meta-analysis to investigate the functional neural overlap between arithmetic and phonological processing in children. Separate meta-analyses produced clusters of concordant brain activity in line with prior research. For arithmetic, clusters were mainly in left lateralized regions, including frontal regions, angular gyrus, fusiform gyrus, and bilateral inferior parietal lobule. For phonological processing, clusters were mainly in left lateralized regions including frontal regions, middle temporal gyrus, and fusiform gyrus. A conjunction analysis showed neural overlap in frontal regions and fusiform gyrus, but not in temporoparietal cortex. Common areas appear to support attentional processes and symbolic processing of arithmetic problems and words. The present meta-analyses illuminate the relationship of arithmetic and phonological processing in the brain, and the brain regions that may support processing of complex symbolic representations such as arithmetic facts and words.
27. Neural Activity Patterns Associated with Retrieval and Procedural Strategy Use in Typically Developing Children

Brecht Polspoel\textsuperscript{1}, Lien Peters\textsuperscript{1}, Bert de Smedt\textsuperscript{1}  
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Introduction Adult fMRI studies have indicated that activation in the arithmetic brain network is modulated by strategy use. In children, alternate activation has been suggested by manipulating problem size, but a trial-by-trial testing to check the children's actual strategy use was yet to be done, leaving it unclear how brain activity alters as different strategies are used.

Method Participants were 23 typically developing 4th graders (9- to 10-year-olds). In a behavioral session, they were asked to solve 100 subtraction and multiplication items, and to verbally report how they solved them. In the fMRI scanning session, the children were presented with 80 of those items. With an event-related design, we were able to analyze the brain responses during retrieval or procedural strategy use, based on the children's verbal reports in the behavioral session.

Results During retrieval, we observed increased activity in the bilateral middle temporal gyrus, hippocampus, medial frontal gyrus and inferior parietal lobe (supramarginal to angular gyrus). For procedural strategies, activation increases were observed in the bilateral superior parietal lobe (intraparietal sulcus), middle and inferior frontal gyri, insula and inferior occipital gyrus. There were no differences between multiplication and subtraction, meaning that differences across items are mainly driven by strategy use, instead of operation.

28. Pedagogical Tools for Enhancing Memory Consolidation

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The aim of our study was to investigate the comparative influence of spaced vs. massive learning on the capacity of young adults (educational students) to conceptualize science material. Behavioral and imaging studies show that breaks during repetition learning (spaced learning) improved learning processes, by enhancing the consolidation of long-term memory. These findings were especially evident with the learning of words or pictures presented in a list, and arithmetic skills. The implications of spaced learning in natural environments are still open. For this purpose, students were taught in 2 groups: a control group taught 2 lessons via massive learning, and a research group taught the same material in one spaced learning lesson. We examined the students' capabilities in 2 tests – which included recognition and recall questions. Our findings revealed: 1. No significant difference was found between the groups in recall and recognition responses (F(4, 32)=2.07, p>0.05). This finding indicates the benefits of time duration in teaching using spaced, as opposed to massive learning. 2. Spaced learning was significantly more beneficial for recalling conceptual knowledge than massive learning, for students with average and above average learning abilities (F(4, 16)=3.24*, p<0.05). This novel study is part of a major research program about introducing neuroscience knowledge into education. The operative implications of these findings will be demonstrated in a poster.
Insight is a unique problem solving process, which is non-incremental. It is considered to be perceived suddenly, with no prior steps leading to the relevant solution. Classically, insight has been considered to have four stages – problem solving, blockage in achieving a solution, giving up and moving to other activities, sudden insight in which all stages of the solution appear at once. This is accompanied by a sharp positive emotional burst. Our aim in the current study was to test whether subliminal visual cues that are relevant to the solution, but not the direct solution, will shorten the time to insight and increase the relative percentage of the sample that will achieve insight compared to without subliminal cues. We chose a quiz that requires no background knowledge yet has a logical mathematical nature, and can be solved both by insight and by incremental processes. Half of 32 subjects separated into two homogeneous equivalent groups, were shown subliminal cues that highlighted for <10 miliseconds the visual parts of the quiz that need to be manipulated for the solution. The solution itself was not shown. We found more insighters in the experimental group. At the same time we connected all to EEG and found significant differences in the levels of changes in Gama and beta frequencies, and in source localization, suggesting different mechanisms that are involved in insight and incremental.
1. The Ability to Concatenate Quantities: The Missing Link between Number Line Judgment and Math Problem Solving Abilities?

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It is well established that children’s ability to accurately mark the location of numbers on a spatial number line (e.g., 0-100 NL) predicts their math abilities. It is often claimed the growth in visuo-spatial working memory (VSWM) supports changes in NL judgment abilities; however, the reason for this claim is rarely specified. We argue that the ability to locate numbers on a NL depends implicitly on the ability to concatenate quantities (i.e., identify A, B, and then A+B) - the same ability required in simple computation - rather than VSWM per se. To test this hypothesis, we assessed 157 5 to 9 years-olds’ conventional 0-100 NL judgement abilities, VSWM, single-digit addition (SDA) problem solving strategies, and performance on a new NL task that measured concatenation ability directly. The new NL task comprised three components: (1) mark number on NL A, (2) mark number on NL B, and (2) estimate concatenation of A+B on NL C. We were interested in the relationship between judgment patterns on the two NL tasks and SDA strategy sophistication, controlling for VSWM. Latent profile analyses yielded three NL and SDA strategy subgroups respectively that overlapped in concatenation abilities. While VSWM was associated with both NL tasks, it did not account for the ordinal overlap between subgroups. Findings support the claim that concatenation abilities underlie conventional NL performance. The assessment and instruction implications of the findings are discussed.

2. Memory Consolidation and Neurofeedback: Self-Regulation of Brain Oscillations Enhances Speed and Relative Accuracy of Performance

Miriam Reiner¹

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Memory consolidation has been largely studied in an attempt to build a model of the underpinning mechanism of memory consolidation. Two major breakthroughs showed that memory consolidation occurs during NII REM night sleep and combined fMRI and EEG studies showed that the process of consolidation at night is associated with enhanced levels of theta oscillations. our question was whether memory consolidation can happen during day time. we used a neurofeedback process to train participants to raise their theta oscillations, and found that immediately after the performance of a previously learnt motor task was enhanced by >12%. Further enhancement was found after first and second (up to sixth night sleep). In a currently completed study we also found that not only that the speed of performance was enhanced, but the speed-accuracy-tradoff, expecting to see more errors when the speed is increased was broken down and although speed increased errors did not. this provides a new method for enhanced learning.
3. A Potential Framework for Educational Neuroscience Research: Example of the Underpinning Mechanism of Learning in 2D vs Stereoscopic 3D Virtual Worlds

Miriam Reiner¹, Alex Dan¹

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The Virtual Reality and NeuroCognition lab, http://vrneurocog.wix.com/vrneurocog

Technion, This paper brings a methodology that integrates immersive virtual/augmented reality, with synchronized EEG measures of emotional states, to study mechanisms of learning in 2D and 3D virtual worlds in a social setting. We extract mental load from EEG measures as a base for Brain-Computer-Interface adaptive learning environments. We developed and apply a unique immersive virtual reality (VR), in which one can see, hear and touch virtual objects. In a typical experiment, participants perform a task in VR while connected to systems that measures EEG. Our goals are to identify the neural correlates of enhanced learning. We apply this to study whether stereo-3D immersive virtual environments are at all beneficial for learning beyond a flat 2D screen, and if so, what are the associated underpinning mechanisms that improve learning in VR.

Subjects were asked to watch and learn a origami task of a box in 2d/3D VR. Our EEG results show surprisingly that EEG index of mental load in 2D is higher significantly than in 3D VR, and learning is superior in 3D VR.

4. Does Non-symbolic Comparison Reflect Numerical Processing or Inhibition? Results from a Training Study with tDCS

Delphine Sasanguie¹, Nicky Daniels¹, Hans op de Beeck¹, Roi Cohen Kadosh²


Evidence has shown that the acuity of the Approximate Number System (ANS) is related to mathematical competences (e.g. Fazio et al., 2014). These findings have led researchers to suggest that the ANS plays a critical role in mathematics learning. The most popular task to examine ANS acuity is a non-symbolic comparison task (i.e. deciding which of two dot arrays contains more). However, Gilmore et al. (2013) have suggested that the performance on this task reflects inhibitory skills which are necessary to ignore non-numerical cues to successfully perform the task. To dissociate between both hypotheses, we trained 36 adults during three consecutive days on a non-symbolic comparison task while stimulating their brains with transcranial direct current stimulation over 1) the right posterior parietal cortex (PPC), a key brain area for magnitude processing; 2) the right dorsolateral prefrontal cortex (PFC), a key brain area for inhibition skills. A third group received sham stimulation. Non-symbolic and symbolic comparison tasks, two experimental inhibition tasks, and a calculation test were assessed pre- and post to this training. The current results indicate that stimulation was effective as a function of stimulation, with significant improvement in performance during the earlier stage of training with PFC stimulation, but not PPC. The relationship between these results, numerical processing, and inhibition are discussed with regards to their impact on education.
5. Text-picture Integration During Learning - EEG Frequency Band Power Correlates of Congruency Effects

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In the current study we were interested in how the amount of congruency between textual and pictorial information would alter the induced cognitive load (CL) during a memorization phase as measured by EEG frequency band power. The congruency of text-picture combinations was manipulated by simultaneously presenting a simple line drawing and a single sentence whose information content was either fully congruent with the picture, partly congruent (i.e., providing information partly contained in the picture), or incongruent (i.e., providing information different from the picture). We expected the incongruent condition to induce more CL during the memorization phase as compared to the other conditions because of the impossibility to integrate the textual and pictorial information in this condition.

We observed increased EEG theta frequency band power in the incongruent as compared to the congruent conditions early after stimulus onset. This might indicate the detection of the incongruence per se. We also observed decreased alpha frequency band power in the incongruent as compared to the congruent conditions in a late time window. This might indicate the increased CL when the two different information contents have to be memorized.

For a more in-depth analysis of CL during text-picture learning we examined variations in EEG frequency band power eye-fixation related. We will discuss this methodology to study CL in free viewing situations and the present outcomes.

6. Brain Response to Arithmetic Errors is Modulated by Individual Differences in Mathematical Competence in the Inferior Frontal Gyrus (IFG)

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Numerous studies have investigated brain activity during mental arithmetic as well as its modulation by individual differences in mathematical competence. Most of these studies have focused on correctly solved problems, discarding error trials from further analyses. As a consequence, comparatively little is known about how arithmetic errors are processed in the human brain, and how error processing is modulated by mathematical competence. The aim of the present fMRI study was therefore to examine arithmetic error processing in individuals with varying levels of mathematical competence. For this, two groups of 15 participants (low vs. high competence) validated additions in the base-7 system. Calculating in the base-7 system is error-prone because solutions can differ from the common base-10 system (e.g. 32 + 5 = 40). Contrasting errors with correctly solved trials revealed three brain areas in the left hemisphere: inferior frontal gyrus (IFG), insular and anterior cingulate cortex (ACC). A region of interest analysis further indicated that this contrast was more pronounced for the high competence group in the IFG; no significant difference between groups was found in the other regions. While ACC and insular have been suggested to be related to error detection, the IFG is thought to implement adjustments to errors. Taken together, results suggest that highly mathematical competent individuals show stronger adjustments to arithmetic errors than lower competent individuals.
7. Caught in a Web of Expectations and Concerns: The Complexity of Issues that Arise from the Availability and Education-Related Use of TES-Based Cognitive Enhancers
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An increasing number of healthy adolescents are using products that can enhance their cognitive performance in educational settings. Currently, pharmaceuticals are the most widely discussed enhancement method in the literature, but new evidence suggests that methods based on Transcranial Electric Stimulation (TES) have potential as cognitive enhancer as well. Just like pharmaceutical enhancers, the availability and education-related use of TES-devices raises a broad range of ethical, legal and societal issues that need to be addressed by policy-makers. Few studies, however, have specifically studied these issues in relation to child wellbeing. In this systematic review, we explore the issues for child wellbeing that could arise from the availability and education-related use of TES-devices by healthy minors. We demonstrate that the issues form a complex web of expectations and concerns, which are incited by high levels of factual uncertainty and moral diversity. Little is known yet about the working mechanisms of TES and its (long-term) effect on healthy developing brains, and different perspectives towards virtues such as autonomy and authenticity lead to discussions on whether certain enhancement effects would be desirable, and whether potential risks would be acceptable. We argue for a co-constructive policy approach to deal with the identified issues effectively.

8. Lexical and Multiplication Decisions: Effect of General Giftedness
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This study reports the performance on lexical decision (words or non-words) tasks as compared to simple single digit multiplication verification tasks. Of the 170 high-school students who participated in this study, 71 were identified as being generally gifted (IQ≥130). Using event related potentials (ERP) methodology, behavioral and electrophysiological measures were collected and analyzed.

The reaction time for the lexical decision tasks was shorter than for the multiplication tasks among all the participants, yet no differences were found between the gifted (G) and non-gifted (NG) students in their accuracy or reaction time. P300 was identified in both tasks, and significant differences were found between the two types of tasks, with longer latency and lower amplitude for the multiplication task as compared to the lexical decision task. In addition, a significant interaction between the task and G factor was found in both the latency and amplitude of P300. A significant gap in P300 was found between G and NG participants on the multiplication task only, with a shorter latency and lower amplitude for the G individuals.

These results suggest that the processing of lexical decisions differs from the processing of numeric information. G level did not affect the lexical task, which seems to be more automatic and demands fewer cognitive resources.
9. Developmental changes in the Neural Correlates of Symbolic Number Processing: A Functional Neuroimaging Meta-Analysis

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A growing number of neuroimaging studies have indicated that the neural correlates of symbolic number processing undergo both a fronto-parietal shift and a shift towards greater left-lateralization of parietal activation across development. These developmental changes in the neural correlates of number processing likely reflect both maturation and experience (e.g. education). However, there are conflicting results between individual studies and there is a need to synthesize the existing data. Therefore, we used Activation Likelihood Estimation (ALE) to conduct quantitative meta-analyses comparing neural correlates of symbolic number processing in adults and children. Conjunction analyses revealed overlapping activation for children and adults in frontal and parietal lobes. A contrast analysis comparing children>adults revealed medial frontal gyrus activation, which is consistent with the notion of greater involvement of frontal regions in children compared to adults. The reverse contrast, comparing adults>children revealed greater activation in the left parietal lobe, which supports the concept that adults recruit left parietal regions for symbolic number processing more than children. These meta-analytic findings indicate that over developmental time, the neural correlates of symbolic number processing undergo both a fronto-parietal shift and increasing left-lateralization of parietal activation correlated with symbolic number processing.

10. Children Learn Arithmetic Differently Than Adults: Evidence from Simultaneous fNIRS-EEG Study

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Learning is associated with a shift from procedural to retrieval processes, subserved by a decreasing brain activation in the frontoparietal network along with an increasing activation of specific cortical and subcortical areas. However, little is known about specific activation changes in multiplication learning in children. 20 children were trained in simple and complex multiplication over seven sessions using a web-based learning platform. Before and after training simultaneous functional near-infrared spectroscopy and electroencephalography data were calculated during multiplication problem solving. Training improved performance for trained as compared to untrained sets. This improvement was subserved by decreased activation in the left angular gyrus and middle temporal gyrus, and the right middle frontal gyrus in trained compared to untrained complex multiplication, but not in simple multiplication. Moreover, in trained problem sets increased alpha power was observed compared to untrained sets. In line with multiplication learning in adults and addition learning in children, these findings indicate a decreased activation of frontoparietal network after multiplication training. However, contradictory to the multiplication training in adults, decreased activation of left angular gyrus was found. We conclude that strategy shift from procedural to retrieval in children engage different neural patterns than in adults and that the role of angular gyrus activation may differ.
11. Reliability and Validity of Numerical and Non-numerical Ordinality Processing, and its Relationship to Arithmetic Fluency

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A growing body of evidence has indicated a link between individual differences in processing numerical order (e.g., deciding whether numbers are arranged in an ascending/descending order or in a mixed-order) and arithmetic achievement. The reliability of this association as well as its validity in relation to non-numerical (i.e., letters) order processing is currently unknown. This study aimed to fill this gap by investigating differences and commonalities of numerical and non-numerical order processing as well as their relationship to arithmetic fluency.

We invited 36 adults twice (within a time period of 6-9 days) to our laboratory to perform three order tasks on a computer, consisting of Arabic-digits, dot-arrays and letters of the alphabet. Participants judged whether stimuli were arranged in an ascending/descending order (e.g., 2 3 4; B C D) or in a mixed-order (e.g., 3 6 4; C F D). Arithmetic fluency (addition, subtraction and multiplication) was measured with a paper pencil test.

Results of the study demonstrated reliable reaction time differences between all conditions. Furthermore, reliable associations between arithmetic test scores and reaction times of the Arabic-digit and letter condition were observed, however, not so for dot-arrays. A performed hierarchical regression analysis showed that judging the order of Arabic-digits explained a significant amount of unique variance in arithmetic fluency, over and above dot-arrays and letters.

12. Relations Between Teacher's Perception of Nature-Nurture Question, Neuromyths, and Metaphorical Conception of Teaching Students with Learning Disorders

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Misunderstanding about brain function and development also relates to teacher's opinions on issues such as learning disorders and so, in turn may influence outcome of students with these disorders" (Howard-Jones, 2014, p. 817). To more fully examine this issue we investigated mentioned relations using quantitative and qualitative study design. 98 primary school teacher in inclusive education participated in the study. A questionnaire consisting of three parts was designed. (1) series of items selected from a survey of neuroscience literacy adapted from Howard-Jones (2009) and focusing on statements on brain plasticity, e.g. "Learning problems associated with development differences in brain function cannot be remedied by education". (2) Walker and Plomin's survey about teacher's perception how education, genes, and home contribute to educational outcomes of students with LD. (3) In addition, metaphor analysis technique was applied for gaining deeper and more profound insight into teacher's beliefs, implicit theories and tacit knowledge regarding their teaching of students with LD, which may determine classroom practice. Participants were prompted to complete the sentence "Teaching students with learning disorders is like ..... because .....". Subsequent qualitative data analysis used the methodology of inductive thematic analysis. Obtained results have practical application in raising teachers' neuroscience literacy and improving their teaching of students with LD.
13. Translation of Research Knowledge in Neuroscience into Improvement of Teaching and Learning: A Case Study on Teaching a Course in Neuropedagogy
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In Israel, awareness of the need for cooperation between research findings in the field of neuroscience and educational practice and policy is on the rise. Twenty-six students studying for an M.Ed degree in the administration of education systems participated in a one-semester course on "Neuropedagogy: Brain Research for Improving Teaching and Learning". The students were exposed to the neurological basis of learning, memory and behavior and to the possible contribution of research innovations in neuroscience to improvement of teaching and learning. At the end of the course, the students presented possibilities for the implementation of neuroscience findings in the following fields: Confirmation and scientific basis for the actions and work procedures they employ, which increased their confidence ("We always did this, and now we have the basis to think that we are acting correctly"); new directions for thinking and acting, that were not familiar to them prior to the course ("The knowledge of how the brain works enables us to construct different modes of teaching"); new thinking and teaching tools based on neuropedagogic knowledge; change in their attitude towards the students ("Now we better understand the difficulties and needs of our students"). These fields create possibilities for improving the teaching, for increasing the teachers' interest in their work, for creating a more suitable relation between the student and the teacher and for a richer and better learning life.

Kelly Trezise¹, Robert Reeve¹
1. University of Melbourne, Australia

While math anxiety (MA) is known to affect math problem solving, it is not known whether it changes as a function of problem difficulty. Most MA indices are based on questionnaire data, which often assume MA is a fixed personality trait. However, fMRI and physiological evidence suggest MA is affect by problem difficulty. A better understanding of how problem context and/or difficulty impacts MA may help clarify its effects on math achievement. If a student's MA is higher for difficult problems, it may impair the ability to learn new math material or result in math avoidance. If a student’s MA is higher under time pressure it may affect test outcomes. To investigate these issues, we report findings from two studies in which adolescents rated their level of worry as they solved algebra equations that differed in difficulty (novice, easy, moderate, hard, and advanced equations), and time available to solve them (short or longer time). Latent variable analysis identified four problem solving accuracy patterns, and five worry patterns that varied as a function of equation difficulty and problem presentation time. Moreover, worry patterns and problem solving accuracy patterns were associated with each other in meaningful ways. Overall, the findings caution against a general account of MA and highlight the importance of identifying patterns of individual differences in MA-problem solving relationships.
15. The Influence of Reading Problems on Basic Numerical Processing in Children with and without Math Difficulties

Anniek Vaessen¹, Patty Gerretsen¹
1. Regional Institute for Dyslexia, The Netherlands

It has been claimed that children with reading problems often also experience math problems and the other way around. Studies report an overlap between reading and math problems varying between 17 and 81%. The question is in which way the cognitive problems underlying reading difficulty relate to arithmetic performance. Do children with reading difficulties mainly have problems with math because they have difficulties with automatizing arithmetic procedures and higher order mathematical tasks that (partly) rely on verbal processes, or do they also have problems with basic numerical processing? And do children with combined math and reading difficulties (RDMD) show the same deficit pattern on basic numerical tasks as children with math difficulties only (MD) or not? In the present study, the relationship and overlap between reading fluency problems and arithmetic problems is investigated in a large Dutch school population of more than 1200 primary school students. The influence of reading performance on numerical processing is investigated, and children with reading problems only (RD), MD, and RDMD are compared on a number of arithmetic and basic number processing tasks. Results suggest that reading problems affect some basic numerical processes, but leave other processes unaffected. Results and practical implications will be discussed.

16. Incorporating Children's Everyday Context in the Reading the Mind in the Eyes test

Anna van der Meulen¹
1. Vrije Universiteit, The Netherlands

Theory of Mind, which includes the ability to read mental states from facial cues, can contribute to children’s academic and social functioning at school. Recent insights emphasize the contextual embeddedness of different Theory of Mind abilities. For mental state reading and emotion recognition it has been shown that familiarity with the characteristics of an interaction in which these abilities are applied enables performance. Our aim is to gain insight in these context effects for mental state reading in children, often assessed with the Reading the Mind in the Eyes (RME) task that consists of pictures of adult eyes. Since interacting with other children is an important part of children’s everyday social context and therefore familiar for them, it can be expected that their mental state reading performance depends on whether this is assessed by reading adults’ or children’s eyes. In order to test this, a new 14 item child RME with pictures of children’s eyes instead of adults’ eyes was developed. This task was used and compared to the original child RME in two age groups, 6-9 year olds (N = 718) and 8-14 year olds (N = 182). In both age groups performance on the new children’s eyes RME was higher. Test-retest reliability of the new RME in a sub group (n = 95) of the older children was adequate (.47). These results suggest that an RME with children’s eyes can be a valuable instrument to assess children’s mental state reading ability in the context of other children.
17. Electrophysiological Correlates of Symbolic and Non-symbolic Numerosity Processing in Adults and Children

Anne van Hoogmoed¹, Evelyn Kroesbergen¹
1. Utrecht University, The Netherlands

In the current study, we investigated the electrophysiological correlates of magnitude representations, controlling non-symbolic stimuli for visual input. Contrary to former ERP studies, we used a match-to-sample instead of a comparison task as this task has been shown to tap into magnitude representations without measuring decisional processes (Van Opstal et al., 2008; Van Opstal & Verguts, 2011). Two stimuli were presented after each other, and participants had to respond only if the target matched the sample (10% of the trials). Distances between stimuli were manipulated. Next to tasks with non-symbolic samples and targets (Ns-Ns), and symbolic samples and targets (S-S), tasks with non-symbolic samples and symbolic targets (Ns-S) and vice versa (S-Ns) were included to examine mapping of symbolic and non-symbolic numerosity. Behavioral results in adults show distance effects in the Ns-Ns, Ns-S, and S-Ns tasks. Moreover, they show that adults underestimate non-symbolic numerosity. ERP results in adults show no effects in the early N1 and N1-P2 time windows. Processing of non-symbolic targets shows a clear distance effect in the P3 time window, preceded by a small effect in the N2 window. For symbolic targets, no distance effects were found. Children’s data are currently being collected as will also be presented. In addition to the ERP paradigm, behavioral measures of mathematics are included to examine the relation between the ERP distance effect and math performance.

18. Dynamic Scaffolding: How Child-Directed Actions Influence Children’s Learning

Johanna van Schaik¹, Marlene Meyer¹, Camila van Ham¹, Sabine Hunnius¹
1. Radboud University Nijmegen, The Netherlands

Adults scaffold young children’s learning by exaggerating their actions during demonstrations. This study quantifies whether and how parents dynamically modify repeated demonstrations depending on their infant’s behavior and whether this facilitates infants' learning. Motion tracking was used to record parents' (N=44) kinematics while they were demonstrating novel objects with unique affordances to their 14-month-old. Following an initial object demonstration, parents were free to exchange the object with their infant and repeat demonstrations as desired. Infants' memory of the actions was tested after a break. Preliminary analyses indicate that parents dynamically modified their kinematics. For example, the more infants attempted one of the actions, the more parents repeated the action (r=.775,p<.001) and the closer to the infant they demonstrated the action (r=.624,p=.01). The more successful infants already were, though, the less often (r=-.635,p=.008) and further away (r=-.607,p=.013) parents demonstrated the action. Further analyses investigate specific kinematic parameters and, crucially, their effect on infants’ learning. An ensuing EEG study compares the effects of child-directed actions on infants' attentional processing as measured by theta oscillations and investigates the relationship between theta and later memory performance. Together, the pending results provide insights into the mechanisms through which live pedagogy facilitates action learning.
19. Symbolic Magnitude Processing is as Important to Arithmetic Development as Phonological Awareness is to Reading

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1. Katholieke Universiteit Leuven, Belgium, 2. University of Western Ontario, Canada

In 1999, Gersten and Chard already theoretically suggested that understanding the meaning of numbers might be “an analog as important to mathematics learning as phonemic awareness has been to the reading research field”. The present longitudinal study, tested whether the strength of the consistent symbolic magnitude processing-arithmetic association is similar to the well-established phonological awareness-reading association. Typically developing children (n = 74) were tested at the start of third (Time 1) and fourth (Time 2) grade. At Time 1, symbolic magnitude processing was assessed with a standard comparison task and phonological awareness with a classic phoneme deletion task. At Time 1 & 2, arithmetic and reading abilities were measured. Cross-sectional and longitudinal correlations revealed that symbolic comparison was a domain-specific and unique predictor of arithmetic and that phonological awareness was a domain-specific and unique predictor of reading. Bayesian hypothesis testing further revealed that the strength of these independent associations was not significantly different. The current longitudinal data indicate that symbolic magnitude processing is an at least as powerful predictor of arithmetic development as phonological awareness is to the acquisition of reading, and moreover suggest that symbolic magnitude processing is a good candidate for screening children at risk for developing mathematical difficulties.

20. Special Education Neuroscience Literacy Amongst Prospective Teachers

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1. University of Thessaly, Greece, 2. National and Kapodistrian University of Athens, Greece,

While neuroscience literacy amongst teachers has been receiving attention in the past years, neuroscientific knowledge that taps specifically on special education has been overlooked. In the current study we surveyed 568 (514 females; mean age = 20.77 years, SD = 4.67) enrolled in Pedagogical Departments in the University of Thessaly (UoT) and the University of Athens (UoA), using a 50-item questionnaire to assess general knowledge on the brain, including 8 items on special education. Over the whole sample, 33.95% of the participants responded to the special education assertions correctly, 33.89% responded incorrectly, and 32.16% opted for the “do not know” option. A univariate ANOVA was performed with sex (male or female) and course (undergraduate in primary education UoA, postgraduate in special education UoA, postgraduate in neuroscience and education UoA, undergraduate in special education UoT, and undergraduate nursery education UoT) as the between-participant factors and the error scores for the special education assertions as the depended variable. The between-participant factors were significant (p = .039 for sex, p = .036 for course), with females and undergraduate students from the UoA having higher error scores (significantly different from all other courses, except for the graduate course in neuroscience and education UoA). No interaction was found (p > .43). Implications of these findings will be discussed.
21. The Neural Representation of Symbolic Numbers: Investigations with fMRI Adaptation

Stephan Vogel¹, Ian Lyons², Joshua Bohnenberger³, Karl Koschutnig¹, Gernot Reishofer⁴, Roland Grabner¹, Daniel Ansari²

1. University of Graz, Austria, 2. Western University, Canada, 3. Georg-August-University of Göttingen, Germany, 4. Medical University of Graz, Austria

Humans possess the unique ability to represent numerical quantities using numerical symbols. A small but growing body of evidence from functional Magnetic Resonance Imaging adaptation (fMRIa) has recently implicated the left intraparietal sulcus (IPS) as a crucial brain region representing semantic meaning of number symbols. However, it is still unknown to which extent the left IPS brain activity can be generalized across different languages and number notations (e.g., Arabic digits and spoken number words).

In two separate fMRIa experiments we habituated the brain response of 20 native English-speaking (1st experiment) and 38 native German-speaking (2nd experiment) adults to Arabic digits or spoken number words. Using different statistical approaches, we tested whether participants’ brain response demonstrated a robust and replicable numerical ratio dependent signal recovery and whether voxel-wise brain activation patterns (representational similarity analysis, RSA) are similar between number notations.

The results of both experiments revealed a reliable numerical ratio dependent signal recovery in regions of the IPS. Activations associated with number notations showed a significant overlap in the left IPS, indicating a format-independent representation of numbers. However, the RSA indicated a difference in voxel-wise activation patterns between number notations, suggesting some degree of notation-independent representation.

22. Numerical magnitude processing, working memory and mathematical skills in children with Developmental Coordination Disorder

Chiel Volman¹

1. Utrecht University, The Netherlands

Children with Developmental Coordination Disorder (DCD) often show co-morbid learning disabilities including difficulties with math. In the present study we examined whether children with DCD show a deficit in working memory (WM), non-symbolic and/or symbolic numerical magnitude processing (NMP), and whether WM and NMP predict achievement in math skills. Children with DCD (7-12 years; N=25) and age-matched typical developing (TD) peers (N=48) participated. NMP skills were assessed with a non-symbolic comparison task (Panamath) and a symbolic number line estimation task. WM was measured with the Automated Working Memory Assessment Battery. Fifteen children with DCD (60%) and 8 TD children (16%) were lagging behind on a Dutch math skills test for more than one year. DCD children scored significantly lower on math skills, visuo-spatial and verbal WM, and on symbolic and non-symbolic NMP compared to TD children. Hierarchical regression analyses revealed that only in the DCD group visuospatial WM was a significant predictor of math skills, and that non-symbolic and symbolic NMP significantly contributed to the explained variance in math skills. Children with DCD show relatively more problems with mathematical skills compared to age-matched TD peers. Both domain-general working memory processes and domain-specific numerical magnitude processing contribute to these poorer math skills in children with DCD.
23. Predicting Arithmetic with the Processing of Order Sequences of Digits, Letters and Months

Helene Vos¹, Delphine Sasanguie¹, Wim Gevers², Bert Reynvoet¹
1. Katholieke Universiteit Leuven, Belgium, 2. Université libre de Bruxelles, Belgium

The efficiency of ordering digits has been shown to be highly related to arithmetic. However, the underlying mechanisms in the different conditions during order judgments are still unclear. Therefore, the current study aimed to examine how distance and direction are processed in ordered sequences and to study the extent to which the relation between arithmetic and order processing is specific for digits. In the first experiment, participants performed an order judgment task and had to indicate whether a sequence of three digits was presented in the correct order. In the second experiment, participants conducted order judgments of digits, letters and months. In the order judgment tasks, ascending, descending and non-order trials were presented. Additionally, half of the trials for each direction were close triplets, the other half were far triplets. Results showed a reversed distance effect for ordered trials of digits, letters and months. In addition, ascending trials elicited faster performance compared to descending trials and the reversed distance effect was stronger in ascending than descending trials. With regard to non-ordered trials a standard distance effect was found. This suggests different mechanisms can play a role depending on the characteristics of the triplet that is presented. Arithmetic was related to order performance in all tasks, suggesting that the relation between arithmetic and order is domain-general.

24. Does the Development of Digital Skills Influence the Development of Basic Numerical Skills in Children from Three to Four Years Old?

Line Vossius¹, Marie-Pascale Noel², Laurence Roussel¹
1. University of Liège, Belgium, 2. Catholic University of Louvain, Belgium

Several authors claimed that children¹s ability to use their fingers in numerical context contribute to the development of basic numerical skills (Fayol & Seron, 2005; Gunderson et al., 2015) while others suggest that children learn to use number gesture as arbitrary symbols and do not benefit from this iconic tool (Nicoladis, Pika and Marentette, 2010). In this study, we examined longitudinally how and, more importantly, when children come to master the numerical content conveyed by verbal numbers and number gesture to determine whether children go through a stage where they are able to express numerical information with their fingers that they are not yet able to express verbally or inversely. Fifty preschoolers are tested five times every four months from the age of 3 year-old using tasks assessing their ability to express or understand the numerical content conveyed by finger configuration or verbal numbers as well as their digital gnosis and dexterity. In March 2016, growth curve analyses will allow us to estimate inter-individual differences into intra-individual changes in basic numerical development in this longitudinal design.
### 25. Brain Activation Differences in Oddball Tasks: An ERP Study

*Ilana Waisman¹, Oshra Petrushka¹, Roza Leikin¹, Mark Leikin¹*

1. University of Haifa, Israel

Within the big scale study aimed to characterize mathematical abilities, in this study we implemented event-related potentials (ERP) methodology using the oddball paradigm. Eighty-four right-handed male study participants comprised four research groups formed according to varying combinations of general giftedness (G) and excellence in school mathematics (EM). They were asked to cope with two oddball tests: numerical test (4 for rare stimulus and 9 for frequent stimulus) and geometry test (triangle for rare stimulus and pentagon for frequent stimulus). We analyzed effects of G and EM factors on the P300 ERP component. In the numerical oddball test, we found a significant interaction G×EM on the latency of the P300: it was significantly shorter for the EM than for the NEM students among G participants only. The P300 amplitude was significantly lower for G than for NG students. In contrast, in the geometry oddball test, the latency of P300 was significantly longer for G than for NG students, while (surprisingly) its amplitude was significantly higher for EM than for NEM students. The shorter latency of P300 can be related to the higher speed of information processing, while lower amplitudes of P300 can be linked to the lower cognitive load. The results demonstrate that while cognitive processing related to the oddball tests is task dependent, each of the tests is affected differently by G and EM factors which are thus different in nature.

### 26. Differential Dynamics of Episodic and Semantic Memory Consolidation During Sleep in Children and Adults

*Jing-Yi Wang¹, Frederik Weber¹, Jan Born¹*

1. Institute of Medical Psychology, Germany

Sleep consolidates both episodic memory and semantic memory in human adults, and is thought to rely on slow-wave sleep (SWS). Children sleep deeper and spend more time in SWS. We investigated, whether the sleep advantage of school children (8-12 yrs.) affects consolidation of episodic memory vs. semantic memory, as compared to adults. Children and adults encoded two short episodes 1 h apart, after each they also learned word-pair lists. Each episode comprised four distinct faces at different locations on a screen. Lists consisted of age-appropriate and semantically close word-pairs presented on the screen. Memory recall was tested either after a short 1 h retention following an evening encoding, or after a ~10.5 h retention of overnight sleep, or daytime wakefulness. After long retention, episodic memory of children and adults was comparable and both, as expected, better after sleep than after wakefulness. Surprisingly, after short retention and prior to sleep the episodic memory of children was comparable to their Sleep cohorts, whereas for adults it was markedly better than in children and the Sleep adults. On the contrary, semantic word-pair memory was reduced from before to after sleep only in children, but not in adults. We suggest that sleep facilitates episodic memory in both children and adults, however benefits episodic over semantic memory in children, with the opposite tradeoff in adults.
27. Altered Patterns of Directed Electrophysiological Connectivity
Within the Reading Network of Dyslexic Children and their Relation
to Reading Dysfluency
Gojko Zaric1, Correia João1, Gorka Fraga González2, Jurgen Tijms3, Maurits van
der Molen2, Leo Blomert1, Milene Bonte1
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Reading is a complex cognitive skill subserved by a distributed network of visual and
language-related regions. Disruptions of anatomical and/or functional connectivity
within this network have been associated with developmental dyslexia. Here we
investigate whether these disruptions scale with the level of reading dysfluency, by
examining electroencephalographic signals in 9-year-old typically reading children (TR)
and two groups of dyslexic children: severely dysfluent (SDD) and moderately dysfluent
(MDD) dyslexics. We analyzed directed connectivity and event-related potential (ERP)
measures recorded while the children processed visual words and false font strings.
Both types of analyses indicated weaker occipito-temporal responses together with
stronger fronto-temporal responses in dyslexic as compared to typical readers. While
this was restricted to the visual word condition in moderately dysfluent dyslexic
children, the severely dysfluent dyslexic group also showed these deviations in the false
font condition. Moreover, reading fluency was positively related with forward
connectivity. Our results confirm dysfunctional connectivity patterns in the reading
network of dyslexic children with reduced posterior-to-anterior and enhanced anterior-
to-posterior connectivity. Furthermore, they suggest different patterns of dysfunction in
dyslexic children dependent on the severity of their reading dysfluency.
# LIST OF PARTICIPANTS

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