Educational Neuroscience

2014 Meeting of the EARLI SIG 22
June 12-14, 2014
Göttingen, Germany

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Preface

Dear Participant,

We are very pleased to welcome you to the 3rd biannual EARLI SIG22 *Neuroscience and Education* meeting at the Georg-August-University Göttingen, Germany. Since its first meeting in Zurich in 2010 the bridge between Neuroscience and Education has been further strengthened and established. Today, the number of empirical studies in this field is increasingly rising, which successfully demonstrates that the once claimed gulf between neuroscience and education may not be too big after all. The 2014 program of the SIG22 Neuroscience and Education meeting reflects these recent advances. The question of whether *Educational Neuroscience is a field* at the 2010 meeting has been positively answered and replaced by the question of *where and on what level* can the neurosciences contribute to questions of education.

Against this background, we are very much pleased to present an outstanding list of seven keynote speakers including *Sian Beilock, University of Chicago, USA; Eveline Crone, Universiteit Leiden, NL*; *Roland H. Grabner, University of Göttingen, GER; Yulia Kovas, Goldsmith University of London, UK; Nora Newcombe, Temple University, Philadelphia, USA; Michael Nitsche, Göttingen University Medical School, GER; and Eric Pakulak, University of Oregon, USA.*

In addition to these keynote lectures, more than 70 poster proposals have been submitted to the conference this year from which 5 were selected for oral presentations and over 60 will be presented in three different poster sessions. Various fields from learning and instruction, mathematics, reading, language development, science learning, motivation, emotion, creative thinking and general cognitive abilities will be presented in these sessions and will stimulate interesting theoretical and methodological discussions. Hereby we would like to thank all presenters for their contributions to the SIG22 2014 meeting.

We are also very happy to announce two important changes in the present meeting. First, we have introduced a poster award for the best poster presentation. And, second, a conference dinner will take place to further support discussions among all participants of the meeting.

We hope that you will enjoy the program and that you will have a stimulating and interesting stay in Göttingen. We hope that the meeting will provide an excellent environment for scientific exchange and research collaboration.

Last but not least, we would like to express our gratitude to the members of the local organizing team as well as the student assistants and to the European Association for Research on Learning and Instruction (EARLI) who supports the SIG meeting.

We wish you a great time in Göttingen,

Daniel Ansari
Bert De Smedt
Roland H. Grabner
Stephan E. Vogel

About Göttingen

Göttingen, the university city steeped in tradition, is situated right in the middle of Germany. This city, with approximately 129.000 inhabitants of which more than 25.000 are students, is characterized by a creative flair and a unique atmosphere.

The village 'Gutingi', to which the city goes back, was first mentioned in 953 in a document by Emperor Otto I. Today's old town combines in a charming way the memory of the medieval merchant community (member of the Hanseatic League 1351-1572) with the ambience of a modern business location.

With 13 faculties the Georg-August-University, founded in 1737, is well represented in nearly all scientific disciplines. Also, more than 40 Nobel Prize winners are associated with its name.

A plethora of sights from different eras shapes the special face of Göttingen, as for example the double winged altar in St. Jacob's church dating from 1402 or the Old Town Hall (around 1270/1369-1443) with its decoration of the hall from the late 19th Century.

A very special jewel is the 'Gänseliesel', the city's landmark. This art nouveau figure is the darling of all freshly promoted doctors, who kiss her bronze cheeks after having passed their exams.

Colorful and diverse is also the cultural, historic and economic offer of the city. The pedestrian zone and cozy back streets invite to a stroll and to extensive shopping tours. In regard to the cultural sphere, Göttingen also impresses with an interesting and diverse offer, like the international Händel Festival, the concerts of the Göttingen Symphony Orchestra or the annual 'Literaturherbst'.

Georg-August-University Göttingen

IN PUBLICA COMMODA - FOR THE GOOD OF ALL reads the inscription on the Foundation Medal of the “Georg-August-Universität Göttingen”. Established in the age of the Enlightenment (1737) and committed to its critical spirit, the "Georgia Augusta" was one of Europe's first universities to abandon the supremacy of theology and achieve equality for all faculties. Today the University is distinguished by the rich diversity of its subject spectrum particularly in the humanities, its excellent facilities for the pursuit of scientific research, and the outstanding quality of the areas that define its profile.

The University bears the name of its founder Georg August, King George II of Great Britain, Elector and Duke of Brunswick-Lüneburg, (Hanover). In affinity with the spirit of the Enlightenment, Göttingen abandoned the supremacy of theology and set its faculties on an equal footing. As an academic location Göttingen was long regarded as the hub of the mathematical world – a position lost, however, in 1933 when under Nazi rule more than 50 professors and lecturers were forced to leave the University, among them several of the 44 Nobel laureates whose names are associated with the city. After the end of World War II, Göttingen University was the first in Germany to resume its teaching operations and it went on to become one the largest higher education institutions in the country. The founding of the Göttingen University Library in 1734 was a landmark: For the first time in library history the concept of a modern research library was put into practice and the institution became the first comprehensive academic library of European standing.

From 2007 to 2012 the Georg-August-University Göttingen was rewarded with funding from the Initiative of Excellence of the German Federal and State Governments. With its constantly expanding range of Master’s and Ph.D. programmes the University cultivates excellence and offers a high proximity to research. Approximately 26,300 young people currently study here, some eleven per cent of whom are from abroad – a clear demonstration of the pull that the University has long exerted internationally.

For more information about the Georg-August University, please visit the website:

http://www.uni-goettingen.de/en/the-university/50217.html

The History of the Pauliner Church

The Pauliner Church – which now forms part of the historical building compound of Göttingen State and University Library – is an architectural monument of the highest rank. It was the first church in Göttingen built in Gothic style and was used by the Dominicans as part of their monastery (founded in 1294). The building reflects the architectural tradition of the mendicant order.

When the reformation started in Göttingen in 1529, the Dominicans had to struggle for the survival of their monastery. Since the town council had no authority over parish churches the city leaders decided to hold Lutheran services in the mendicant churches, in particular in the Dominican church, as it was the town’s largest. Thus, the Pauliner Church was the place in Göttingen where the earliest protestant baptism was administered.

After secularization in the sixteenth century, a grammar school was set up in the former Dominican monastery and soon enjoyed widespread reputation. The school formed the heart of what later became the university (founded in 1737) and its library (found in 1734 already).

Initially the church was used for religious services, but soon these were held elsewhere since there was not sufficient space for the rapidly growing library. Gradually it took over the entire building complex including the Pauliner Church itself.

In 1812, Jérôme Napoleon had a mezzanine floor inserted into the church. The upper storey thus created was transformed into a library hall, in a harmonic blend of Gothic and Classic style as it can be seen again today.

Goethe, Heinrich Heine, and the Grimm Brothers visited the library frequently. Johann Wolfgang von Goethe was one of the most ardent admirers of the library and a keen user of its holdings. For Christian Gottlob Heyne, professor and librarian in Göttingen, the “Historical Hall” (the name stems from the fact that the history books were kept here), constituted the culmination of decades of hard work. Heinrich Heine made this hall the climax of the library dream in his *Harzreise.*

In World War II, the Pauliner Church was destroyed. After its reconstruction, the book hall was first used as the largest lecture hall. Later it housed the Union Catalogue of Lower Saxony. Since moving into its new building in 1992, Göttigen State and University Library has used the hall as an exhibition room. Successful exhibitions of national importance, such as “Wagnis der Aufklärung – Georg Christoph Lichtenberg” [Venturing the Enlightment – Georg Christoph Lichtenberg], “700 Jahre Paulinerkirche” [Seven-hundred years Pauliner Church], and “Goethe, Göttingen und die Wissenschaft” [Goethe, Göttingen and science] were presented there.

With “Gutenberg und seine Wirkung” [Gutenberg and his effects] in June 2000, the hall was reopened to the public again in its historical from – with the addition of the air-conditioned and high-security *Schatzhaus,* allowing for the display of very valuable items. The Pauliner Church is not only a venue for public exhibitions; it provides a special ambience for public events as well.

General Information

Local organizing committee
(Georg-August-University Göttingen, Germany)

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Meeting venue

Paulinerkirche
Papendiek 14
37073 Göttingen

Sponsors

European Association for Research on Learning and Instruction (EARLI)

Internet access

A wireless network is available at the premise of the conference. The following SSIDs are available to your wireless devices:

eduroam (recommended)
This service is encrypted.
In order to use eduroam an account with an institution that is part of the eduroam network is required.

GoeMobile
This service is unencrypted.
After opening a web browser a portal page is available for login to the service.
A guest account is required for login: **see coupon in your welcome package**.

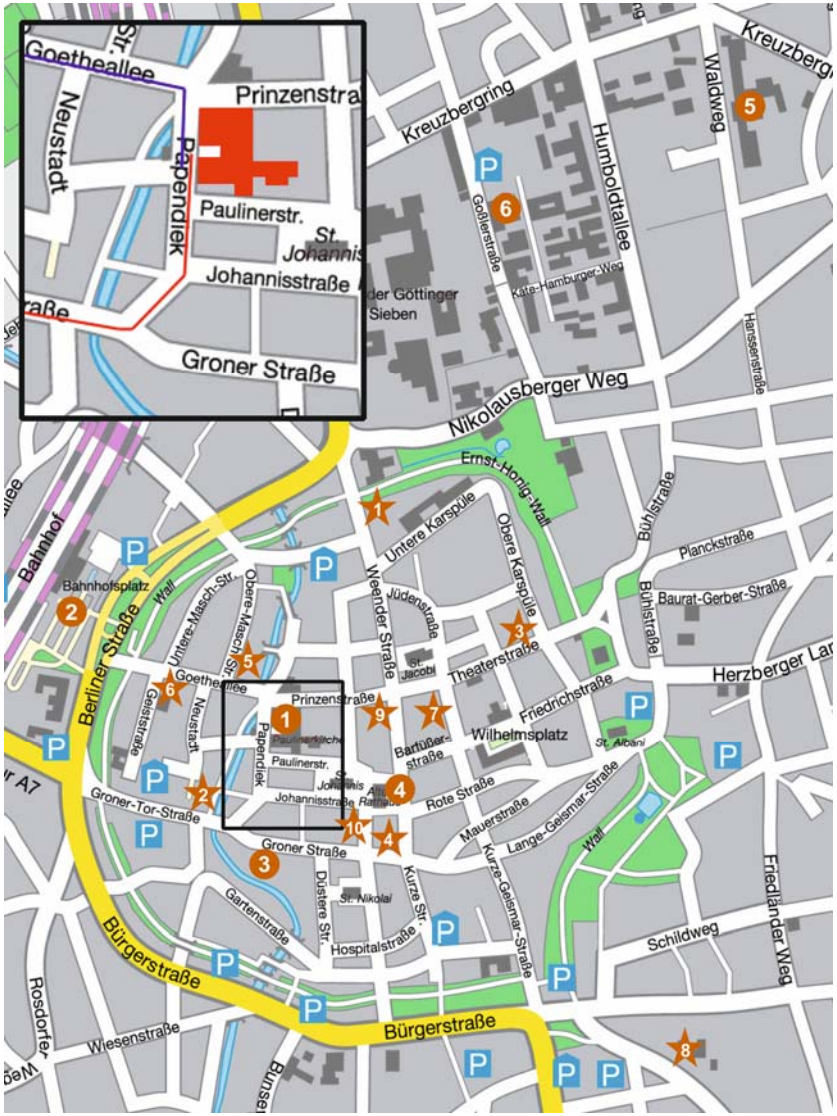
Poster information

The posters are presented in the poster room at the meeting venue. The poster walls are numbered from A1 to A21, from B1 to B21, and from C1 to C21 for the poster sessions A (Friday morning), B (Friday afternoon), and C (Saturday). You can find your poster number in the overview of posters on pages 28-31.
Please set up your poster during the coffee breaks on Friday for session A and B, and during the coffee break on Saturday for session C. Please remove your poster after the poster session.
The presenting authors are asked to be present during the poster session.

Coffee breaks and Lunch

In the coffee breaks, hot and cold drinks as well as some snacks are offered to you.
There is no organized lunch for the meeting participants but we will provide an overview of restaurants near the conference venue.

Map of Göttingen



Important Locations

1. Conference Venue (focus upper left)
2. Main Station
3. Bus Stop *Groner Straße*
4. Conference Dinner (Restaurant *Bullerjahn*)
5. Department of Educational Neuroscience
6. Georg-Elias-Müller-Institute of Psychology

Directions

The conference takes place in the 1st floor of the *Paulinerkirche* (1) – a former monastery in the heart of Göttingen. You can access the venue conveniently by foot from most parts of the city, including the main station (2) and the majority of hotels. Taking a public bus, you can either go to main station and continue on foot, or switch to line 3, 5-10, 13, 28 or 29 exiting at *Groner Straße* (3). The entrance to the venue is located at *Papendiek 14* (see focus on the map), and can be accessed via *Goetheallee/Prinzenstaße* (blue line), or via *Groner/Groner-Tor Straße* (red line).

Lunch map

The city center of Göttingen offers ample lunch and dinner opportunities. The following list is a short selection of restaurants around the conference venue with indication of price ranges (€: <10, €€: 10-20, €€€: >20 Euro).

1	Falafel Point	€	Good falafel
2	Fellini	€€	Italian cuisine
3	Gauß	€€€	International cuisine
4	Glöckle	€	Bratwurst (meat only)
5	Kartoffelhaus	€€	German cuisine
6	Rani Dhaba	€	Indian food

7	Shirini	€	Persian vegetarian food
8	Sternwarte (Planea)	€€€	International cuisine
9	Szültenbürger	€€	East-European cuisine
10	Villa Cuba	€€	Caribbean cuisine

Programme

Thursday, June 12, 2014

15.00	**Welcome address**
15.30	**Keynote lecture 1:** Genetics for Education: the good, the bad and the ugly. *Yulia Kovas, Goldsmiths University of London, UK*
16.30	**Coffee break**
17.00	**Oral presentations** (until 18.45)

Friday, June 13, 2014

09.00	**Keynote lecture 2:** A longitudinal analysis of brain development in relation to cognitive control and reward sensitivity. *Eveline A. Crone, Leiden University, NL*
10.00	**Coffee break**
10.30	**Keynote lecture 3:** Neurocognitive mechanisms underlying mathematical competencies. *Roland H. Grabner, University of Göttingen, GER*
11.30	**Poster Session A**
12.30	**Lunch break**
14.00	**Keynote lecture 4:** Academic performance under stress. *Sian Beilock, University of Chicago, USA*
15.00	**Keynote lecture 5:** Thinking about quantity: The intertwined development of spatial and numerical cognition. *Nora Newcombe, Temple University, Philadelphia, USA*
16.00	**Coffee break**
16.30	**Poster Session B** (until 17.30)
19.30	**Conference dinner**

Saturday, June 14, 2014

09.00	**Keynote lecture 6:** Development, implementation, and assessment of an evidence-based training program for at-risk preschoolers. *Eric Pakulak, University of Oregon, USA*
10.00	**Coffee break**
10.30	**Poster Session C**
11.30	**Keynote lecture 7:** Neuromodulatory brain stimulation: Basics and functional implications. *Michael Nitsche, Göttingen University Medical School, GER*
12.30	**Closing address**

Keynote lectures

Thursday, June 12, 2014
15:30

Genetics for education: the good, the bad and the ugly.

Yulia Kovas
Goldsmiths University of London, UK

The talk considers potential contributions of genetics to education, the general view about genetics in education, and attempts to date to identify specific genes throughout the genome responsible for ubiquitous genetic influence. Many important for education findings have recently emerged from genetic research, suggesting that genetic effects are not static or deterministic, but change throughout life and in different educational and cultural contexts. For example, academic achievement - such as performance in reading, language and mathematics - has been found to be highly heritable throughout school education in the UK. On the contrary, heritability of general cognitive ability is only moderate in the early school years and increases gradually, reaching substantial levels in adulthood. It is possible that high heritability of reading and mathematics can be explained by the high homogeneity of educational environments. For example, the UK National Curriculum is highly uniform and therefore may decrease the environmental contribution to the variance in these traits. On the contrary, general cognitive ability is not explicitly taught at schools, and therefore may be under highly variable environmental influences across individuals, especially early in development. As children go through school, they may begin to use their acquired new skills in ways to further develop their general cognitive ability. Gene-environment correlations, whereby children experience, modify, and select their environments, may contribute to the observed increase in heritability of IQ. I will also describe recent advances in molecular genetic and genomic research into the aetiology of individual differences in educationally relevant traits.

Friday, June 13, 2014
09.00

A longitudinal analysis of brain development in relation to cognitive control and reward sensitivity.

Eveline A. Crone
Leiden University, NL

Adolescence is a natural time for explorative learning, risk taking and sensation seeking. Developmental neuroimaging studies including children, adolescents and adults reported protracted development of cortical brain regions which are important for cognitive control, and heightened activation in reward related regions, with most emphasis on the ventral striatum as a key brain region involved in reward seeking behavior. These studies led to the hypothesis that adolescent brain development can be explained as an imbalance between the development of cortical and subcortical brain regions.

However, most studies show considerable variability between adolescents. This leads to the question whether some adolescents develop faster than others, and whereas some adolescents are more sensitive to social-affective influences than others. An important direction to understand this variability is by examining changes within children and adolescents over time. This longitudinal approach has several advantages over previously used cross-sectional comparisons, for example, when there is large variability between individuals, individual slopes are more informative for detecting change because each individual at the second measurement provides its own control at the first measurement. Second, a longitudinal design gives the possibility to use behavioral and neuroimaging data to predict future behavioral outcomes. In a large study called 'Braintime', participants between ages 8-27 years were scanned on two time points, with a two year interval in between, while performing a cognitive control and a gambling task in the scanner. Outside of the scanner, participants completed questionnaires for puberty, impulsivity, working memory, reading and arithmetic. We investigate whether neural responses in adolescence over time 1) are stable within individuals, 2) are related to age-related changes and 3) are related to behavioral changes over time.

The neuroimaging results support the model of protracted development of the frontal-cortical network and heightened ventral striatum response in early and mid-adolescence. The results further show that neuroimaging is a valuable method to detect and predict educational outcomes (reading, arithmetic). This study provides the first prove for longitudinal change by testing the whole range of adolescence with multiple measurements within each individual, and has the potential to unravel some of the previously suggested patterns and resolve inconsistencies with respect to individual variability.

Neurocognitive mechanisms underlying mathematical competencies

Roland H. Grabner
Department of Psychology, Georg-August-University of Göttingen, GER

In light of the increasingly recognized importance of mathematical competencies for life success, the number of educational neuroscience studies on school-relevant mathematical cognition has remarkably grown in the past years. These studies have generated incremental knowledge on the cognitive and neural mechanisms of mathematical information processing and have opened up new ways to treat mathematical learning difficulties. In this talk, I will present evidence from functional magnetic resonance imaging (fMRI), electroencephalography (EEG) and transcranial electric stimulation (tES) studies, which illustrate the value added of neuroscientific techniques in the investigation of questions related to mathematics education. Specifically, I will focus on individual differences in mathematical competencies, arithmetic problem-solving strategies, and the potential to enhance mathematics learning by means of non-invasive brain stimulation. In addition, avenues for future research will be outlined.

Academic Performance under Stress

Sian Beilock
University of Chicago, USA

For many people, the desire to perform their best in academics is high. Consequences for poor performance, especially in examinations, include poor evaluations by mentors, teachers, and peers; lost scholarships; and relinquished educational opportunities. But, why do poor performances occur in those very situations where students are set on doing their best? What cognitive and neural processes drive less-than-optimal outcomes when the pressure is high? And, can we use knowledge about how cognitive control is altered under stress to shed light on why some people thrive while others fail in high-stakes situations? In this talk, I will discuss behavioral and brain imaging work examining how students' knowledge and general cognitive abilities interact with social and emotional factors (e.g., a student's fear of test taking) to impact performance in academic arenas such as math. Implications for education and assessment, as well as how neuroscience can inform our understanding of the interplay of emotion and cognitive control in academic settings, will be discussed.

Thinking about Quantity: The Intertwined Development of Spatial and Numerical Cognition

Nora Newcombe
Temple University, Philadelphia, USA

This talk considers how children and adults encode and reason about the many continuous dimensions that collectively define the physical world. Philosophical, psychological and neural work has focused especially on space and number, and somewhat on time. However, there are other important continuous dimensions (e.g., mass) and space can be broken down into distinct dimensions (e.g., perimeter versus area). While formally distinct, variation on these quantitative dimensions is typically correlated, e.g., if one marching band has more members than another, that band will also occupy more space and take longer to march past the reviewing stand. Number has a distinctive characteristic among these dimensions, namely that count words and early teaching of arithmetic emphasize the discretization of numerical quantity. Debate concerning the origins and development of quantitative thinking has centered on several questions: (1) whether a generalized magnitude system (see Walsh, 2003) exists, and if so, whether it is a starting point for development, an endpoint, or both; (2) following on from the answer to the first question, whether development consists of differentiation of a generalized magnitude system into separable dimensions, or mapping of separated processing systems onto each other, or a mixture of each at different developmental points; (3) what factors lead to increasing precision in magnitude estimation, both spatial and numerical. Answers to these questions have educational implications, e.g., for teaching fractions.

Development, implementation, and assessment of an evidence-based training program for at-risk pre-schoolers.

Eric Pakulak
University of Oregon, USA

For several years we have employed multiple neuroimaging techniques to study the development and plasticity of the human brain. Over the course of this research we have observed that different brain systems and related functions display different 'profiles' of neuroplasticity, or the degree to which these systems are changeable and vulnerable. Guided by these findings, we developed a training program for 3-5 year-old children who are at risk for school failure for reasons of poverty. This program targets changeable and vulnerable systems for attention and self-regulation and includes both parenting and child training programs. Relative to children randomly assigned to one of two comparison groups, children in our training program showed significant improvements in several domains including child brain functions supporting selective attention, standardized measures of cognition, and parent-reported child behaviors. Caregivers in the program also showed improved parenting behaviors and reduced parenting stress relative to the comparison groups. We are currently conducting a longitudinal follow-up study to assess the degree to which these effects endure. In addition, we have culturally adapted and translated the program into Spanish and are currently assessing the efficacy of this program when implemented with Latino families. Finally, we are assessing the program when more broadly implemented in preschools and are testing hypotheses that participation in our program will result in improvements in stress physiology and self-regulation in both children and caregivers as well as in longer-term improvements in family well-being.

Neuromodulatory brain stimulation: Basics and functional implications

Michael Nitsche
Göttingen University Medical School, GER

Major physiological derivates of cognitive processes and behaviour are task-specific alterations of cortical activity, and excitability. For learning and memory formation, even long-lasting alterations take place. Functional imaging and electroencephalographic methods have increased our knowledge about these physiological processes in the human brain largely. More recently, brain stimulation tools have been developed, which are able to promote or counteract these physiological alterations. These enable us to explore the causal relationship of physiological and cognitive behavioural processes. Moreover, these techniques might also be able to improve functions. In this talk, an overview of effects and mechanisms of neuromodulatory brain stimulation techniques will be given, including options to improve functions in health and disease.

Poster presentations

Poster session A
Friday, June 13, 2014
11.30

A1. Proportional reasoning: Insights from a preliminary EEG study. *(Babai et al.)*

A2. Ergometer cycling enhances executive control in task switching. *(Barenberg et al.)*

A3. Acute intense physical exercise fosters shifting performance in adolescents. *(Berse et al.)*

A4. Probing the nature of deficits in the 'Approximate Number System' in children with persistent Developmental Dyscalculia? *(Bugden & Ansari)*

A5. Format-dependent neural representations of numbers as revealed by multi-voxel pattern analysis. *(Bulthé et al.)*

A6. The benefits of computer-training programs on mental calculation for the development of mathematical abilities. *(Caviola et al.)*

A7 The nature of abacus-based mental calculation training is one kind of working memory training: a functional MRI and behavior study. *(Cheng & Chang)*

A8. Non-symbolic and Symbolic Magnitude Comparison Judgment Profiles in Children. *(Chew & Reeve)*

A9. Memory encoding and retrieval in children and young adults: ERP and oscillatory evidence for age-related similarities and differences. *(Czernochowski)*

A10. The detrimental effect of interference in multiplication facts storing: typical development and individual differences. *(De Visscher)*

A11. DSM-5 Impact on the Description and Prevalence of Learning Disorder in ADHD Children and Adolescents. *(Dorneles et al.)*

A12. Relationships between Cognitive and Behavioral Measures of Executive Function in Preschoolers. *(Evers et al.)*

A13. Approximate non-symbolic operation, approximate and exact symbolic operations, and mathematical proficiency. *(Furman & Rubinsten)*

A14. Looking for predictors of performance in single digit addition, subtraction and multiplication: evidence from a one-year longitudinal study. *(García-Orza)*

A15. Association of physical activity and sedentary behavior with learning outcomes in adult students. *(Gijselaers et al.)*

A16. Neural Correlates of self-, friend- and teacher-evaluations in adolescents - loneliness as predictor and school self-concept as outcome. *(Golde et al.)*

A17. How does the mathematical brain develop? A longitudinal fMRI study in children with and without dyscalculia. *(Grond et al.)*

A18 Investigating the role of the PPC in arithmetic fact learning: a simultaneous tDCS-fMRI study. *(Hauser et al.)*

A19. Is Implicit Memory Independent from Sustained Attention: An Eye Tracking Validation Study. *(Ilgaz et al.)*

A20. The Knowledge and Misconceptions of Primary and Secondary School Teachers about the Brain and Their Perceptions about Neuroscience in Education: A Mixed Methods Research to Analyse the Situation in Turkey in 2013. *(Karakus)*

A21. Effects of working-memory training on academic abilities in middle childhood. *(Karbach et al.)*

Poster session B
Friday, June 13, 2014
16.30

B1. Raise your hands to specify - gestures meeting dorsal and ventral streams for learning mathematics. *(Krause)*

B2. A relationship between brain activity data and eye tracking data during mathematical tasks from the view of educational research. *(Kuroda & Okamoto)*

B3. Mind, Brain, and Education: A case study of student perceptions of an interdisciplinary graduate program. *(Lees)*

B4. Brain activity associated with solving geometry area-related problems: effect of general giftedness and excellence in mathematics. *(Leikin et al.)*

B5. Brain activity associated with solving short insight-based problems: focusing on generally gifted and excelling in mathematics adolescents. *(Leikin et al.)*

B6. Dudeman & Sidegirl: Operation clean World. A new Number Game used to train Number Processing Skills in 5-year-olds. *(Martens)*

B7. Educational Neuroscience Applications: Memory of Multiplication Facts as a Model. *(Mark-Zigdon & Katzoff)*

B8. How the 1st year of formal schooling shapes symbolic number development- evidence from brain and behavior. *(Matejko & Ansari)*

B9. Perceptual information influences the formation of numerical representations: evidence from an artificial learning paradigm. *(Merkley & Scerif)*

B10. The relation between home numeracy, exact number skills and non-symbolic audiovisual matching abilities. *(Mutaf et al.)*

B11. Field Dependence-Independence cognitive construct and the human brain: A neuro-educational approach. *(Nisiforou)*

B12. Cognitive Change: The Effects of Aquatic Motor Activities on Early-Childhood Motor and Cognitive Development. *(Nissim et al.)*

B13. Kindergarten Children's Number Comparison Skills Predict First Grade Math Scores: Evidence from a Two-minute Test. *(Nosworthy et al.)*

B14. Neural efficiency in working memory tasks: The impact of task demand and training. *(Nussbaumer et al.)*

B15. How Expert Mathematicians Compare the Numerical Values of Fractions: Evidence from Eye Movements. *(Obersteiner & Reiss)*

B16. More than subitizing: Symbolic manipulations of numbers. *(Olkun et al.)*

B17. Feedback's informative value as the driving force of the feedback-related negativity (FRN). *(Opitz)*

B18. Structural and Functional Neuroimaging of Reading in Children. *(Partanen et al.)*

B19. Eye movements during dot enumeration: The influence of visual and numerical information. *(Paul et al.)*

B20. Neural representations in visual cortex for numerical magnitudes presented in different formats. *(Peters et al.)*

B21. The association between digit comparison performance and individual differences in arithmetic unravelled. *(Sasanguie et al.)*

Poster session C
Saturday, 15 June, 2014
10.30

C1. Neural Correlates of Fatigue During Task Switching. *(Plukaard et al.)*

C2. Exploring Mental Representations for Literal Symbols Using the Priming Distance Effect. *(Pollack & Leon Guerrero)*

C3. From executive functions to number knowledge: Neuropsychological performance in Portuguese preschoolers. *(Rato & Castro-Caldas)*

C4. Symbolic numerical processing deficit in people with Williams syndrome. *(Rousselle & Noël)*

C5. Examining the problem size effect: a tDCS and EEG study. *(Rütsche et al.)*

C6. Music in the Baddeley model of working memory in TD and SLI children. *(Sallat)*

C7. Effects of psychological and physiological variables on students subjective stress experience. A multilevel longitudinal analysis in naturalistic educational settings. *(Sembill & Kärner)*

C8. On the development of the multiplication fact network in elementary school children. *(Soltanlou et al.)*

C9. Teachers' perception of the brain function in Latin America. *(SoniGarcía et al.)*

C10. Processing numerical Ordinality: is it a core ability? *(Sury & Rubinsten)*

C11. The neuroscience literacy of pre-service special needs educators and predictors of neuromyths and knowledge. *(Tancig et al.)*

C12. Neuromyths among secondary and college teachers. *(Tardif et al.)*

C13. Patterns of change in the cognition-emotion relationship predict math problem solving. *(Trezise & Revee)*

C14. The influence of reading problems on basic numerical processing in children with and without math difficulties. *(Vaessen & Gerretsen)*

C15. Cognitive and neural characteristics of mathematical difficulties in children with mild traumatic brain injury (mTBI). *(Van Beek)*

C16. Developmental specialization of the parietal cortex for symbolic numerical magnitude representation. *(Vogel et al.)*

C17. The link between preschooler's executive function and theory of mind. *(Volckaert et al.)*

C18. Cognitive intervention in preschoolers. *(Volckaert)*

C19. Brain activity associated with translation from a visual to a symbolic representation in Algebra and Geometry. *(Waisman et al.)*

C20. The borrowing effect in two-digit subtraction: Developmental aspects and neural correlates. *(Woitscheck et al.)*

C21. Different developmental onsets of symbolic approximate arithmetic skills across countries: How numbers are named matters. *(Xenidou-Dervou et al.)*

Poster Session A

A1.

Proportional reasoning: Insights from a preliminary EEG study.

Reuven Babai[1], Ruth Stavy[1], Orly Rubinsten[2] and Nachshon Korem[2]

1 Department of Science Education, School of Education, Tel Aviv University, Tel Aviv, Israel
2 Department of Learning Disabilities, Faculty of Education, University of Haifa, Haifa, Israel

Children and adults have great difficulty with proportional reasoning. Proportion involves the comparison of two ratios and in order to compare ratios one frequently needs to form fractions. Fractions are regarded as one of the most difficult topics in primary schools and improper fractions represents a greater difficulty to the students than proper ones.

Proportional reasoning was studied by EEG on 18 adults. They were asked to compared intensities of color of two mixtures of red and white paint drops, represented by two digits, one colored red and one white, i.e., to judge whether the right or left mixture had a darker shade (color intensity of each mixture is determined by the ratio red/white). The 320 comparison of ratio stimuli were equally divided between ratios with proper and improper fractions.

Behavioral findings showed, as expected, significantly higher accuracy rate and a shorter RT for proper fractions than for improper ones. With regards to the EEG findings, one of the major findings was a significantly more negative peak for proper fractions around 150-170ms post stimulus. This early effect presumably arising from occipito-temporal cortices suggests that a distinction between proper and improper fractions occurs very early during the processing of proportional reasoning

A2.

Ergometer cycling enhances executive control in task switching.

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Numerous studies examining the role of working memory in learning processes highlighted the relevance of executive functions. In sports and neurosciences, several studies found beneficial effects of physical exercise on executive functions that were supposed to be mediated by neurophysiological processes. It was shown that even single bouts of exercise can improve executive performance in inhibition tasks. But it's unclear whether executive performance in task switching paradigms can also benefit from physical exercise. We examined the impact of intense ergometer cycling on task switching in two studies. In Study 1, 50 participants were tested after cycling and after resting in two different sessions. The order of interventions was randomized across participants. Participants only showed reduced switch cost after exercise when cycling but not resting coincided with Session 2. In Study 2, 50 participants also performed task switching in two sessions but exercise was manipulated between participants in Session 2. Controlling for baseline performance in Session 1, participants who cycled in Session 2 showed lower switch cost than participants who rested in Session 2. The results of both studies will be discussed in the context of learning processes in executive tasks.

A3.

Acute intense physical exercise fosters shifting performance in adolescents.

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Research on the influence of physical exercise on cognition has shown that even acute exercise can have beneficial effects. Effect sizes seemed to vary at least partly due to the type of cognitive demands and inter-individual differences. With regard to the executive functions of working memory, it is assumed that neurophysiological changes (e.g., in the dopamine system) mediate the effect. Most of these results were obtained with samples of adults. As there are only few studies investigating adolescents and executive performance is highly relevant in the context of education, we investigated 254 students (13 to 17 years). Participants performed a shifting task after acute intense physical exercise on a bicycle ergometer and after a period of rest. The order of conditions was counterbalanced between participants. The experimental procedure was run in a mobile laboratory at schools and inter-individual difference variables (e.g., genetic markers) were assessed. After exercise we observed reduced shift costs compared to the resting condition. This was interpreted as first evidence for a beneficial effect of physical exercise on executive functions in adolescents. Further analysis revealed that genetic polymorphisms affecting the dopamine system predicted performance in specific task components suggesting dopaminergic mediation

A4.

Probing the nature of deficits in the 'Approximate Number System' in children with persistent Developmental Dyscalculia?

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In the present study we examined whether children with Developmental Dyscalculia exhibit a deficit in the so-called ‘Approximate Number System’ (ANS). To do so, we examined a group of children who demonstrated consistently low math achievement over 4 years and compared them to typically developing (TD), aged-matched controls. The integrity of the ANS was measured using the Panamath (www.panamath.org) dot discrimination test. Children with DD were found to perform significantly worse on this test than the TD controls, suggesting an impaired ANS. However, given recent findings showing that numerosity discrimination is affected by visual parameters we went further and investigated whether children performed differently on trials on which number of dots and their overall area were either congruent or incongruent. This analysis revealed that DD and TD children only differed on the incongruent trials. Thus their overall deficit can be explained by a difficulty in extracting number from an array of dots when area is anti-correlated with number. These data converge with recent findings showing the importance of inhibitory control in dot discrimination and demonstrate that close attention needs to be paid to perceptual processes invoked by tasks purported to represent measures of the ANS.

A5.

Format-dependent neural representations of numbers as revealed by multi-voxel pattern analysis.

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During the last decade there has been a boost of neuroimaging research about numerical cognition in order to reveal the underlying neural mechanisms of number processing. However, most research has mainly focused on the activation of the parietal lobe. To increase knowledge about number processing, there is a need for understanding number processing not only in the parietal lobe, but also in other brain regions. In two fMRI studies (study 1: n = 16 & study 2: n = 12) the participants were given a number comparison task. We performed multiple multivoxel pattern analysis, allowing us to focus on the neural representations of the different digit and dots. We looked into different ROIs in the occipital lobe, frontal lobe, temporal lobe and parietal lobe. In the study 1 we found different neural representations for symbols and dots in all the ROIs. There was no evidence for overlapping neural representations, suggesting a format-dependent representation of numbers. In the study 2, we showed that the link between symbols and dots was the number of visual elements on the screen and not the numerical magnitude underlying both formats. These results were observed in several ROIs in the human cortex, including the IPS. This knowledge of how numbers are processed in the brain might help us to further understand how dyscalculia emerges.

A6.

The benefits of computer-training programs on mental calculation for the development of mathematical abilities.

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There is increasing interest in developing programs for improving children's mathematical abilities. However, previous research focused on training in the approximate (Dehaene, 2009) and exact (Butterworth, 1999; 2005) number system, with unclear results concerning their impact on arithmetic achievement (Wilson, et al. 2009). Hence, in the present project we focused on mental calculation training by comparing a repeated practice training or a strategy instruction training. Children attending 3rd (N=117) and 5th (N=102) grades were randomly assigned to 3 different groups: a computerized strategic training on mental calculation problems; a computerized practice training on mental calculation; a control group (education as usual). Children were tested individually at the pre-test and post-test with tasks involving mental calculation problems, math fluency and written calculations. Moreover, to assess transfer effects verbal, spatial and numerical reasoning were tested. Results showed that children of both the strategic and the practice training groups took benefits from the training when compared to the control group, by improving their speed (practice training) or accuracy (strategic training) on mental calculations. Moreover, both training groups improved in math fluency and written calculation.

A7.

The nature of abacus-based mental calculation training is one kind of working memory training: a functional MRI and behavior study.

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3 National Taiwan Normal University, Taipei, Taiwan

The aims of our unique longitudinal study are to evaluate the relatively short termeffect of six-month abacus-based mental calculation (AMC) training on the functional connectivity network, and to investigate the possibility of AMC training effect transfer to the untrained working memory task. Abacus experts have demonstrated extraordinary potential of mental calculation in the past cross-sectional studies. Non-experts show activity in the prefrontal and perisylvian areas, while experts, with long-term training of at least three to five years, show more activation over premotor and parietal regions. The trained children advanced 9.11 percentile on the WISC-IV exam's working memory subsection (from 81.19 to 90.30, $p = 0.037 < 0.05$). Resting state MRI revealed increased connectivity between the left inferior frontal area and the left inferior parietal lobe.The combined results suggested six months of AMC training can generalize to untrained working memory exams, and a midway paradigm shift can be expected along the fronto-parietal circuitry within the relatively long time required to become an expert. Compared to the common practice of task repetition, AMC is not only an arithmetic operation, but an appropriate and interesting tool to improve working memory capabilities by exercising visuo-motor and visuo-spatial skills.

A8.

Non-symbolic and Symbolic Magnitude Comparison Judgment Profiles in Children.

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The speed and accuracy with which children compare non-symbolic quantities and Arabic digits predict their math problem solving abilities; and the significance of non-symbolic judgments diminishes with age. Some researchers assume that (1) little variation exists in non-symbolic magnitude (NSM) judgment abilities, (2) that NSM scaffolds symbolic magnitude (SM) abilities, and (3) difficulties with SM reflects NSM-SM mapping difficulties. To evaluate these assumptions, 160 6- to 8-year-olds' NSM and SM judgment, visuo-spatial working memory (VSWM), number-line judgment, number naming speed, non-verbal IQ and RT abilities were assessed. Latent class analysis of NSM and SM speed and accuracy judgments yielded a five subgroup solution: subgroups were only partially related to age. VSWM and number naming speed, but not RT nor IQ, predicted subgroup membership. Subgroup membership was related to NL and number naming speed. One subgroup exhibited good SM but poor NSM abilities; members exhibited the poorest NL and number naming skills. Poor NSM and VSWM abilities were associated with poorer math abilities; but good SM abilities alone do not guarantee good math abilities.

A9.

Memory encoding and retrieval in children and young adults: ERP and oscillatory evidence for age-related similarities and differences.

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Based exclusively on behavioral outcome, it is difficult to dissociate memory development from control abilities contributing to memory judgments. Despite potential implications for education, the cognitive processes and functional maturity of the brain regions supporting memory during development are still largely unknown. ERPs and EEG oscillations allow real-time tracking of cognitive processes during both memory encoding and retrieval on a trial-to-trial basis. Here, we compared children aged 7 and 10 years and young adults during incidental and intentional memory encoding and retrieval. During intentional compared to incidental encoding, theta oscillations were larger for frontal electrodes in young adults, and also for parietal sites in children. During memory retrieval, participants distinguished between identical, perceptually changed and new pictures. Performance increased for intentional relative to incidental encoding, in particular for changed pictures, but recognition accuracy was age-invariant. ERPs revealed parietal old-/new effects associated with recollection across age groups, but the topography of earlier ERP effects changed with development. In sum, electrophysiological measures reveal similarities and differences in the cognitive processes underlying episodic memory in the absence of performance differences.

A10.

The detrimental effect of interference in multiplication facts storing: typical development and individual differences.

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While different profiles of dyscalculia are suggested, the difficulty to memorize arithmetic facts (AF, very simple arithmetic problems like 3x5) is a general and persistent hallmark of this math learning disability. Recently, it has been suggested that hypersensitivity-to-interference in memory could prevent someone in storing AF. The features overlap between AF is suggested to provoke interference and, learners who are hypersensitive-to-interference would therefore face difficulties in storing AF. In this paper, we created a measure of the interference weight of each multiplication. We first tested whether the interference parameter can predict the performance across multiplications, beyond the problem-size. We reported data from third- and fifth-grade children and undergraduate students, data from a published case study of dyscalculia as well as longitudinal data of fourth-grade-children tested twice, one year apart. Results showed that the interference parameter predicts a substantial part of the performance across multiplications. Moreover, the individual sensitivity to the interference parameter determined a part of the individual differences in multiplication performance in the three data sets. This finding contributes to the understanding of the typical and atypical arithmetic development.

A11.

DSM-5 Impact on the Description and Prevalence of Learning Disorder in ADHD Children and Adolescents.

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Prevalence studies on learning disabilities (LD) in children and adolescents with ADHD show inconclusive results, despite the frequent comorbidity between these syndromes. This paper describes and analyzes the prevalence of LD in a referred sample of 270 children and adolescents with ADHD treated at Attention-Deficit/Hiperactivity Disorder Program at Hospital de Clínicas de Porto Alegre-UFRGS, in Porto Alegre, Brazil, according to the diagnostic criteria of the DSM-IV-TR. We verify a high rate of comorbidity (46,7%) between the two disorders, and the Written Expression Disorder is the prevalent (32,6%), results that confirms previous findings. These data must be considered in school planning and in interventional education programs, as we know that when both disorders appear together (Barkley, 2008) students show attentional and academics deficits more important than that of children with only one of the disorders. The impact of the changes in the diagnostic criteria for LD proposed by DSM-5 in the prevalence of these disorders is discussed. Although changes will occur in the rates of LD prevalence, the impact of DSM-5 on the prevalence, specificity and comorbidity of LD remains uncertain, as there are some proposed changes that will broaden the scope of the criteria and others that will reduce it.

A12.

Relationships between Cognitive and Behavioral Measures of Executive Function in Preschoolers.

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Performance in cognitive tests of executive functions (EF) does not always correspond to behavior and emotion regulation of children in real-life situations. The aim of the present study was to assess the relationship between performance in cognitive EF tests, behavioral EF tests, and teacher ratings of children's self-regulation. Three- to six-year old children (119 boys, 104 girls) were administered. Cognitive EF were assessed using four tests (Digit Span, Block Recall, Day-Night Stroop, Dots) and two putative tests of behavioral EF (Tower Building, Head-Toes-Knees-Shoulders [HTKS]). For the teachers' ratings we used two dimensions of the observation scale "Social-emotional well-being and resilience of children in early childhood settings" (PERiK): self-control/thoughtfulness and task orientation. We found that all measures differentiate with regard to age. Correlations between cognitive EF measures with the HTKS were about twice as high as their correlations with the Tower Building. This indicates that the HTKS taps similar processes as the cognitive EF measures. Teacher ratings did not show higher correlations with behavioral than with cognitive EF measures as it was expected as sampling frame is more similar. It will be discussed to what extent a distinction into cognitive and behavioral measures of EF is possible.

A13.

Approximate non-symbolic operation, approximate and exact symbolic operations, and mathematical proficiency.

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Numerical representations are thought to rely on two representation systems: symbolic (e.g., Arabic numerals "6" or number words) and approximate non-symbolic (ANS) representation (e.g., group of dots). The fact that these representations are related is well documented. However, the current literature is inconclusive regarding their relationship with mathematical proficiency. ANS is commonly examined by comparison tasks, but recently some studies have focused on the performance of math operations (e.g., addition).

Methods

Participants were presented with two inverse (X+Y-Y) and non-inverse (X+Y-Z) computer animations of mathematical operations. The first, represented addition and subtraction operations and the second, multiplying and division ones. All of the tasks were presented in four formats: (1) ANS operations (e.g., operations using groups of dots and estimating the result), (2) exact non-symbolic operations (e.g., exact computation of the result), (3) approximate symbolic operations (e.g., operations using numerals and estimating the result), (4) exact symbolic operations (e.g., exact computation of the result).

Results and Conclusions

Relationships were found among the four types of operations and between them and mathematical proficiency. This was found when controlling working memory ability.

A14.

Looking for predictors of performance in single digit addition, subtraction and multiplication: evidence from a one-year longitudinal study.

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Recent research has explored the numerical skills that act as predictors of arithmetic fact knowledge. However, most of these studies suffer from some limitations: some studies explored only the predictive role of one or two tasks; arithmetic fact knowledge has been considered globally in some other studies; finally, some studies used a transversal methodology instead a longitudinal one. Here we explored the predictors of single-digit addition, subtraction and multiplication in a one-year longitudinal study. The basic numerical skills of 70 students were evaluated at the end of first-grade and their performance at arithmetic operations was measured at the end of second-grade. Regression analyses were carried out separately for each operation. The performance in a non-symbolic comparison task, an Arabic number comparison task, a transcoding task (dictation of one- and two-digit Arabic numbers), and a numerical sequence counting task, were included as predictors. Results indicated differences between operations. Whereas for addition the predictor was the Arabic comparison task, the significant predictors for multiplication were the dictation of Arabic numbers and the non-symbolic comparison task. No significant predictors arose for subtraction. Results are discussed in relation to models of arithmetic fact learning.

A15.

Association of physical activity and sedentary behavior with learning outcomes in adult students.

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Physical activity and sedentary behavior are related to learning outcomes in children. Research in adults, concerning this relationship, is not apparent. Therefore, we investigated if and how they are related in adults participating in distance education. Data on the independent variables were collected via an online survey at the start of the study. Learning outcomes were measured by the amount of attained European Credits (EC's) after 6 months. We corrected for possible confounders. 1811 participants were included. A two-hurdle model was used as different predictors may matter for each hurdle. A logistic regression for attaining any EC's (1st hurdle) and a linear regression for the subgroup that attained EC's (2nd hurdle).Physical activity was a slightly negative predictor for passing the first hurdle. The model explained the data for 13.6% of which physical activity added 0.6%. Possibly, time spent on physical activity in this specific group of students could detract from the time they spent on learning, as it is likely that their spare time is limited. In addition, sedentary behavior was not associated with learning outcomes. Linear regression on the students that passed the first hurdle did not yield any significant associations for physical activity or sedentary behavior.

A16.

Neural Correlates of self-, friend- and teacher-evaluations in adolescents - loneliness as predictor and school self-concept as outcome.

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Recent meta-analyses have argued that the ventromedial prefrontal cortex (vMPFC) is specifically involved in self-related cognitions. It is unknown whether this region is also involved in neural processing of close others in adolescents, such as friends and teachers. 41 adolescents judged during fMRI whether trait adjectives described either themselves, their friends or their teachers. Additionally, we used structural equation modeling (SEM) to analyse the relationship between loneliness, neural responses to self-, friend- and teacher-judgments within the vMPFC and school self-concept (SSC). fMRI analysis ($p<.05$ family-wise error corrected) revealed higher activation in the vMPFC during self- and friend-judgments than during teacher-judgments. SEM showed that loneliness negatively predicted activations in all judgment conditions. In turn, high response to self-judgments predicted a high SSC, high neural response to teacher-judgments a low SSC. Our findings indicate that friends might be more relevant to the self of adolescents than teachers. Furthermore, findings suggest that neural processing of teachers in 'self-specific' regions is related to lower self-ratings of academic abilities. Overall, lonely adolescents keep a greater psychological distance to others, which could explain our results.

A17.

How does the mathematical brain develop?A longitudinal fMRI study in children with and without dyscalculia.

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Children with developmental dyscalculia (DD) show distinct problems in numerical processing and aberrant activation of the numerical network compared to typically developing (TD) peers. Cross-sectional studies reveal a functional specialization of the numerical network over development. Aim of the study is to investigate the neuronal development of numerical abilities in TD and DD children based on longitudinal data. Seventeen children with DD and 11 TD children between 7-11 years were evaluated twice by neuropsychological tests and fMRI over a 4-year period. The behavioural results showed that children with DD performed significantly lower in numerical skills at both time points of the study. The fMRI data revealed an activation increase in the fronto-parietal network of children with DD over time. In contrast, no difference in brain activation was found in TD children. Furthermore, regression analysis revealed a negative correlation between the activation increase over time and the number of correctly solved subtractions and additions. The behavioural results of this longitudinal study confirm the persistence of the deficits in numerical processing in DD. On the neuronal level, developmental activation patterns in DD are less focused compared to TD children and might therefore reflect a more effortful use of the numerical network.

A18.

Investigating the role of the PPC in arithmetic fact learning: a simultaneous tDCS-fMRI study.

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The development of mathematical skills is a central aim of formal schooling. One important step to achieve this aim is the acquisition of arithmetic skills, which is typically characterized by a transition from the application of effortful calculation strategies to an increasing use of arithmetic facts from memory. People suffering from developmental dyscalculia often show impairments in the establishment of arithmetic fact knowledge. Neuroimaging studies have revealed that the posterior parietal cortex (PPC) surrounding the angular gyrus is critically involved in arithmetic fact retrieval. In addition, recent studies have shown that it is possible to modulate mathematical performance by means of non-invasive transcranial Direct Current Stimulation (tDCS) of the PPC. In this study, we used simultaneous tDCS-fMRI to evaluate whether arithmetic fact learning can be positively influenced by brain stimulation and to investigate the neural correlates of these learning effects. Specifically, we compared the effects of anodal, cathodal and sham stimulation on performance in an arithmetic learning task and the accompanying brain activity. Our findings provide a better understanding of the potential of tDCS to enhance learning and the neural mechanisms underlying these effects.

A19.

Is Implicit Memory Independent from Sustained Attention: An Eye Tracking Validation Study.

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The aim of this study is to extend and verify whether implicit memory is independent from sustained attention in a digital environment. 15 undergraduate students (7 males and 8 females; mean age 22) at Hacettepe University participated in this study. For directing the participants' attention, contextual cueing paradigm was used. A computer based test with Multiple Object Tracking (MOT) paradigm was used for identifying participants' sustained attention levels. The test was run on a touchscreen monitor and consisted of four difficulty levels: demonstration, easy, medium and hard. Mean scores from each level were calculated as sustained attention score for each participant. A novel form of a short story was designed with two different types of contextual cueing (static and dynamic) in a web-based environment. Once the reading task was completed, participants had given a simple mathematical operations test as a distraction task. After distraction task, learners are requested to complete a word stem completion task. Each correct response was given a score for analysis. Eye movements were recorded with TOBII Studio. Non-parametric analyses were conducted and the results show that despite using contextual cueing for directing attention, implicit memory was not affected by that manipulation.

A20.

The Knowledge and Misconceptions of Primary and Secondary School Teachers about the Brain and Their Perceptions about Neuroscience in Education: A Mixed Methods Research to Analyse the Situation in Turkey in 2013.

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1 Mersin, Turkey

This study firstly explores primary/secondary school teachers' knowledge and their misconceptions about brain; secondly, the source of their misconceptions; and finally, teachers' perceptions about neuroscience in Turkey. In this study, a mixed methods approach was taken by using a questionnaire and interviews. The questionnaire was taken from Dekker et al.'s (2012) paper and consisted of 32 statements. 15 of these were actually misconceptions about brain. In total, 278 primary and secondary school teachers completed the questionnaire; with 6 of them being interviewed. Findings from the questionnaires showed that teachers agreed with 53.02% (SD=27.80) of the neuromyths in Turkey. This statistic is lower in UK (49%) and Netherlands (49%) (Dekker et al., 2012). Therefore these results could strongly validate the concerns about the prevalence of neuromyths(OECD, 2002).Findings from the interviews revealed that teachers' personal experiences/observations were more influential as being the source of their misconceptions about brain. This outcome could show how "scientific" is the education. To conclude, by taking into consideration the prevalence of neuromyths, it is suggested that training is needed in order to prevent unscientific applications throughout classrooms in Turkey.

A21.

Effects of working-memory training on academic abilities in middle childhood.

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Working memory (WM) capacity is highly correlated with general cognitive ability and has proven to be an excellent predictor for academic success. Given that WM can be improved by training, our aim was to test whether WM training benefited academic abilities in elementary school children. We examined 28 participants (mean age=8.3 years, SD=0.4) in a pretest-training-posttest-follow-up design. Over 14 training sessions, children either performed adaptive WM training (training group, n=14), or non-adaptive low-level training (active control group, n=14) on the same tasks. Pretest, posttest, and follow-up at three months after posttest included a neurocognitive test battery (WM, task switching, inhibition) and standardized tests for math and reading abilities. Adaptive WM training resulted in larger training gains than non-adaptive training. The benefits induced by the adaptive training transferred to an untrained WM task and a standardized test for reading ability, but not to task switching, inhibition, or math. Transfer to the untrained WM task was maintained over three months. The analysis of individual differences revealed compensatory effects with larger gains in children with lower WM and reading scores at pretest.

Poster Session B

B1.

Raise your hands to specify - gestures meeting dorsal and ventral streams for learning mathematics.

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A main issue for learning mathematics is to detach from concrete representations although mathematical objects can only be accessed through them. In my PhD-study I investigate the role of gestures in social processes of mathematical knowledge construction. I framed my research in the theoretical background of symbolic interactionism and embodied cognition. Mathematical learning as a process was reconstructed within two methodologies, combining an epistemic action model (Bikner-Ahsbahs 2006) and a model respecting the intertwined development of relations between speech, gesture and inscription (Arzarello 2006). This is based on two assumptions made about the learning of mathematics: First, mathematical objects are individually constructed but established within social interaction. Second, learning is a multimodal process. This approach already respects research on mirror neurons and the role of Broca's area (Gallese & Lakoff 2005, Rizzolatti & Craighero 2004, Rizzolatti & Arbib 1998). One of my results describes how gestures specify the where, what and how of mathematical objects, supporting the genesis of socially negotiated mathematical meaning. I suggest a connection to the dorsal and the ventral system (Ungerleider & Miskin 1992, O'Reagan & Noë 2001) and aim to discuss future prospects that may follow adopting this approach.

B2.

A relationship between brain activity data and eye tracking data during mathematical tasks from the view of educational research.

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Since the 1990's, several brain activity measurement devices have been developed. Some of the advantages of these devices include the ability to take non-invasive measurements and the ease-of-use in measuring the brain activity of students while learning. In addition, very efficient eye tracking measurement devices have been developed recent years. The purpose of this study is to explore the relationship between brain activity data and eye tracking data during mathematical tasks from the view of educational research. In the experiments, we measured hemoglobin changes in prefrontal cortices using NIRS (Near Infra-Red Spectroscopy) system, which could measure hemoglobin changes in seated-positions, while solving mathematical tasks. At the same time, we measured how many times to have moved fixation point using eye tracking measurement device system. We found that physiological data of student changed greatly by the difference of the difficulty level of the mathematics tasks. In addition to the conventional ways of behavioral data and test scores, the brain activity data and the eye tracking data would be new index to learning diagnosis. However, in order to make the data useful, there is a need to clarify typical characteristics of the data under various learning situations.

B3.

Mind, Brain, and Education: A case study of student perceptions of an interdisciplinary graduate program.

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Advances in developmental neuroscience research, calls for educational reform, and an emphasis on interdisciplinarity have generated interest in how science might inform educational practice and policy, resulting in the emerging field of mind, brain, and education (MBE). A primary goal of the field is to connect the cognitive and developmental sciences, biology, and education to develop a scientific grounding for educational practice and policy by creating new institutions where research and practice are closely connected. One aspect of this infrastructure includes training a new generation of interdisciplinary researchers and practitioners who have skills and knowledge in the multiple disciplines. This study uses a mixed-methods case-study design to investigate students' perceptions of their experiences developing interdisciplinary knowledge in an MBE graduate program, their perceptions of the potential and limitations of MBE to address educational problems, and how these perceptions vary based on disciplinary background.

B4.

Brain Activity associated with solving geometry area-related problems: Effect of general giftedness an excellence in mathematics.

Mark Leikin[1], Ilana Waisman[1], Shelley Shaul[1] and Roza Leikin[1]

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In this paper we report on the study that uses ERP methodology in order to examine the impact of general giftedness (G) and excellence in school mathematics (EM) on high students' mathematical performance associated with area-related problems. The research sample included 83 right-handed male high school students (16-17 years old) divided into five research groups: four groups designed by a combination of levels of G and EM factors while the fifth group included students with superior mathematical abilities (S-MG). We found effects neuro efficiency effect in gifted students who excel in mathematics (G-EM and S-MG students), whereas the highest overall electrical activity was found in EM students who were not identified as generally gifted (NG-EM students). NG-EM students were (naturally) more accurate than NG-NEM students while NG-EM students displayed the highest electrical potentials when solving the problems. It appears that electrical potentials in G-EM and NG-EM students were similar while in S-MG students they were significantly lower as compared both groups of students who excel in mathematics. We suggest that a combination of the ERP technique, along with more traditional educational research methods, enables obtaining reliable measures on the mental processing involved in mathematical problem solving.

B5.

Brain Activity associated with solving short insight-based problems: Focusing on generally gifted and excelling in mathematics adolescents.

Roza Leikin[1], Mark Leikin[1], Ilana Waisman[1] and Shelley Shaul[1]

1 University of Haifa, Haifa, Israel

We use ERP methodology to explain the differences in adolescents' mathematical abilities. Seventy-one male participants formed four research groups designed according to the combination of general giftedness (G) and excellence in mathematics (EM). We focus on brain electrical activity associated with solving short insight-based mathematical problems. G and EM factors had significant effects on problem-solving strategies expressed in laterality and the strength of brain activation on problem-solving. The study demonstrates that G and NG individuals recruit both hemispheres differently: the mean amplitude at the right hemisphere was greater in G students as compared to NG participants, while the mean amplitude at the left hemisphere was greater in NG students as compared to G participants. Our research demonstrates that each G factor and EM factor separately does not lead to a neuro-efficiency effect, whereas their combination is clearly expressed in lower electrical brain activity. Based on our findings, we hypothesize that G and EM are different individual traits. We suggest that students from G-EM groups need different learning environment with enhance insight-based problem solving in order to realize their mathematical potential.

B6.

Dudeman & Sidegirl: Operation clean World. A new Number Game used to train Number Processing Skills in 5-year-olds.

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Humans possess basic number processing skills (e.g. number comparison and number line estimation) of which previous studies have demonstrated that those are related to mathematics achievement. In these studies, it was assumed that both number processing tasks share the same underlying representation located in the intra-parietal sulcus (IPS). Recent research, however, observed no relationship between the performance on the comparison task on the one hand and the number line estimation task on the other, suggesting that different mechanisms and consequently other brain regions may play a role in both tasks. For this reason, we designed an intervention study focusing on both basic number processing skills using a new tablet game. Playing this game, in several levels, 70 kindergartners practiced either their comparison skills (group 1) or their estimation skills (group 2). By means of a pre- and post-test consisting of experimental (non-)symbolic comparison and number line estimations tasks, it was measured whether tablet game training on one of these basic number processing skills could be generalized to the other. Results and implications for education will be discussed at the conference.

B7.

Educational Neuroscience Applications: Memory of Multiplication Facts as a Model.

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The aim of this study is to extend knowledge regarding the best conditions for declarative memory formation at school. As a model, we used learning of basic multiplication facts, due to its importance as a basis for learning complex mathematical procedures. Recent neurocognitive studies provided evidence that memorized multiplication facts involve verbal brain areas. Therefore, we combined neurobiological research on memory with pedagogical findings on learning multiplication facts, following the approach of educational neuroscience. Declarative memory formation consists of 2 labile phases requiring stabilization: consolidation and reconsolidation. In these phases, memory can be impaired if new competing learning tasks turn up. In this study, third grade children were trained to memorize multiplication facts. For the consolidation phase, we used different kinds of interferences (similar/non similar information) and at the reconciliation phase different time measures for reactivation (24h/1 week). We found that memory was disrupted if there was interference during the two labile phases with new competing learning especially with similar information and timing influences the strength of the interference on reconsolidation. These results have practical application for learning and teaching declarative mathematical information.

B8.

How the 1st year of formal schooling shapes symbolic number development-evidence from brain and behavior.

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1st grade is a sensitive period for number skill development. Research has shown that Grade 1 children are more accurate on nonsymbolic (dot) than symbolic number comparison (Arabic numerals). By Grade 2 and 3, children perform equally well on these tasks, suggesting that symbolic processing improves between 1st and 2nd grade. To further explore this, we conducted a longitudinal investigation of Grade 1 children. Specifically, we explored whether individual differences in neural representations of magnitude comparison predict symbolic & nonsymbolic number development over time. 31 Grade 1 children were assessed on measures of math and symbolic & nonsymbolic number comparison at the beginning & middle of Grade 1. At the beginning of Grade 1 children completed a symbolic & nonsymbolic number comparison task while functional neuroimaging data were acquired. Analyses suggest children are more proficient on nonsymbolic vs. symbolic number comparison at the outset of Grade 1. In addition, the data show that greater activity in the left superior parietal lobule during symbolic processing correlates with math achievement. This is the first study to examine how individual differences in activation during symbolic & non-symbolic number processing in Grade 1 predict variability in the trajectories of early number development.

B9.

Perceptual information influences the formation of numerical representations: evidence from an artificial learning paradigm.

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It is commonly assumed that numerical symbols are mapped onto core nonsymbolic representations of number. Recent evidence has revealed that processing nonsymbolic representations of number is significantly influenced by the associated visual properties of these representations, including area and density. Here, we tested whether congruency between numerosity and visual parameters in nonsymbolic arrays facilitated adults' learning of novel symbols. Since there are three representations of number (words, digits, nonsymbolic arrays), we also tested whether providing verbal auditory nonword labels facilitated learning. Forty undergraduate students were trained to associate novel abstract symbols with numerical magnitudes. Half of the symbols were associated with arrays in which total surface area and numerosity were correlated. Participants were randomly assigned to the visual only or audiovisual condition. Following training, participants completed a symbolic numerical comparison task with the learned symbols, a two-alternative forced-choice mapping task between symbols and nonsymbolic arrays, and an ordinality test. Results revealed an interaction between ratio and area on the symbolic comparison task, suggesting that visual parameters of the nonsymbolic arrays did influence learning. There were no significant group differences on any measures.

B10.

The relation between home numeracy, exact number skills and non-symbolic audiovisual matching abilities.

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In the field of numerical cognition, magnitude processing has commonly been investigated using non-symbolic number comparison tasks (i.e. which dot array contains the most dots). Recently, however, it is suggested that the performance on this task might be confounded by visual processing. In the current study, we alternatively examined non-symbolic magnitude processing in 4 year olds using an audiovisual matching task (i.e. matching auditory presented sounds of falling apples with a visual display of apples in a basket). Additionally, a Free-Counting task (i.e. count as high as you can), a Count-Elicitation task (i.e. count as high as you can using one-to-one correspondence with lined poker-chips up to 15), and a Give a Number task (i.e. give a certain amount of poker-chips from the bunch of 15) were conducted to assess exact number skills. Parents also filled in a questionnaire on home numeracy activities and their SES, and the association between these questionnaires and the performance on the experimental tasks was investigated. The results will be discussed in the light of developmental theories on the relation of approximate and exact number skills.

B11.

Field Dependence-Independence cognitive construct and the human brain: neuro-educational approach.

Efi Nisiforou[1]

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Cutting edge technologies are fundamental in neuroscience studies of learning and cognition. The blend of neuroscience, education and new technologies is of great importance and may provide a positive impact on young people cognition with respect to the way they learn. Electroencephalography (EEG) was used to demonstrate what happens to the human brain as it receives visual information. Specifically, the study aims to identify users' visual attention with refer to the Field-Dependent/ Independent cognitive style construct while they were processing visual stimuli. Additionally, it attempts to provide in depth understanding of the relation between cognitive abilities and brain cognitive process. The target audience of the study consists of a number of students, recruited from a public University in Cyprus. The quantitative variables used in the study were analyzed with the software's device and the use of the statistical package SPSS. Results revealed the necessity to develop learning stimuli that reflect user's cognitive ability. Eventually, by understanding how cognitive styles affect user's visual behaviour we can further enrich our knowledge on how to design online environments which will improve users' web experiences and lead to accelerated and more efficient learning.

B12.

Cognitive Change: The Effects of Aquatic Motor Activities on Early-Childhood Motor and Cognitive Development.

Michal Nissim[1], Ronit Ram-Tsur[1], Michal Zion[1], Tal Dotan Ben-Soussan[1] and Zemira Mevarech[1]

1 Bar-Ilan University, Ramat-Gan, Israel

The effects of Aquatic Motor Activities (AMA), On-Land Motor Activities (OLMA) and Non-Motor Activities (NMA) following six months of intervention, on motor and cognitive development were compared in a sample of 94 children aged 4-6. Our hypothesis suggests that changing the environment of the activity to water may strengthen specific neurological connections, thereby improving motor and cognitive abilities, which might be connected to cerebellum functioning. Evidence for the connection between motor experience, cognitive development and cerebellum functionality are still under investigation. Evidence for the effect of different environments on cognitive development is remarkably scarce. Developmental-functionality tests, including motor, Raven's Colored Progressive Matrices (RCPM), cross-out and visual matching tests were used. AMA was found to predict the changes in gross motor, time-estimation and RCPM scores. Moreover, improvement in gross motor abilities moderates the association between AMA and children's visual matching score. These findings increase the understanding of child-development professionals, regarding the connection between the aquatic environment and motor and cognitive development, possibly leading to improved early-childhood interventions.

B13.

Kindergarten Children's Number Comparison Skills Predict First Grade Math Scores: Evidence From a Two-minute Test.

Nadia Nosworthy[1], Samuel Zheng[2] and Daniel Ansari

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Children's ability to compare symbolic (e.g., Arabic numerals) and nonsymbolic (e.g., dot arrays) numerical magnitudes has been found to correlate with their math achievement. Most research, however, has focused on computerized paradigms, which may not always be suitable for quick application in classrooms. Consequently, we designed a two-minute paper-and-pencil assessment to measure kindergarten children's ability to compare symbolic and nonsymbolic numerical magnitudes and assessed the degree to which performance on this measure explains individual differences in achievement. Children were required to cross out the larger of two, single-digit numerical magnitudes. Results from 250 kindergartners revealed that symbolic and nonsymbolic number comparison accuracy scores correlated with individual differences in arithmetic achievement. Results also demonstrated that participants' scores on the paper-and-pencil test in kindergarten was a significant predictor of math performance in first grade. These findings suggest the important role of symbolic and nonsymbolic processing in children's higher-level math abilities and the importance of assessing this very basic skill in children, highlighting the potential of this tool for the assessment of early, foundational numerical abilities.

B14.

Neural efficiency in working memory tasks: The impact of task demand and training.

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Studies of human intelligence provide strong evidence for the neural efficiency hypothesis: More efficient brain functioning in more intelligent individuals, that is, less cortical activation in brighter individuals. The main goal of this study was to explore the relationship between intelligence and cortical activation in combination with a cognitive training. In 83 participants, cortical activation was assessed by means of event-related desynchronization (ERD) before and after working memory (WM) training. In a pre-test training post-test design, ERD during performance of trained as well as untrained transfer tasks was correlated with scores in a psychometric intelligence test (Raven's Advanced Progressive Matrices test). We found a negative correlation between ERD and intelligence for moderately difficult tasks. A decrease in cortical investment from pre- to post-test was found for simple tasks but likewise for individuals with lower and higher intelligence. We could not find a stronger activation decrease from pre- to post-test for individuals with higher intelligence. These findings suggest partial confirmation of the neural efficiency hypothesis for moderately difficult tasks and they provide an indication that training can help in reducing cortical activation while solving simple tasks.

B15.

How Expert Mathematicians Compare the Numerical Values of Fractions Evidence from Eye Movements.

Andreas Obersteiner[1] and Kristina Reiss[1]

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Fraction comparison tasks are frequently used to study the mental representation of fractions. It has been a matter of debate if individuals solve such tasks componentially by comparing the fraction numerators and denominators, or holistically by considering the fraction magnitudes. Recent research suggested that expert mathematicians use componential strategies for fraction pairs with common components, and holistic strategies for pairs without common components. These conclusions were based on response time measures, which are an only indirect indicator of individual strategies. This study recorded for the first time eye movements to test if this method allows distinguishing strategy use depending on problem type. Results from a first experiment with eight academic mathematicians showed that participants fixated the numerators significantly longer on fraction pairs with common denominators, and vice versa for fraction pairs with common numerators, hinting to componential strategies. There were no such differences for fraction pairs without common components, hinting to holistic strategies. We are currently collecting data from a larger sample of university students majoring in mathematics. So far, eye movements seem to be a promising method for assessing individual strategies on fraction comparison tasks.

B16.

More than subitizing: Symbolic manipulations of numbers.

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This study tested the hypothesis that subitizing ability may cause achievement differences in mathematics especially for students with mathematics learning disabilities. Students from 1st through 4th grade were applied to curriculum based math achievement tests (MAT). Based on MAT scores, they were dividied into four groups as Mathematics Learning Disorder (MLD) risks, low achievers (LA), typical achievers (TA), and high achievers (HA). All students were asked randomly and canonically arranged dot enumeration tasks with 3 through 9 dots. Median response times (MRT) were calculated for each task and plotted for each grade level and task types. There were virtually no differences in MRTs for number 3 and 4. On the other hand, the MLD risk group spent relatively more time on enumerating canonically arranged dots from 5 through 9. Results provided more support for the claim that rather than subitizing, numerosity coding mechanisms or the type of symbolic quantity manipulations is different in children with different mathematical achievements especially the lower group, the MLD risk group.

B17.

Feedback's informative value as the driving force of the feedback-related negativity (FRN).

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The fast and efficient evaluation of feedback is essential for learning in humans. The feedback-related negativity (FRN) of the event-related potential has been identified as a neurophysiological marker of feedback processing. Here we consider a novel account where learning serves to minimize uncertainty about (future) states and feedback that provides the most information about the current state is most useful for learning. Thus, the amplitude of the FRN scales with the information provided by the feedback. In the present study volunteers performed a stimulus-response association learning task with varying proportions of positive, negative, and non-informative feedback. The informative value of was calculated by assessing the average of self-information of the feedback. Participants learned stimulus response associations very well with an average proportion of 90% correct responses. A stepwise regression analysis revealed that only the informative value was associated with a significant regression weight explaining 31% of the total variance of the FRN amplitude. The present results indicate that the FRN reflects the accumulated neural activity elicited by the computation of the informative value of the most recent feedback. The net outcome of this computational process is subsequently utilised for learning.

B18.

Structural and Functional Neuroimaging of Reading in Children.

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Neuroimaging research has shown that reading involves the left hemisphere and that white and grey matter structures are related to reading ability. However, the analysis of brain networks used for reading is rarely conducted with more than one neuroimaging method and thus further evidence is needed to associate brain structure with function. The purpose of this study was to examine reading networks using several neuroimaging techniques. Children with varying reading abilities (7-9 years old) completed an MRI scan to measure orthographic and phonological reading (fMRI), functional connectivity (resting state fMRI), grey matter volume (T1), and white matter density (diffusion tensor imaging). Whole brain activation and regions of interest (ROI) were determined from the fMRI reading tasks. We subsequently analyzed the ROIs for functional connectivity, grey matter volume, and white matter density. Results showed activation for reading in left frontal, insular, parietal, and fusiform gyri. The time courses of the ROIs were positively correlated to each other from the resting state scan, indicating that reading networks work in tandem even at rest. Grey matter volume and white matter density within the ROIs were also related to reading ability, suggesting that both structure and function are important for reading ability.

B19.

Eye movements during dot enumeration: The influence of visual and numerical information.

Jacob Paul[1], Jason Forte[1] and Robert Reeve[1]

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Individual differences in dot enumeration (DE) abilities predict math problem solving success; however, the reason for differences in DE abilities is unclear. We test the hypothesis that differences in DE abilities reflect differences in visual processing capabilities, reflected by visual scanning efficiency. To test this claim we analyzed eye movement patterns as individuals completed a DE task. Ten observers viewed dot displays in which visual and numerical information were manipulated. To assess the affect of dot structure canonicity, two configurations for DE set sizes 1 through 12 were randomly generated and presented at 0°, 90°, 180°, and 270° orientations so that inter-dot distances remained constant. Observers made two judgements: the number of dots and the apparent canonicity of dot displays. Analyses revealed individual differences in the efficiency, regularity and similarity of scan paths and fixation patterns. Eye movements for identical dot patterns varied as a function of dot numerosity, apparent canonicity, and exposure frequency. Individual differences in visual scanning efficiency were associated with computation success. Implications for math learning theories and intervention practices are considered.

B20.

Neural representations in visual cortex for numerical magnitudes presented in different formats.

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One intriguing question with clear education relevance deals with how the brain processes numbers. In this study, we investigated the effects of different ways of representing numbers (digits, dots, number words) during calculation. We examined how different representations are processed in the brain and how they evolve across the visual system. The study included two fMRI-experiments. In Experiment 1, subjects had to subtract magnitudes up to 20 presented as dot patterns, digits and number words, and compare the result to a reference magnitude. We consistently found a region in lateral-occipital (LO) cortex that responded more to digits than words. In Experiment 2, we manipulated format (letter versus digit) and string length. Subjects performed an ordinal task. The LO preference for digits versus words from Experiment 1 was not replicated here and might have reflected a task-dependent preference. Furthermore, we found a shift in representation of letters and digits throughout the visual processing stream from grouping based on number of characters to grouping based on stimulus category. We are currently replicating Experiment 1 in children, attempting to investigate the effect of different representations (digits, words, dots) on brain functioning. Preliminary results of this study will be presented at the conference.

B21.

The association between digit comparison performance and individual differences in arithmetic unraveled.

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Studies in both adults and children showed that the performance on a single-digit comparison task (i.e. deciding which one is larger) is concurrently as well as predictively associated with individual differences in arithmetic. To date, however, it is unclear which specific process within the comparison of digits causes this relation. Potential candidates include the processing of cardinality information, order information, digit-word matching or fast digit recognition, all of which have been suggested to rely on different brain areas. The present study aimed to clarify this issue. Adult participants performed a digit recognition task (i.e. is this a digit or not?), an audiovisual matching task (i.e. are 7 and /seven/ numerical identical?), a relative-order judgment task (i.e. is the number pair 6 – 7 in the correct ascending left to right counting order?) and a comparison task (e.g. is 7 larger than 6?). The performance on these tasks was related to the performance on an arithmetic test. In addition, similar tasks with letters were conducted to control for general non-numerical factors. Results and implications for education will be highlighted at the conference.

Poster Session C

C1.

Neural Correlates of Fatigue During Task Switching.

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Fatigue in healthy students is a common problem and associated with reduced academic achievement. However, the effects of fatigue on cognition are poorly understood. In the current fMRI study, 25 female students with long-term fatigue were compared to 26 female students without fatigue on a task-switching paradigm. Both groups were scanned following a fatigue manipulation (i.e., 1.5 hours of demanding cognitive tasks) in one session and a control manipulation (i.e., 1.5 hours of non-demanding activities) in another session. The sessions took place in counterbalanced order on two separate days. There were no differences between the groups or sessions on behavioural performance. Across the groups and sessions, activation was observed in the left premotor, supplementary motor, inferior parietal, middle temporal and dorsolateral prefrontal cortex, and in the right posterior cingulate cortex and posterior insula. The group with long-term fatigue activated the left anterior cingulate cortex more than the group without fatigue. Interactions between group and session were found in the left dorsolateral prefrontal, somatosensory association and premotor cortex. These results indicate that a mental fatigue induction differently affects prefrontal areas in students with and without long-term fatigue while switching between tasks.

C2.

Exploring Mental Representations for Literal Symbols Using the Priming Distance Effect.

Courtney Pollack[1] and Sibylla Leon Guerrero[1]

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Prior research has investigated how symbolic representations of number link to representations of quantity on a notation-independent mental number line. Unknown is whether ‘short-term’ symbolic representations of quantity, such as literal symbols (e.g., ‘x’) that have been given quantitative meaning, can also map onto this mental number line. Prior research has substantiated a priming distance effect (PDE), in which ease of comparing a target number to a fixed standard is a function of prime-target distance (e.g., Defever et al., 2011; Reynvoet et al., 2002). Can literal symbols map to the mental number line and produce a PDE as other symbolic representations do? Forty participants completed a series of number comparison tasks involving Arabic numerals and literal symbols, a training task, and a working memory task. While a PDE was present during comparison with Arabic numerals, we found no evidence of a PDE with literal symbols. Our findings suggest that literal symbols with quantitative meaning may not access the same mental number line as other number formats or may not access it in the same way. Additional research is needed to understand the types of mental representations utilized in higher-level mathematics (e.g., algebra), which includes both Arabic numerals and literal symbols.

C3.

From executive functions to number knowledge: Neuropsychological performance in Portuguese preschoolers.

Joana Rato[1] and Alexandre Castro-Caldas[1]

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Previous literature suggests that early number knowledge is under-assessed by neuropsychological tools, compared with other cognitive skills. In the present study we analysed the relation between component abilities (as the executive functions and finger gnosis) and the early number knowledge, evaluating their predictive power. The sample comprised 35 typically developing children (19 boys and 16 girls) with 5 years-old (60-71 months; M=67.26, SD=5.43). A neuropsychological assessment protocol was developed for this purpose. Executive functions, subitizing and finger gnosis skills were found to be predictors of number knowledge. These components seem to contribute to performance on numerical tasks, and should be considered in mathematics education. Our findings support several views concerning the foundations of numeracy and have implications for the early identification of preschoolers' math skills. The conclusions of this study strengthen the efforts for reforming mathematics education under the developing field of Educational Neuroscience.

C4.

Symbolic numerical processing deficit in people with Williams syndrome.

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Recent studies suggest that people with Williams syndrome (WS) present specific deficit in processing numerical magnitudes (Krajcsi et al.,2009; O'Hearn et al.,2007; Paterson et al.,2006).As patients with WS were always tested in the visual modality, their deficit could either be specific to the processing of numerical magnitude or result from their basic visuo-spatial impairment (main characteristic of their cognitive phenotype). Supporting the second hypothesis, a first study showed that people with WS have lower numerical acuity only in numerical tasks with high visuo-spatial processing requirements (i.e. comparing two lengths or two arrays of elements but not when comparing two durations or two sequences of flash in a single location; Rousselle et al., 2013). Recently, we tested whether a similar dissociation would be observed in processing the meaning of numerical symbols. Patients with WS were asked to compare the numerical magnitude of two Arabic d vs two spoken verbal numerals. Their subitizing abilities were also assessed through the enumeration of 1 to 7 dots shown for 250 ms. Participants with WS were compared to children matched on verbal or nonverbal mental abilities. Results show that they have difficulties in accessing the meaning of numerical symbols whatever the format and present smaller subitizing range.

C5.

Examining the problem size effect: a tDCS and EEG study.

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The problem size effect is a well-established finding in arithmetic problem solving characterized by worse performance in problems with larger compared to smaller operand size. We used transcranial direct current stimulation (tDCS) to evaluate whether electroencephalography (EEG) oscillations shown to be indicative of problem size are causally related to performance and whether the effects of brain stimulation depend on problem size. Participants underwent anodal (30 min, 1.5 mA, over left posterior parietal cortex) and sham tDCS. EEG was recorded while they solved small and large problems. Anodal stimulation decreased response latencies and increased lower alpha desynchronization (8-10 Hz) in large problems, whereas it decreased theta synchronization (4-7 Hz) in small problems. These findings provide first evidence of a causal link between oscillatory theta and alpha activity and arithmetic processes, and reveal that problem size moderates the effects of brain stimulation.

C6.

Music in the Baddeley model of working memory in TD and SLI children.

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Verbal working memory performance in TD children and adults was shown to correlate with comprehension of spoken language (Daneman & Merikle, 1996; Just & Carpenter, 1992), written language (Daneman & Merikle, 1996; Gathercole & Baddeley, 1993), word acquisition (Baddeley, Gathercole, & Papagno, 1998), and syntax processing (Ellis & Sinclair, 1996). Due to its importance for language acquisition Baddeley et al. (1998) proposed one of the subsystems, the phonological loop, as Language Learning Device. Children with specific language impairment (SLI) show deficiencies in verbal working memory (WM), as reflected in poor performance in word, non-word or sentence repetition paradigms (Marton & Schwartz, 2003; Montgomery, 2003). Beside the problems in speech processing SLI children also show problems in musical and thus nonlinguistic tasks (Jentschke et al., 2008; Sallat, 2008; Sallat, Stachowiak & Jentschke, in prep., see also Mampe et al. 2009). Up to now it is a matter of discussion whether the phonological loop is also involved in storing musical or tonal information (Pechmann & Mohr, 1992; Semal, Demany, Ueda, & Halle, 1996). In the study we compared verbal working memory performance (AGTB 5-10, Hasselhorn et al. 2012) with musical working memory results in 40 7-8year old TD and SLI children.

C7.

Effects of psychological and physiological variables on students' subjective stress experience. A multilevel longitudinal analysis in naturalistic educational settings.

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Learning in school entails an amount of potential stressors but most of the cross-sectional studies are based only upon self-reports. Considering that there are several levels involved, we have to measure psychological as well as physiological variables. Academic self-concept is considered. By continuous state sampling psychological states were measured (perceived resources, subjective stress experience). The physiological level is represented by the baseline saliva cortisol concentration and the heart rate variability (LF/HF-ratio). The aim of the study was to identify cross-level interactions explaining learners stress experience. 28 prospective industrial clerks were investigated during 9 school lessons in school. There are 10 to 38 state-measurements per person which add up to 775 measurements in total. Analyzing influences of several variables on the subjective stress experience a multilevel model with two levels was applied: Time based measurements are nested in individuals. A significant positive effect of the LF/HF-ratio ($p < .05$) on stress experience can be reported. Furthermore there is a significant cross-level interaction of baseline saliva cortisol concentration with the subjective stress experience ($p < .05$). Video based observations will complement these data for better explanations of learning processes.

C8.

On the development of the multiplication fact network in elementary school children.

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Number facts are commonly assumed to be stored in an associative multiplication fact retrieval network. Prominent evidence for this assumption comes from so-called operand errors (e.g. 4 x 6 =28, belonging to the multiplication table of 4 because 4 x 7 = 28). Errors related to one of the operands constitute about 2/3 or more of all errors in healthy adults. However, little is known about the frequency and the development of operand-related performance in elementary children. Therefore, in this longitudinal study, we explored elementary children from 3rd and 4th grade in a multiplication verification task and recorded responses to problems with operand-related errors and operand-unrelated errors. Performance increased with age and experience. Most importantly, an operand-relation effect was observed from 3rd grade on, but seemed to change over time. The results suggest that even in children multiplication facts are stored in an associative network, which, however, seems to develop and stabilize with age and experience.

C9.

Teachers' perception of the brain function in Latin America.

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Europe has produced several studies exploring how neuroscience can inform education. This pioneer project aims to explore ideas about the brain held by educators in Latin America (L.A.) and to contribute towards building a bridge for dialogue between neuroscience and education in this region. An interpretive, qualitative method design used a semi-structured interview approach, and because of the large geographical coverage attempted, it was conducted via Skype. 15 basic education level teachers from eight L.A. countries, with little to no knowledge of neuroscience and its use in education, were interviewed individually. A theoretical thematic analysis revealed a number of prominent ideas: a belief that emotions play an important role in brain functioning and learning, and that dopamine can be activated by being in a "pleasant environment" or practicing "brain gym". Participants showed interest, and little caution, in becoming more informed about the use of neuroscience in education. As observed in Europe and the U.S., L.A. teachers seemed keen on learning about neuroscience, which could make them vulnerable to obtaining information from the wrong sources (e. g. pseudo-neuroscientists, the media, or out of date research). However, some of the beliefs about the brain had not been present in other countries before.

C10.

Processing numerical Ordinality: is it a core ability?

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Ordinality is a hallmark feature of numbers that might be affected by language (i.e., the direction of writing system). We report three studies that are aimed to evaluate the cognitive basis of numerical ordinal processing: (1) three groups of Hebrew speaking Israeli children (5-9 y.o.) completed an ordinal judging tasks with quantities (i.e., dot patterns) or Arabic numbers while the direction of the sequence (ascending/descending) was manipulated. Findings indicate that children from the age of five are able to process numerical ordinality while in school aged children, responses to ordinal sequences were modulated by direction; In the symbolic task, ordinality effect was significant only in the 8-9-years old group. (2) In Belgian children who use a left to right writing system, the effect of direction was reversed (i.e., the ordinal ascending direction was processed more accurately). (3) In a third experiment, we evaluated the effect of masked primed, ordinal vs. non ordinal numerical sequences on the ability to estimate quantity in adult participants. Priming ordinal sequences affected the patterns of estimation, suggesting automatic processing of ordinality.

We suggest that there are two separate cognitive representations of ordinal and quantity information and that ordinal processing act as a core ability.

C11.

The neuroscience literacy of pre-service special needs educators and predictors of neuromyths and knowledge.

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One of the main objectives of the MBE science is to assure best practice teaching through scientific evidence of neuro- and cognitive sciences, while application of neuromyths in education should be avoided. Raising neuroscience literacy should prevent misunderstandings about how the brain works. Training and professional development should thus include a component of neuroscience relevant to education. The main purpose of this study is to investigate the neuroscience literacy and predictors of neuromyths and knowledge of the brain. The study also investigates motives and interests of educators in MBE science. Measures–Instruments: A questionary for background information and interests in MBE science; a survey of neuroscience literacy adapted from Hurculano-Houzel (2002) and Howard Jones (2009); Walker and Plomin's survey (2005) about teachers' perception how genes and environment influence educationally relevant behavior. Participants: All instruments were administered to students of special pedagogy (N=200) at the Faculty of Education. Data analysis: Descriptive statistic and regression analysis were applied to obtained data. Discussion: The results will be discussed in the context of planning actions for raising the neuroscience literacy and implementing the MBE science findings in the study programs.

C12.

Neuromyths among secondary and college teachers.

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Many so-called “brain-based” approaches have been strongly criticized for their lack of empirical support and sometimes for the use of pseudoscientific concepts. Several authors are therefore using the term *neuromyths* referring to false beliefs or misinterpretations regarding neuroscientific facts. We surveyed teachers and trainee teachers about their agreement toward hemispheric preferences, modality preferences and the Brain Gym © method. More than 80% of the respondents agreed that some individuals use more one hemisphere over the other and that some are more visual while others are auditory. They also though that this was supported by brain research. Although most subjects (73%) responded that they were not taking in account hemispheric preferences in their teaching practices, most of them agreed that a pedagogy based on such differentiation would favours learning. Together with other studies, the results suggest that teachers and trainee teachers would benefit from appropriate training in this new field of research.

C13.

Patterns of change in the cognition-emotion relationship predict math problem solving.

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Surprisingly little is known about whether relationships between cognitive (C) and emotional (E) states remain stable or change over time, or how different patterns of stability and/or change in C-E relationships affect math problem solving abilities. However, cross-sectional fMRI data show that anxiety/worry-problem solving relationships are mediated by frontal regions; variations among which are associated with an ability to coordinate task demands. To investigate the implications of stability and/or change C-E relations over time, 120 14-year-olds' algebraic WM and worry levels were assessed twice in a single day as they studied for an algebra test. We used latent class transition analysis to identify stability/change in E-C relations, which yielded a six subgroup solution. Subgroups varied in WM capacity, worry, stability/change in these relationships and algebraic test abilities. In particular, the high WM capacity-low worry "stable across time" subgroup performed best on the algebra test; and in contrast, the low WM capacity-high worry "unstable across time" subgroup performed worst. The findings are interpreted as showing that it important to assess variations in C-E relationships over time (rather than assessing C or E states alone) to account for differences in academic problem solving abilities.

C14.

The influence of reading problems on basic numerical processing in children with and without math difficulties.

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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 with 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 a similar deficit pattern on basic numerical tasks as children with math difficulties only (MD)? In the present study, the relationship and overlap between reading fluency problems and arithmetic problems is investigated in a large Dutch sample of 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.

C15.

Cognitive and neural characteristics of mathematical difficulties in children with mild traumatic brain injury (mTBI).

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Impairments in academic skills have been reported following pediatric mTBI and mathematics rather than reading or spelling is the most compromised in these children. However, a precise characterization of these mathematical difficulties (MD) is unavailable. This study aims to provide a characterization of the MD in pediatric mTBI at both behavioral and neuroanatomical level. Twenty semi-acute pediatric mTBI patients and 20 matched controls underwent cognitive assessment and MRI-examination. Mathematical competence was measured with standardized and experimental measurements. Because diffuse axonal injury is common in TBI and is widely believed to account for persistent cognitive problems after TBI, we used Diffusion Tensor Imaging (DTI) to examine white matter abnormalities. Preliminary behavioral results show that children with mTBI scored lower on block recall tasks, suggesting poorer visuo-spatial working memory and they were also less accurate in comparing numerical magnitudes, indicating a deficit in numerical processing. By using DTI-tractography, we are currently delineating white matter tracts that are involved in mathematics/often damaged after mTBI. The results of these analyses will be available at the conference and will allow us to see how white matter is related to mathematics achievement in children with mTBI.

C16.

Developmental specialization of the parietal cortex for symbolic numerical magnitude representation.

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Previous neuro-imaging work has suggested that the intraparietal sulcus (IPS) becomes increasingly specialized for representing symbolic numerical magnitudes over developmental time. In these studies, however, non-numerical dimensions such as response selection and task performance were insufficiently controlled. Confounding influence on previous results can therefore not be ruled out and observed developmental differences may be biased. To reduce the impact of confounding variables, functional Magnetic Resonance Imaging Adaptation was used in order to measure the brain response of 6- to 14-year-old children. A single-digit numeral was repeatedly presented on a computer screen and interspersed with the presentation of novel digits deviating as a function of numerical-ratio. Signal recovery in response to the presentation of numerical deviants was analyzed for age differences. Results demonstrate that age and numerical-ratio modulated signal recovery in the left IPS, suggesting an age-related specialization of symbolic numerical magnitude representation in the left hemisphere. Activation of the right IPS was modulated by numerical-ratio but not by age. Together, the results provide novel evidence that the left and right IPS may be differentially engaged in constructing symbolic numerical knowledge over developmental time.

C17.

The link between preschooler's executive function and theory of mind.

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In the last 20 years, the link between executive function (EF) and Theory of Mind (ToM) was regularly explored in the scientific literature (e.g., Carlson, Mandell, & Williams, 2004; Hughes, Dunn, & White, 1998; Kloo & Perner, 2003). Results of those studies are not always congruent.
The aim of this study was to assess the specific relation between performance of 77 4- to 6-year-olds' Belgian french speaking children on several tasks measuring EF (specifically inhibition) and different tasks in ToM. In addition, parents assessed ToM and EF abilities by questionnaires.
After controlling for age and intellectual quotient, some correlations between ToM and EF measures were found. These results suggest that ToM may be a crucial factor for EF development (and inversely). Furthermore, regression analyses will be presented and discussed. Some of the children received a training aiming at improving their TOM skills, others received a training aiming at improving their EF skills and the others received a control training. Analyses (still in progress) will examine whether improvement in EF after the training is correlated with improvement in TOM and conversely. Similar analyses are in progress with externalizing behavior preschoolers (N = 63) and will be discussed, in comparison with typically developing preschoolers.

C18.

Cognitive intervention in preschoolers.

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In this research we want to observe if a cognitive intervention aiming at enhancing inhibition capacities, would not only have an impact on cognitive capacities, but also would lead to behavioral changes with a decrease in external behavioural problems. 47 preschoolers took part in a pretest involving cognitive (attention, motor and cognitive inhibition, flexibility and working memory) and behavioural measures (questionnaires and an observational paradigm for externalizing behaviors). Children were then randomly allocated to control versus experimental groups. Every child received 2 intervention sessions of 45 minutes per week during 8 weeks. While children from the control group received free hand craft sessions, children from the experimental group received games/exercises aiming at increasing their inhibition capacities. At the end of the intervention, every child from each group took part in the post-test. We observed significant differences between control and experimental group in favour of the latter group on inhibition, attention and working memory measures. Some differences were also measured on behavioural measures. We thus show that it is possible to enhance inhibition capacities in preschoolers and that this has also an impact on other cognitive functions as well as, to a smaller extend, on external behaviour.

C19.

Brain activity associated with translation from a visual to a symbolic representation in Algebra and Geometry.

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We investigate brain activity - using ERP methodology - of male adolescents when solving mathematical problems in algebra and geometry. The study design links mathematics education research with neurocognitive studies. Both in algebra and geometry, we perform a comparative analysis of brain activity associated with the translation from visual to symbolic representations of mathematical objects. Algebraic tasks require translation from graphical to symbolic representation of a function, whereas tasks in geometry require translation from a drawing of a geometric figure to a symbolic representation of its property. The findings demonstrate that electrical activity associated with the performance of geometrical tasks is stronger than that associated with solving algebraic tasks. Additionally, we found different scalp topography of the brain activity associated with solving algebraic and geometric tasks. Based on the study results, we argue that problem solving in algebra and geometry is associated with different patterns of brain activity. The findings lead to new research hypotheses as well as to the explanation why different students are not equally good in geometry and algebra.

C20.

The borrowing effect in two-digit subtraction: Developmental aspects and neural correlates.

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In general, it is assumed that the borrowing operation in subtraction (for 42-27, a decade unit has to be borrowed) increases task difficulty, i.e. response latencies and error rates. However, as compared to the carry effect in addition – theoretical knowledge and empirical evidence for the borrowing effect in subtraction are relatively scarce. In two studies, we investigated developmental change in children and possible neural correlates of the borrowing operation in adults.

In a longitudinal sample of children in third and fourth grade, respectively, the borrowing effect could be demonstrated for two-digit subtraction problems. Additionally, the children showed a learning-associated decrease in reaction times for solving subtraction problems within one school year, independently of the borrowing effect suggesting dissociable mechanisms of borrowing and general subtraction performance. By using functional near-infrared spectroscopy (fNIRS) we examined the brain activity for the borrowing effect in a sample of adults. Activation was observed in a fronto-parietal network underlying two-digit subtraction. These activation patterns, particularly in the parietal cortex, were modulated by the borrowing operation. The results suggest that the borrowing procedure is a dissociable developmental process with specific neural correlates.

C21.

Different developmental onsets of symbolic approximate arithmetic skills across countries: How numbers are named matters.

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Approximate arithmetic with large symbolic (Arabic) numerosities is an important predictor of math. Evidence suggests that this skill emerges in kindergarten. Symbolic mental representations are assumed to map onto pre-existing nonsymbolic ones (abstract magnitudes). Although Arabic numerals are universal, number naming systems are not and they can influence performance in nonverbal tasks. Dutch number naming is cognitively more demanding compared to English, due to the inversion property for numbers above twenty. We conducted two experiments: 1) We tested English-speaking and Dutch-speaking children, before school entry, matched for exact addition, counting and SES. Dutch children performed worse and demonstrated WM overload in symbolic but not nonsymbolic approximate addition. Importantly, symbolic -not nonsymbolic- approximate arithmetic correlated highly with number naming above twenty. 2) In the Dutch children, we found different developmental trajectories for nonsymbolic and symbolic approximate addition. In contrast to nonsymbolic approximate addition, the expected ratio effect for symbolic was only demonstrated in Grade 1, and not earlier. Cumulatively, our results highlight the importance of number naming in numerical development and suggest that cross-linguistic differences can affect the onset of symbolic approximation.

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