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Development of Numerical Processing and Language

From Neurocognitive Foundations to Educational Applications

7th -8th October, 2013

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN



University of Tuebingen, Department of
Psychology
Section Diagnostics and Cognitive



Knowledge Media Research Center, Tuebingen



University Hospital and Faculty of Medicine Tuebingen,
Psychiatry and Psychotherapy, Research Group
Psychophysiology & Optical Imaging



Monday, 7th October 2013, 9:00 – 19:00

Talks by speakers

09:00 – 09:15

Workshop Opening, Prof. Hans-Christoph Nuerk

NEUROCOGNITION

09:15 – 10:00

Prof. Hans-Christoph Nuerk

10:00 – 10:45

Prof. Daniel Ansari

Coffee Break

11:15 – 12:00

Dr. Roi Cohen-Kadosh

12:00 – 12:45

Prof. Marco Zorzi

Lunch Break

FOUNDATIONS OF EDUCATION

14:00 – 14:45

Prof. Michael Schneider

14:45 – 15:30

Prof. Laura Martignon

15:30 – 16:15

Prof. Martin Fischer

Coffee Break

LANGUAGE

16:45 – 17:30

Dr. Annika Hultén

17:30 – 18:15

Prof. Hartmut Leuthold

18:15 – 18:30

Outlook, Prof. Hans-Christoph Nuerk

19:30

Dinner

Tuesday, 8th October 2013, 9:00 – 12:00

Poster presentation and discussion

09:00 – 10:00

Poster Session A

Coffee Break

10:30 – 11:30

Poster Session B

11:30 – 12:00

General Discussion & Farewell, Prof. Hans-Christoph Nuerk

Abstracts Talks

Neurocognitive Foundations and Educational Applications in Numerical Processing

Prof. Hans-Christoph Nuerk, University of Tuebingen

The presentation gives an overview about neurocognitive foundations and educational applications in numerical processing as studied by our Tuebingen Research Group. First, I will give an overview how embodied numerosity may aid educational efforts for better numerical and arithmetic learning. Second, exploration of the neurocognitive foundations of numerical and arithmetic processing will be presented. Third, the role of sleep and sleep impairments on numerical processing will be explored. In the final section of my talk, I will go beyond integer range, which is the domain of most numerical cognition studies, and present new findings and models about the way we process non-natural numbers.

Number Symbols in the Brain: Development, Enculturation and Individual Differences

Prof. Daniel Ansari, University of Western Ontario

Humans share with animals the ability to process numerical quantities in non-symbolic formats (e.g. collections of objects). Unlike other species, however, over cultural history, humans have developed symbolic representations (such as number words and digits) to represent numerical quantities exactly and abstractly. These symbols and their semantic referents form the foundations for higher-level numerical and mathematical skills. It is commonly assumed that symbols for number acquire their meaning by being mapped onto the pre-existing, phylogenetically ancient system for the representation of non-symbolic number over the course of learning and development. In this talk I will challenge this hypothesis for how numerical symbols acquire their meanings ('the symbol grounding problem'). To do so, I will present a series of behavioral and neuroimaging studies with both children and adults that demonstrate that symbolic and non-symbolic processing of number is dissociated at both the behavioral and brain levels of analysis. I will discuss the implications of these data for theories of the origins of numerical symbol processing and its breakdown in children with mathematical learning disorders.

Using Non-Invasive Brain Stimulation to Enhance Numerical Abilities

Dr. Roi Cohen Kadosh, University of Oxford

Numbers are the lingua franca in science, economics, sports, education, and everyday life. In this talk I will discuss: 1) whether we can improve numerical abilities in typical and atypical populations; and 2) what the potential underlying neurocognitive mechanisms that involved in such enhancement are. In a series of experiments with healthy adults and children with mathematical learning difficulties we found that it is possible to enhance performance in a variety of numerical tasks, using transcranial electrical stimulation (tES) to core brain regions in the numerical brain network. In some cases the observed improvement was long-lasting, and was specific to the trained material, and to the stimulated site. Cumulatively, these experiments advance our understanding of how numerical abilities are subserved in the human brain, and provide a possible means to improve numerical cognition, thus having important implications for education, learning, and neuroplasticity.

Core processing deficits in dyslexia and dyscalculia

Prof. Dr. Marco Zorzi, University of Padova

In this talk I will argue that understanding the basic computations underlying learning and cognition is a key aspect of educational neuroscience research. Drawing from studies on numerical cognition and word reading, I will show that learning models offer an account of both typical and atypical developmental trajectories. Formal models can shed light on how the impairment of core processing components might affect learning, thereby providing important insights for the development of screening tests as well as a principled approach to remediation. In the context of dyslexia or dyscalculia, this will allow to move from standard assessment of learning disability to early predictive screening based on ancillary tasks that are not influenced by the outcome of curricular instruction.

Fractions: The New Frontier for Theories of Numerical Development?

Prof. Michael Schneider, University of Trier

Magnitude representations of whole numbers, whole-number arithmetic, and math achievement are closely related. Aspects of these relations have been investigated with brain-imaging techniques, reaction time paradigms, mathematical problem solving tasks, and instructional interventions. This line of research is a rare and good example of how neuroscience, behavioral psychology, and educational research can complement and inspire each other. Many researchers are currently trying to transfer the paradigms that already worked successfully with whole numbers to the domain of numerical fractions. There is virtually no difference in the perceptual complexity of fractions like $\frac{3}{4}$ and whole numbers like 314. Yet, fractions and whole numbers differ substantially in their mathematical and psychological properties. Ongoing research investigates why fractions are much harder to understand than whole numbers, what gives rise to highly persistent faulty strategies in the domain of fraction arithmetic, whether there is a whole-number bias in human numerical cognition, and whether the relations between magnitude representation, arithmetic and achievement are similar for fractions than they are for whole numbers. The talk will give a short overview over selected empirical findings, open questions, methodological considerations, and educational implications of this newly emerging and highly dynamic field of research.

**Gender Differences in Reasoning and Problem Solving:
The Perspective of Math Education**

Prof. Laura Martignon, University of Education Ludwigsburg

Gender differences in math performance have been an object of debate during the last 60 years, with intensification after the PISA studies exhibited not just gender differences in the scores obtained by boys and girls but also cultural discrepancies in these gender differences. In fact, in some countries like Iceland and Denmark, girls scored better than boys, whereas in countries like Germany, Austria and Japan boys scored better than girls. The debate on what is now called "The science of gender in science" was promoted in 2005 by Pinker and Spelke at Harvard. My focus in this talk will be on the importance of the instruments used to evaluate tests on gender differences and how the differences may depend on the instruments. I will also discuss a useful dichotomy concerning problem solving in Math: "predicative versus functional solution paths". Finally I will discuss the paramount importance of parents' behavior with their toddlers and young children for the development of different attitudes towards Math.

A Hierarchical View of Grounded, Embodied, and Situated Numerical Cognition

Prof. Martin H. Fischer, University of Potsdam

There is much recent interest in the idea that we represent our knowledge together with the sensory and motor features that were activated during its acquisition. This talk reviews the evidence for such “embodiment” in the domain of numerical cognition, a traditional stronghold of abstract theories of knowledge representation. The focus is on spatial-numerical associations, such as the SNARC effect (small numbers are associated with left space, larger numbers with right space). Using empirical evidence from behavioral research, I first describe sensory and motor biases induced by SNARC, thus identifying numbers as embodied concepts. Next, I propose a hierarchical relationship between grounded, embodied, and situated aspects of number knowledge. This hierarchical conceptualization helps to understand the variety of SNARC-related findings and yields testable predictions about numerical cognition. I report several such tests, ranging from cross-cultural comparisons of horizontal and vertical SNARC effects (Shaki & Fischer, 2012) to motor cortical activation studies in adults with left- and right-hand counting preferences (Tschentscher et al., 2012). It is concluded that the diagnostic features for each level of the proposed hierarchical knowledge representation, together with the spatial associations of numbers, make the domain of numerical knowledge an ideal testing ground for embodied cognition research.

The Language-Learning Brain – the How, When and Where of Processing Newly Learned Language in Adults

Dr. Annika Hultén, Max Planck Institute for Psycholinguistics, Nijmegen

The human language-learning ability persists throughout life, indicating considerable flexibility at the cognitive and neural level. This ability spans from expanding the vocabulary in the mother tongue to acquisition of a new language with its lexicon and grammar. My research suggests that newly learned words seem to get well integrated into the existing mental vocabulary, and that is novel the mental representation can be very stable up to 10 months later. Moreover, by quantifying neural processing in the temporal lobe we can distinguish between short- and long-term phonological encoding. An essential goal of foreign language-learning is to be able to use it for carrying a conversation. This goes beyond phonological and single word-level knowledge, as words need to be combed into meaningful utterances according to the grammatical rules of the new language. In the final part of the talk I describe the neural correlates underlying production of short utterances that entail using a novel morphosyntactic structure.

**On-line Processing of Magnitudes in Language:
Insights from ERP Studies Using Quantifier Statements**

Prof. Hartmut Leuthold, University of Tuebingen

Inferred magnitudes for quantifiers such as many, a few, hardly any, not many, depend on the sentential and discourse context in which they are used. Previous studies indicate that positive (e.g. many) and negative (e.g. not many) quantifiers cause readers to focus on different sets of entities. For example, in *Many of the fans attended the game*, focus is on the fans who attended (the reference set), and subsequent pronominal reference to this set, as in *“Their presence was a boost to the team”* is facilitated. In contrast, if many is replaced by not many, focus shifts to the fans who did not attend (the complement set), and reference to this set, as in *“Their absence was disappointing”* is preferred. I will discuss evidence from event-related brain potential (ERP) studies regarding the on-line processing of sentences containing such quantifier statements. Together with some other ERP evidence, it appears that information provided by quantifier expressions is rapidly integrated with world knowledge during sentence comprehension. In perspective, I suggest that such a neurocognitive approach also promises to advance our understanding of the development of magnitude processing in children.

Titles Posters

SESSION A

Strategies in Number Line Estimation: Task Dependency and the Influence of Skills

Julia Bahnmueller, PhD student
University of Tuebingen

Lifetime Development of Spatial-Numerical Associations

Krzysztof Cipora, PhD student
Jagiellonian University, Krakow

Towards a Generalized Parallel Componential Processing Account for Multi-Symbol Numbers: Eye-Tracking Evidence from the Sign-Decade Compatibility Effect in Negative Numbers

Sonja Cornelsen, PhD student
Hertie-Institute for Clinical Brain Research, University of Tuebingen

The SNARC Effect and its Relationship to Spatial Abilities in Women

Carrie Georges, PhD student
University of Luxembourg

Different Brains Process Numbers Differently: Structural Bases of Individual Differences in Spatial and Non-Spatial Number Representations

Florian Krause, PhD student
Radboud University of Nijmegen

Estimation Abilities of Large Numerosities in Preschool Children

Dr. Sandrine Mejias

University of Luxembourg

Stable Numerosity Representations Irrespective of Contextual Task

Changes in Macaque Prefrontal Cortex

Maria Moskaleva, PhD student

University of Tuebingen

Titles Posters

SESSION B

Simulating Effects of Cognitive Control in Two-Digit Number Processing

Stefan Huber, PhD student

Knowledge Media Research Center, Tuebingen

Training the Equidistance Relation of the Mental Number Line

Tanja Link, PhD student

University of Tuebingen

Multiplication Facts and the Mental Number Line - Evidence from Unbounded Number Line Estimation Task

Regina Miriam Reinert, PhD student

University of St.Gallen/Center for Disability and Integration (CDI-HSG)

Magnetoencephalographic Signatures of Numerosity Discrimination in Fetuses and Neonates

Franziska Schleger, PhD student

fMEG Center Tuebingen

Principles in Finger-Number Associations: Related but not the Same

Mirjam Wasner, PhD student

University of Tuebingen

Spatial Interferences in Mental Arithmetic: Evidence from the Motion-Arithmetic Compatibility Effect

Michael Wiemers, PhD student
Radboud University of Nijmegen

Individual Differences in Solving Arithmetic Word Problems

Dr. Sabrina Zarnhofer
University of Graz

Costs: There is no conference fee. For outside PhD students up to 50 Euros will be refunded for accommodation.

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