The MathChild study: An introduction

I. Friso-van den Bos[1], I. Xenidou-Dervou[2], L.P.M. Essers[3], E.H. Kroesbergen[1], M. van der Schoot[2], E. van Loosbroek[3], E.C.D.M. van Lieshout[2], L.M. Jonkman[3], & J.E.H. van Luit[1]

Address of correspondence: i.vandenbos@uu.nl. 1: Department of Pedagogical and Educational Sciences, Utrecht University. 2: Department of Special Education, VU Amsterdam. 3: Department of Cognitive Neuroscience, Maastricht University.

Children start developing number skills at an early age, a long time before they start learning formal mathematics. Their ability to reason about number is not only important for school success, but also for later employability, productivity and wages[1, 2, 3]. The MathChild study investigates 5 to 8 year-old children's development of early mathematical abilities in a longitudinal, interdisciplinary study. It has previously been suggested that screening children at a young age can be used to predict later achievements and guide interventions that remediate problems before children fall seriously behind in school[4, 5]. Three part-projects are being executed: 1) longitudinal predictors (math-specific and general ability) of the development of math knowledge, 2) the development of mental number representation in young children and the neurological correlates, and 3) training of cognitive skills and number sense in low math performers. The three part-projects are linked by the topic of research in the domain of transition from non-symbolic into symbolic mathematics, shared concepts, such as working memory and number sense, and instruments.

Literature references:
1. Bishop, J. H. (1989). Is the test score decline responsible for the productivity growth decline? *American Economic Review, 79,* 178-197. 2. Boissiere, M., Knight, J. B., & Sabot, R. H. (1985). Earnings, schooling, ability, and cognitive skills. *American Economic Review, 75,* 1016-1030. 3. Rivera-Batiz, F. L. (1992). Quantitative literacy and the likelihood of unemployment among young adults in the United States. *Journal of Human Resources, 27,* 313-328. 4. Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematical difficulties. *Journal of Learning Disabilities, 38* (4), 293-304. 5. Jordan, N. C., Glutting, J., & Ramineni, C. (2009). The importance of number sense to mathematics achievement in first and third grade. *Learning and individual Differences, 20* (2), 82-88.

Part project VU Amsterdam

The MathChild part-project situated at the VU Amsterdam, "Understand & Predict", examines the development of children's math skills from a cognitive perspective. They aim to understand the early math-specific and non-specific cognitive predictors which underlie the development of children's math skills[1]. They study non-specific predictors such as working memory capacity, executive functioning, intelligence and math-specific such as number sense, nonsymbolic approximate skills and counting strategies. Three general research questions will be examined: Which early cognitive variables predict later mathematical achievement? Does the power of the cognitive predictors change over grades? Is the predictive pattern different for different math problem formats? These questions will be examined in a longitudinal study by assessing the development of several cognitive skills of children from 5 to 8 years of age.

1. Mundy, E., & Gilmore, C. K. (2009). Children's mapping between symbolic and nonsymbolic representations of number. *Journal of Experimental Child Pychology, 103*, 490-502

Part project Maastricht University

The MathChild part-project executed at Maastricht University focuses on the mental representations of quantity and their relation to mathematical proficiency. It has been proposed that problems in mathematics are due to imprecise mental representations of number symbols[1]. On the other hand, more general brain processes also seem to play a possible role[2]. With the use of the brain imaging method EEG it is investigated: 1) which brain processes underlie the representations of symbolic and non-symbolic quantities, 2) whether they explain the relation with mathematical proficiency and whether they are number-specific, 3) how children's knowledge of magnitude is related to their knowledge of counting order, and 4) to what extent the more efficient representations of the number line are related to different cognitive functions. For all these purposes, ERP data are analysed to gain insight in the mental representations and mappings in the frontal and parietal-occipital areas of the brain.

1. Holloway, I. D., & Ansari, D. (2009). Mapping numerical magnitudes onto symbols: The numerical distance effect and individual differences in children's mathematics achievements. *Journal of Experimental Child Psychology, 103,* 17-29. 2. Van Opstal, F., Gevers, W., De Moor, W., & Verguts, T. (2008). Dissecting the symbolic distance effect: Comparison and priming effects in numerical and nonnumerical orders. *Psychonomic Bulletin & Review, 15,* 419-425.

Part project Utrecht University

The MathChild part-project conducted at Utrecht University focuses specifically on the proximal causes of learning problems in mathematics. Previous studies have shown that the most important precursors of mathematics proficiency in elementary school are number sense and working memory[1]. Using an experimental design, the causal relations between early mathematics and number sense, and between mathematics and working memory are investigated. The experiments consist of trainings directed at: 1) number sense, and 2) working memory which will be given both in Kindergarten and First Grade. Hypotheses include that both proficiencies can be improved by training, that proficiency in these skills generalises towards proficiency in mathematics, and that both working memory and number sense are prerequisites for the successful acquisition of mathematics skills. In addition, a comparison between the effectiveness of early and later intervention will be made.

1. Passolunghi, M. C., Vercelloni, B., & Schadee, H. (2007). The precursors of mathematics learning: Working memory, phonological ability and numerical competence. *Cognitive Development, 22,* 165-184.

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