Description for the General Public

Non-Symbolic and Symbolic Numerical Representations, Cognitive Abilities, and Mathematical Achievement in Preschoolers and Early School-Aged Children

The discovery that even infants can possess the ability to non-symbolically represent numbers was a breakthrough in understanding how humans acquire and develop the concept of numbers and the importance of basic numerical abilities in predicting later success in mathematics. Although research on the relationship between non-symbolic and symbolic numerical representations and mathematical achievement in preschool and early school-age children has been conducted for several years, the results on this matter are inconsistent. Indeed, previous findings indicate that non-symbolic, symbolic, or both numerical representations may or may not be predictors of mathematical achievement in early school age. Some researchers propose that the discrepancies in results may stem from methodological differences in conducted studies, specifically the unknown psychometric properties of tasks measuring both representations of numbers, as well as the control (or absence thereof) of children's domain-general cognitive abilities in assessing the significance of numerical representations in predicting mathematical outcomes. We aim to examine these issues in two studies among preschool and early school-age children.

Study 1/ The first research objective of the project is to establish the psychometric properties of tasks measuring non-symbolic and symbolic numerical representations in preschoolers. Among the most commonly used tasks to measure both representations of numbers are comparing and estimating the numerosity of sets and Arabic numerals. Researchers use various task indicators: e.g., accuracy, total estimation error, reaction time, and *w* (individual Weber's fraction). We intend to answer whether different task indicators are related to each other, and thus whether tasks and indicators can be used interchangeably. Since previous research results are inconsistent regarding whether non-symbolic and symbolic processes are associated or independent, the results of the planned study will contribute to this discussion. We also want to address whether results obtained in the most popular tasks measuring numerical representations among children are stable over time. To achieve these goals, we have planned a study in which we will test 160 preschoolers twice, establishing relationships between tasks and their indicators as well as the test-retest reliability.

Study 2/ The second research objective is to test cognitive predictors of numerical representations and **the third research objective is to test numerical representations as longitudinal predictors of mathematical achievement (with and without control of domain-general cognitive abilities) in a longitudinal study of 400 children from the last year of preschool to the end of the second grade of primary school.** Although some researchers suggest that non-symbolic and symbolic processing of numerical magnitudes is essential for mathematical achievement, others disagree. Previous research results suggest that the strength of the relationship between numerical representations and mathematical achievement decreases when domain-general cognitive abilities are controlled in the study. Interestingly, it is unclear to what extent domain-general cognitive abilities explain the variance in symbolic and non-symbolic numerical representations, so we want to check that. Few studies have taken into account a wide range of domain-general cognitive abilities in a longitudinal study. Therefore, we will check whether based on both numerical representations, it is possible to predict the level of mathematical achievement half a year, a year, one and a half years, and two years later, when domain-general cognitive abilities (visual perception, cognitive control, intelligence) are controlled for. Thus, the second study will answer the research question with implications: What should be focused on in the preschool period to support children in developing future mathematical skills – whether it is better to develop symbolic or non-symbolic numerical representations, domain-general cognitive abilities, or both?