DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

Low numeracy skills leading to research questions

Math disability is a problem not only from the viewpoint of people who know it from their daily experience, but it also matters for their parents, teachers, and then e.g. employers. Therefore, these difficulties (in some cases extremely severe and defined as developmental dyscalculia) can be seen as an issue of social or even economic importance. Research exploring causes of such deficits has shown that the problems cannot be blamed on laziness, socioeconomic status or teaching practices exclusively. Although impact of these factors is unquestionable, today we also know for sure that problems such as dyscalculia have well specified neurobiological basis. There have also been attempts to assess effectiveness of various ways to overcome such deficits, for instance methods based on computer-assisted cognitive trainings. Yet, despite the gravity of the mathematical difficulties and a large body of literature, no publication has yet reported well-designed experimental studies, on the one hand providing a comprehensive picture of the anatomy and functioning of the brain in people experiencing such difficulties and, on the other hand, exploring the relationships between math skills training and possible changes in performance and in the structure, connections and patterns of neural activation.

Brain basis of numerical processing

Given the above, in accordance with one of its objectives, the proposed project is designed to provide a comprehensive picture of the structure and functional organization of the brain in children with learning difficulties in mathematics and to enable comparison with the function and anatomy of the brain in normally developing peers. This will be accomplished with the use of magnetic resonance imaging method which, in addition to measuring brain activation during performance of various tasks involving certain mental processes (in this case, comparison of number magnitudes), makes it possible to examine the density of white and gray matter in particular regions, and to analyze the connections between brain structures. In the first part of the study, two groups of children aged 8-10 years will participate: these showing serious problems in mathematics and a healthy group. Then, the research team equipped with detailed knowledge of brain organization in the children from both groups will proceed to the second stage of the study.

Computer-aided training of mental number line

The goal at this stage is to investigate possible changes in the structure and functioning of the brain in children with low numeracy skills, after they participate in a specially developed computer training. It is designed to train the mental processes underlying the development of mathematical abilities. To identify the effects of the training, another group of children with math disability will be subjected to brain examination, and will perform a series of computer tasks enabling measurement of the basic mathematical abilities, i.e. comparison of numbers given in various formats in terms of their magnitude, numerosity estimation and estimation of the number's position on the line. Then the participants will be assigned to 3 training groups. Some children will use a computer training program designed to strengthen the mental representation of the number line with the help of touch screen monitor. The second group will follow the same training program, but in order to perform the tasks they will be required to move their arms, which will be recorded by Kinect sensor. The third group will receive the same training as the first one, yet the tasks will carry no numerical information. The mental number line training is in the form of computer game, which is attractive for children. The participant's task is to navigate a spaceship and overcome mountain-shaped obstacles appearing in its way by recognizing numbers and localizing them on the number line displayed on the screen.

What does the training change in the brain?

The training will be divided into ten 30-minute sessions, after which the children will again be subjected to brain examination and will perform a set of tasks assessing their math ability. This will be done in order to compare the results of examinations performed before and after the training, so that it can be determined whether, and to what extent, the training has improved the level of basic math skills and whether it has changed the pattern of brain organization towards that which is observed in healthy children. This way, the proposed project will make it feasible to use a single experimental study to determine all aspects of the neuronal underpinnings of math skills and the related disorders, and to identify the nature of changes in the level of performance and in the brain organization prompted by computer-aided training of mental number line.