Pearson

ARTICLE REVIEW:

Mental Number Line Training of Children With Developmental Dyscalculia

Kucian, K., Grond, U., Rotzer. S., Henzi, B., Schönmann, C., Plangger, F., . . . von Aster, M. (2011). Mental number line training in children with developmental dyscalculia. NeuroImage, 57(3), 782–795.

A growing body of research advocates the importance of the number line as a mechanism for helping children develop greater flexibility in mental arithmetic. It is an essential tool for actively constructing mathematical meaning, number sense, and the understanding of number relationships. An internal representation of a correct linear number line is fundamental for the development of more complex arithmetic abilities. As cited in the article, individual differences in children's learning of the linear, mathematical number line have been correlated with mathematics achievement across grades. Specifically, the level of development of the internal representation of the number line in positively related to academic performance in mathematics.

Study Design

Kucian et al. investigated whether or not children with developmental dyscalculia (DD) would improve their internal representation of numbers and, consequently, show better performance on mathematical tasks after completing computer-based training. Sixteen children with DD, mean age of 9.6 years and sixteen age-matched control children participated in the study. None of the children in either group were identified as having neurological or psychological disorders. Because the more sophisticated spatial representation is assumed to rely on a linear number representation, the authors hypothesized that children would show improvement on a number line task, as well as other measures of mathematical performance. The authors postulated that the training leads to an alteration of activation patterns in the brain, including frontal and parietal areas. On the one hand, the parietal lobe underpins neurologically based mechanisms like attention, working memory and other cognitive resources. On the other hand, the frontal lobe hosts the most specific brain center for estimation abilities and numerical understanding. The training is expected to influence both processes antithetically, inducing a general reduction of brain activation, but also fostering an increase in activation if there is an initial impairment as found in children with dyscalculia.

The computer-based training "Rescue Calcularis" was used to train children in spatial understanding of numbers and automated access to the internal mental number line, including:

- an improved association between representations of numbers and space,
- the understanding of the ordinarily of numbers,
- estimation, and
- mathematical skills.

continued

A pre/post evaluation was done to evaluate the impact of training on DD children and the control group. Each student group completed the mathematical tasks and measures prior to training. Children received training for five weeks and then researchers measured performance. To evaluate training success, a group of children with DD and a control group of cohorts who exhibit developmentally appropriate mathematical skills completed measures of number line processing, arithmetic accuracy, and numeric tasks. Children with DD also were assessed with brain imagery (Functional MRI or fMRI).

Summary

This study examined the impact of training with an early version of Calcularis on children with DD. The study focused on evaluating the program's success in facilitating the development of an internal representation of a spatial and linear number line in children with DD.

- **The study added to the body of research that supports the linearity of the conceptual number line over a logarithmic representation and that Calcularis helps facilitate its development.**
- **Calcularis training helped children with DD and children in the control group improve on their overall mathematics performance.** When performance on specific areas of mathematical skills (linearity and variability of number line development) was evaluated, training had a greater impact on children with DD. Their performance after training approximated that of their control cohorts in those areas.
- **The DD group's performance on number line tasks improved significantly.** The number of errors in these tasks decreased by an average of 27%.
- **Positive training effects seem to persist for at least 5 weeks after training.** Children' performance increased significantly after training and maintained stability until the follow-up testing session.
- **The brain imaging effects indicated that after five weeks of training, mathematical tasks used in the study put less demand on quantity processing, executive functions, working memory, and required less attentional effort.** There also was a larger decrease in recruitment of these regions in children with dyscalculia, which is consistent with the more significant improvement on math performance by these children.

The study supports the idea that computer-based training can be used to improve children's performance of mathematical tasks, with an even greater effect on children who struggle with math. The study also found, through the use of a questionnaire, that all children (DD and control groups) liked participating in the game-based training and were able to use the Calcularis without help from their parents. The popularity of the games supports engagement and motivation, which are powerful tools in ensuring student participation and fidelity.

Pearson