Math anxiety and mathematical achievement

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Does math achievement reflect subject anxiety, cognition, or a number sense?

High mathematical achievement is a desirable goal. Children with low levels of mathematical skills at the start of education have more mathematical difficulties later. So, it is very important to pay attention to the diagnosis of factors underlying the differences between children when learning mathematics at the very beginning of school.

Math Anxiety, Working Memory, Number Sense and Math Achievement

One of the factors limiting mathematical achievement in those years is math anxiety. Math anxiety is a negative emotional reaction to mathematics: one that cannot be fully explained in terms of more a general anxiety trait. In previous studies it has been shown that children with high levels of math anxiety have lower mathematical achievement compared to children with low levels of math anxiety. And yet other international studies have shown a *negative* relationship between these two variables. So, it remains unclear just how math anxiety does impair mathematical achievement in young children.

To answer this question, I conducted two studies recruiting large groups of Polish early school age children. The results I presented came from cross-sectional and longitudinal studies conducted with first to third grade Polish children. The studies were conducted in a large city (Kraków) and most of the children came from families with good socio-economic status. The results come from *correlational* study, which means that no confident conclusions about *causality* can be drawn.

My research method

All children were tested individually. The cross-sectional study consisted of two sessions (at the start and the end of the school year in first, second, and third graders). The longitudinal study consisted of four sessions (at the start, the middle and the end of the first grade and the end of the second grade). I used the following scales to measure variables of concern:

– Math anxiety – the Math Anxiety Questionnaire for Children to measure both general and math-specific anxiety in the form of interview with children.

– Working memory – Two tasks were used to measure verbal and nonverbal working memory: the Digit Span Backward task from the Wechsler Intelligence Scale for Children-Revised and the Corsi Block Tapping Task. Both measure how many elements a child can remember and recall.

– Number sense – the non-symbolic and symbolic comparison tasks measure ability to estimate and compare numbers and numerosities. Although there are many definitions of number sense (and tasks to measure it), it is generally believed that the greater the basic numerical ability, the greater the chances of success in mathematics.

– Mathematical achievement – Self-prepared mathematical tasks based on the core curriculum for elementary schools and mathematical education materials as recommended in Poland. The tasks measured (depending on grade level): knowledge of numbers, counting, discovering rules, knowledge of geometric figures, spatial orientation, addition and subtraction, knowledge of money, reading a tape measure, multiplication and division, and clock reading.

Some assumptions

I assumed that math anxiety could impair general *working memory* resources and thereby lower math performance. On the other hand, I also hypothesized that high *number sense* acuity may be a protective factor against the negative effect of high math anxiety on math performance. Finally, I tested whether math anxiety *directly* impairs math achievement level. If that were the case, it would mean that even low math anxiety is a sufficient factor to lower math outcomes at the start of learning.

What I found

Findings indicated that indeed, math anxiety affects working memory resources and in turn it therefore impairs mathematical achievement. This result is interesting because most of these children experienced a low level of math anxiety. Which means that quite low levels of math anxiety may be enough to have a negative effect on math performance. In other words, children’s worry that they may not be able to cope with mathematics may

be a sufficient reason for not coping with tasks. In effect, ‘ruminations’, i.e., ongoing and persistent doubts about the correctness of a task, burden some of the individual’s cognitive resources – including those needed to perform mathematical tasks and this decreases effectiveness for completing tasks.

The second hypothesis was not confirmed. This means that having high acuity in number sense is insufficient as a factor for protecting against the negative effects of math anxiety on achievement. On the other hand, it also means that children with a low level of number sense acuity are not more exposed to negative effects of math anxiety on math performance compared to children with high number sense acuity.

The third hypothesis (that considered a direct negative effect of math anxiety on math achievement) was not confirmed. Although the results of my research did not explore reasons for this, it can be assumed that the lack of a direct path between math anxiety and math achievement results from low level of math anxiety in young children. This hypothesis is based on other research results, conducted in adults, where a direct path *was* observed. It is possible that in adults a direct path is due to a high level of math anxiety that results from years of math avoidance. Young children have not had such experiences – they mostly engage math learning and may enjoy math classes.

Additionally, the obtained results show that math anxiety, working memory, and number sense altogether explained many of the differences between children in mathematical achievement (around 30–50% of the variance). This means that all these mentioned factors are important predictors of math performance. Therefore, a lower level of math anxiety and higher levels of working memory and number sense are each related to a higher level of math achievement in young children.

Practical Tips for Teachers and Parents

Current research suggests that it is helpful for teachers and parents to undertake appropriate actions to overcome math anxiety, improve working memory resources and number sense acuity – all in the interests of advancing mathematical achievement.

Taking into account that feelings of anxiety burden working memory resources and then negatively affect math performance, it is important to prevent the development of math anxiety in young children. Young children may initially feel low levels of math anxiety but during the years of education the level of such anxiety increases. Since even a low level of math anxiety may have a negative effect on the cognitive resources and achievements of children, an *increase* in math anxiety in the future may only exacerbate such negative effects. Some previous studies have shown that expressive writing about negative experiences and feelings related to mathematics may be effective in reducing intrusive thoughts about math and consequently increase the performance of mathematical tasks in those with high levels of math anxiety.

Although number sense is not a protective factor for the negative effect of math anxiety on math achievement, this does not mean that it is insignificant. Acuity of number sense is independently related to mathematical achievement. Children who know number well and distinguish numerosities correctly, have better mathematical outcomes. In other words, if children have some basic mathematical skills in place, it is easier for them to develop new mathematical skills. Thus, effectively supporting the development of math skills contributes to lowering math anxiety and avoiding math difficulties in the future.

My previous study conducted in early school age children also revealed some reasons for children's math anxiety. Children reported that they feel anxiety because of (1) the negative reactions of others (e.g., noise or laughter from teachers, parents, classmates), (2) the sheer difficulty of mathematical tasks, (3) insufficient time to resolve math problems, and (4) bad grades. These observations suggest some directions for teachers' and parents' actions.

First, the learning atmosphere should be free from negative reactions from other people. Children who feel incompetent or humiliated, do not want to get involved in activities that they believe they do not do well. Simply avoiding mathematics, however, causes difficulties that get worse later. Second, providing children with medium-difficulty tasks (not too easy and not too difficult) may positively affect their self-esteem and can thereby motivate them to further constructive actions. Moreover, children's working pace may vary and therefore it will be important to allow them work at her/his own preferred pace. Finally, mistakes should be treated as a part of *learning* process and become a chance for future development.

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