Journal of Research in Science, Mathematics and Technology Education

Volume 1, Issue 1, 47 - 61

ISSN: 2577-6789

http://www.estej.com/

Children Anxiety towards Mathematics: A Selective Bibliographical Review for Mathematical Education

Raquel Fernández Cézar[1]

Universidad de Castilla La Mancha, SPAIN

Received: December 13, 2017 ▪ Accepted: January 8, 2018

Abstract: Anxiety towards mathematics is a crucial aspect influencing children cognition, and so children comprehension of any mathematical concept. In this paper it is presented a bibliographical review of the research on this issue in the last century. All the papers are authored by researchers from fields such as psychology or neuropsychology, and none from mathematical education. The conclusion emphasizes that more collaboration between these researchers and mathematical educators is needed in order to design elementary mathematics programs, to implement instruction and to improve children mathematical education.

Keywords: *Literature review; Mathematics anxiety; Primary education; Young children.*

To cite this article: Fernández-Cézar, R. (2018). Children Anxiety towards Mathematics: a selective bibliographical review for mathematical education. *Journal of Research in Science, Mathematics and Technology Education*, *1*(1), 47-61. doi: 10.31756/jrsmte.113

Introduction

It is common knowledge the depletion of enrollment in Science, Technology, Engineering, and Mathematics (STEM) careers in the western world. Because all the STEM majors do have mathematics as subject, it is crucial to understand the emotions that mathematics creates in individuals, particularly as students. These emotions can be negative, such as aversion, and can also be general when facing whatever mathematical issue, and not only constraint to the academic environments. As a consequence, if students experience mathematics situations as especially challenging, regardless their general level of competencies (Ashcraft, Krause, & Hopko, 2007, cited in Eden, Heine, & Jacobs, 2013; Hembree,

[1] **Corresponding author:** Raquel Fernández-Cézar
Email: raquel.fcezar@uclm.es

1990), it would influence also their professional success. The end loop ends with adults avoiding mathematics situations and fostering negative emotions towards mathematics, which, unfortunately, is often enhanced or reinforced by their social context (Beilock, Gunderson, Ramirez, & Levine, 2010). The emotions are part of the affective domain, considered by experts (McLeod, 1994; Baroody & Cooslick, 1998) composed by other two factors, beliefs and attitudes. Among the attitudes, anxiety is the most determinant factor in the learning and mastery of mathematics (Picos, Alonso, Saez, & del Rincón, 2013). Anxiety is highly linked with achievement and with future academic elections, in such a way that high levels of anxiety associate with low mathematics achievement and avoidance of mathematics-associated careers (Wu et al, 2012).

Anxiety towards mathematics was initially described as *mathemaphobia* by a teacher (Gough, 1954, cited in Eden, Heine, & Jacobs, 2013). Richardson and Suinn (1972) described mathematics anxiety as involving "… feelings of tension and anxiety that interferes with the manipulation of numbers and the solving of the mathematical problems in a wide variety of ordinary life and academic situations". Although this phenomenon has gained attention from the scientific community and the cognitive consequences for the individual and his or her development has been investigated, the main body of the empirical research is performed with young adults at the end of the formal schooling. Consequently, provided that most of the detrimental effects of math anxiety are not reversible at this time, and in order to gain a deeper understanding of biasing factors, research on the impact of math anxiety in children was needed.

The timeline of this research shows that, at the end of the last century, there was a scarce number of empirical studies devoted to math anxiety in children (just 1 in 2001), but, fortunately, it has been overcome in the 21st century, when a wide number of papers emphasizing children math anxiety have been produced (Dowker, Sarkar & Looi, 2016). Consequently, children mathematics anxiety is identified as a concern for mathematics learning by specialist, but unfortunately mainly psychologist, psychiatrist and medical doctors rather than mathematics educators. Currently, with the development of neuro-psychology and neuroscience, the brain connections between emotions and cognition are being determined (Young, Wu & Menon, 2012). Mathematics anxiety influences children cognition, and so children comprehension of any mathematical concept. Since the studies of Piaget, Inhelder and Szeminska (1960), the ages about 7 years have been considered crucial in the development of children, which includes the abstract operations, of vital importance in the learning of mathematics.

Having all that in mind, the purpose of this paper is to explore bibliography in order to determine neuropsychological causes and effects of anxiety towards mathematics in children aged from 7 to 12 years. The age period is chosen because fits the elementary/primary stage of education in most of the educational systems, therefore it is crucial to have this information for mathematics education researchers.

Methodology

This report mainly explores the Web of Science (WOS), Core Collection, searching for the papers published from 2000 to 2017 including the words anxiety, mathematics and children in the title. The chose papers are those devoted to children aged from 7 to 12 years. The analysis of the information is performed in terms of the mathematics anxiety construct; the instruments used to measure it; the influence, if any, of the children context; the mathematical concepts used to test achievement and its possible relation to mathematics anxiety.

Regarding the neuropsychological effects of math anxiety in children, the scope of the search needed to be widened, by considering the words mathematics and anxiety in the title, devoted to explaining that in 7-12 years children.

Results

Despite the crucial role of MA in cognition, it is not abundant the number of papers from the mathematics education community dealing with this issue. The papers found in WOS fulfilling the searching criterion are included in Table 1, ordered by publication year.

Table 1
Papers in the WOS including Mathematics, Anxiety and Children in the title devoted to children of ages between 7 and 12 years, published from 2000 to 2017

Title	Author/s	Publication journal / year
A Confirmatory Factor Analysis of the Mathematics Anxiety Scale for Children	Beasley, T. M., Long, J. D., & Natali, M.	Measurement and Evaluation in Counseling and Development, 2001
Mathematics Anxiety in children with developmental dyscalculia	Rubinsten, O., & Tannock, R.	Behavioral and Brain Functions, 2010
From Parental Involvement to Children's Mathematical Performance: the Role of Mathematics Anxiety	Vukovic, R. K., Roberts, S. O., & Green Wright, L.	Early Education & Development, 2013
Mathematics Anxiety in Young Children: an Exploratory Study	Harari, R. R., Vukovic, R. K., & Bailey, S. P.	The Journal of Experimental Education, 2013
Mathematics Anxiety in Young Children: Concurrent and Longitudinal Associations with Mathematical Performance	Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R.	Contemporary educational psychology, 2013
Effects of Mathematics Anxiety and Mathematical Metacognition on Word Problem Solving in Children with and without Mathematical Learning Difficulties	Lai, Y., Zhu, X., Chen, Y., & Li, Y.	PLoS ONE, 2015
Children's Mathematics Anxiety and its Effect on their Conceptual Understanding of Arithmetic and Their Arithmetic Fluency	Price, J. A. B.	Doctoral dissertation, Faculty of Graduate Studies and Research, University of Regina, 2015
Interactivity Defuses the Impact of Mathematics Anxiety in Primary School Children.	Allen, M., & Vallée-Tourangeau, F.	International Journal of Science and Mathematics Education, 2016
Mental arithmetic Performance, Physiological Reactivity and Mathematics Anxiety amongst UK Primary School Children	Hunt, T. E., Bhardwa, J., & Sheffield, D.	Learning and Individual Differences, 2017

From the point of view of neuropsychological explanation of math anxiety, the searching produced the papers found in table 2.

Table 2
Papers focusing on neuropsychological causes of MA, with Mathematics and Anxiety in the title devoted to children of ages between 7 and 12 years.

Title	Author/s	Publication journal / year
The Neurodevelopmental basis of Math Anxiety	Young, C. B., Wu, S. S., & Menon, V.	Psychological Science, 2012
Math Anxiety in Second and Third Graders and its Relation to Mathematics Achievement.	Wu, S. S., Barth, M., Amin, H., Malcarne, V., & Menon, V.	Frontiers in Psychology, 2012
Math Anxiety, Working Memory, and Math Achievement in Early Elementary School	Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L.	Journal of Cognition and Development, 2013

The Construct of Mathematics Anxiety in Children

The only study found in this review is the one authored by Harari, Vukovic and Bailey (2013) where the nature of mathematics anxiety is explored. The work is performed with a sample of 106 first-grade children which are linguistic and ethnically diverse. An exploratory factor analysis indicated that mathematics anxiety in this sample is a multidimensional construct which includes negative reactions. The construct comprises specifically fundamental mathematical concepts; numerical confidence respecting computation skills; and worry, without relationship with any outcome. The factors sex or language background did not influence on the level of mathematics anxiety. In this sample, the most striking dimensions are the negative reactions and the numerical confidence.

The higher or lower levels of mathematics anxiety in young children seems to be based in foundations of mathematical education, which involves not only the mathematical concepts, but also instructions and the educational systems as a whole. This last part being deeply influenced by culture and context.

Instruments Used to Test Mathematics Anxiety in Children

In all the reviewed studies (see Table 1) either of these two scales for Math Anxiety are used: the Math Anxiety Rating Scale for Children (MASC) validated to measure anxiety towards mathematics in 6th grade children, with the Cognitive Abilities Test as mathematical task (Beasly, Long, & Natali, 2001), or the Scale for Early Mathematics Anxiety, SEMA, validated for 2nd and 3rd graders (Wu et al., 2012) with magnetic resonance images with children facing word problems. Both presented validity, reliability and values of internal consistency good enough for the pursued purpose (Cronbach alpha > .9).

A deeper analysis of MASC is performed in Lai, Zhu, Chen, and Li (2015), where an exploratory factor analysis is presented. Two factors are found: Learning Mathematics Anxiety and Mathematics Evaluation Anxiety. The first factor corresponding to the learning or studying mathematics (for instance, attending a teacher lecture of mathematics or solving problem on the blackboard); and the second one, to evaluations of mathematic learning (for instance, test or surprise quiz in a mathematics class). As far as we know, these two factors are not mentioned in any other study.

Children Anxiety Towards Mathematics, Achievement and Context

The children social context is reflected by the country the study is carried out at, and the geographical region this country belongs to. Most of the papers report on studies carried out in western countries, among which the majority are corresponding to USA. The rest are spread out between different European countries, Asia and just a few from Middle East. In none of them is found the analysis of the context on MA for children of the target ages. The closest situations are the study performed by Lee (2009) with PISA results, involving young students of about 15 yr and not 7 to 12 year old children, and the more recent work of Morony, Kleitman, Lee and Stankov (2013) where not only the math achievement is analyzed. Both works are included in the results because are out of the scope of this review. Nonetheless, in both reports inconsistencies between math anxiety and achievement regardless the cultural context are revealed.

Another cultural situation where differences could be observed is in ethnic varied contexts. The possible differences could emerge related to admit, or not, mathematics anxiety and its possible relation to mathematics achievement. Vukovic, Roberst and Wright (2013) analyzed the role of parental support as mediator between anxiety towards mathematics and achievement, reporting that it acts as mediator, improving achievement and reducing mathematics anxiety, when dealing with specific mathematics concepts, word problem solving and algebraic reasoning; on the contrary, it does not act as mediator for whole number arithmetic.

The picture of the situation involves, first of all, the absence of enough sociocultural studies with primary education children that could stablish whether the differences in anxiety and its relation to achievement could be rather related to test anxiety, or even to other cultural factors, such as unspecified aspects of curricula or national educational systems, still undetermined. Secondly, to deeper analyze whether the differences observed in ethnic minority groups could be related to socio-economic status rather than to race.

Mathematic Concepts Used to Test the Anxiety

Arithmetic calculations:

Michael & Vallee-Tourangeau (2016) present a study carried out with 59 primary school students of 5th or 6th grades, aged between 9 and 11 years, recruited from 5 different schools in Ireland. It was performed under the hypothesis that Math Anxiety (MA) impedes performance in simple arithmetic tasks and that anxiety constrains working memory capacity, and other attentional functions of the central executive brain. In this report, the authors designed an experiment to explore how interactivity mitigated the impact of MA on the performance of elementary school students. The mathematical task used were simple additions. In the experiment, two independent variables were manipulated: the length of the additions (from 7 to 11 digits), and the level of interactivity. The length of the addition had an impact on calculation accuracy in such a way that longer additions contributes to worsen performance. However, the level of interactivity entails outstanding performance, regarding efficiency and accuracy in calculations. Mathematics anxiety results as a predictor of performance, but only in the low interactivity condition. Finally, these authors observe that working memory is augmented by the interactivity with the physical problem representation, smoothing the impact of anxiety on performance.

The impact of MA on performance and achievement in arithmetic calculations is also proved in other study carried out with students with developmental dyscalculia facing tasks affectively primed as an indirect measure of MA (Rubinsten & Tannock, 2010). The authors worked with 23 children, 11 in the control group. The children faced primed simple mathematics task related with operations, whose answer was either true or false. The results show that children respond to target stimuli more quickly after facing an affectively-related prime than after facing one without involving any affective prime. Consequently, a direct connection between emotions, arithmetic calculations and poor achievement in math is proved. Moreover, arithmetic-affective priming might be used as an indirect measure of math anxiety.

Another way to measure MA is presented in the work of Hunt, Bhardwa and Sheffield (2017). The authors test the arithmetic skills of pupils respecting their MA. A mixed experimental design is developed with an opportunity sample of 77 primary school children (42 male and 35 female) from a primary school in the Midlands (U.K.), who performed mental arithmetic problems of increasing difficulty. The MA is measured in this report through psycho-physiological reactivity, with the record of measures such as heart rate, systolic blood pressure (BP) and diastolic BP along with behavioral measures of response time and error rate when children face mental arithmetic problems. MA was also self-reported. Results demonstrated a significant effect of problem type (level of difficulty), to the extent that the systolic BP is greatly increased between baseline and presentation of three-digit mental arithmetic problems. Further, self-reported math anxiety and physiological reactivity to harder mental arithmetic tasks were found to be positively correlated. Findings suggest that mental arithmetic may act as a stressor amongst children, in a similar way to adults, and indicate that an increase in problem size may induce heightened blood pressure amongst children. Furthermore, results highlight the potentially negative psychological and physiological reactions that pupils experience, particularly amongst children who are math anxious.

Since computation skills deal rather with calculations and algorithms a deeper research on MA and its relation to arithmetic comprehension was needed. To enlighten this relation, Price (2015) investigated the characteristics and development of children's MA (9-11 years old) and how it impacts their conceptual understanding and application of arithmetic. This study emphasizes comprehension of concepts, what results more interesting for the mathematics community. The work deepens in the learning process by investigating how children's MA impacts their arithmetic fluency when performing timed mathematics tests. On the other hand, the authors examined teachers' MA and how it may impact their students' MA, students conceptual understanding of arithmetic, and arithmetic fluency. The results showed that the higher the MA in children, the weaker their conceptual understanding of arithmetic, and the worse their arithmetic fluency. In particular, children's mathematics anxiety impacted in a greater extent on their arithmetic fluency, compared to the conceptual understanding of arithmetic tasks. It also showed a sex bias, provided that females had higher mathematics anxiety. However, grade was not a significant factor for MA. The exploratory analysis of teachers' mathematics anxiety did not affect their students' MA, conceptual understanding of arithmetic, or arithmetic fluency, contrary to what was expected. The authors proposed that, improve children's achievement, the future research should emphasize on early identification of MA, and on identification of the appropriate interventions for children and teachers intended to mitigate mathematics anxiety.

Word problem solving:

The most conclusive studies dealing with word problem solving (WPS) is the presented by Lai et al. (2015) and the one reported by Young, Wu and Menon (2012).

In the first one, the possible effects of MA and Math metacognition on word problem solving (WPS) is studied. The authors worked with 10-year-old Chinese children from three elementary schools, and tested the mediating effect of metacognition in the path from MA to WPS in 4 different categories of students, taking into account their learning achievement: high achieving (HA), typical achieving (TA), low achieving (LA), and exhibiting mathematical learning difficulty (MLD). They found, by using a structural equation model, that mathematical metacognition and MA predicted mathematics achievement in such a way that children with MLD reach poorer results in self-image and higher scores in learning mathematics anxiety (LMA) than the TA and HA children, but not in mathematical evaluation anxiety (MEA). MLD children's LMA was also higher that of children in the LA category.

In the second one, the brain response and connectivity while solving word arithmetic problems is investigated in 7 to 11 yr children. By using magnetic resonance imaging, the authors find brain activation differences between high mathematics anxiety (HMA) children and low mathematics anxiety (LMA) ones: the right amygdala is highly activated in HMA; consequently, a more effective connectivity between the right amygdala and brain areas associated with general anxiety is caused. On the contrary, between right amygdala and the brain region involved in numerical and math problem solving (posterior parietal cortex) is observed a poorer connectivity.

These results provide insight into how MA affect WPS, and the factors that may mediate poor WPS performance due to suffering pressure under mathematics situations. It is also suggested that mathematical learning difficulty interventions or programs should be designed encompassing the possible LMA cases, and should aim for preventing them.

Geometric reasoning:

In the longitudinal study reported by Vukovic, Kieffer, Bailey and Harari (2013), the effect of MA on math achievement and WM is examined. The math achievement is measured through geometrical reasoning tasks, among other mathematical tasks. The findings indicate that while MA is the cause of individual differences in achievement when children deal with calculations and other mathematical applications, it doesn't affect their geometrical reasoning.

Other Brain Functions Affected by MA

It has been realized in this review the enlightening that neuropsychology is bringing to the role of MA in mathematics learning concepts. However, in addition to the concepts to be learned, MA also influences the whole learning process by affecting the working memory (WM) and other executive brain functions. In the report of Ramirez, Gunderson, Levine and Beilock (2012), MA, WM and mathematics achievement is analyzed for the first time in early elementary school students. MA and math achievement negatively correlates for children who were higher in WM, but nothing is found for those who are lower in WM. The proposed explanation is that high WM individuals tend to produce solutions for the math tasks which involve WM-intensive strategies, and these strategies are altered when WM capacity is constraint by math anxiety.

In the longitudinal (2^{nd} to 3^{rd} grade students) study reported by Vukovic et al. (2013), the effect of MA on math achievement and WM is examined. The findings concur with those of the previous study in the regard that MA only affects children when performing tasks which involve higher levels of WM. The fact that high MA in second graders predicts lower achievement gains when in 3^{rd} grade is also found.

These results are important to be taken into consideration for mathematics educators, because they proved that mathematics anxiety may affect how some children deploy working memory to learn mathematical applications. Therefore, prevention and treatment (when needed) of MA is important because the anxieties that emerge at early ages may rise, and eventually, make students discard math courses and math-related career.

Discussion and Conclusions: Suggestions to Mathematical Education

Psychologist and neuropsychologist do used questionnaires to measure MA without controversies about whether it is a good way to measure it or not. It is well accepted inside their research community. On the contrary, in the mathematics education community some controversies emerge respecting the use of questionnaires. The time/results balance with questionnaires is widely proved in different research areas, and, with the precautions derived from statistical limitations that must be clearly indicated in each study, it is recommended in this revision: none of the studies reviewed use open questions to test MA.

To measure MA, SEMA and MASC have being the only validated scales with early age children. The two scales do show similar internal consistency, reliability and validity. Therefore whatever of the two would produce good measure of MA. Nonetheless, if differences between math anxiety when learning, and math anxiety when evaluating, would be measured, the use of MASC is suggested.

The effects of MA are not only reflected in achievement, but also in physiology: increasing BP. The effects on cognition and learning process are well documented through brain magnetic resonance: the right amygdala activation produced as a consequence of high MA levels inhibits several neuronal paths in the frontoparietal lobe, hindering the mathematical learning process as a result. The hyperactivity of the amygdala favors other paths, which are those that connect it with the brain areas activated in general anxiety situations. It opens the possibility for specific levels of children MA to be treated as any other phobia.

In most of the found reports the mathematical task used to measure mathematical achievement has to do with arithmetic calculations or WPS. Only one is found in which geometrical tasks are offered. It would seem that rather than the mathematical topic, the higher level brain functions is what is affected by MA, in such a way that the tasks that require higher levels of working memory are greatly and negatively affected. However, it has not been proved for geometrical reasoning, for which high MA doesn't entail low achievement.

The examined reports analyze the influence of MA on mathematical tasks in artificial environments that are different from the children regular class, and identify MA as any other phobia, so susceptible of treatment. Moreover, although in some studies the word problems are used to measure the mathematical achievement, it is mostly measured through mechanic and algorithmic tasks that involve calculations, and hardly ever other kind of mathematical reasoning (arithmetic, geometric, logic, etc) that could be more challenging and/or helpful to the mathematical education community. Therefore, the general recommendation would be that mathematical educators and neuropsychologist should work together to shed light on MA affection in children, as well as on the ways to afford it on mathematics learning in formal schooling.

References

Allen, M., & Vallée-Tourangeau, F. (2016). Interactivity defuses the impact of mathematics anxiety in primary school children. *International Journal of Science and Mathematics Education*, *14*(8), 1553-1566.

Baroody, A., & Coslick, R. T. (1998). *Fostering children's mathematical power: An investigative approach to K-8 mathematics instruction*. Routledge.

Beasley, T. M., Long, J. D., & Natali, M. (2001). A Confirmatory Factor Analysis of the Mathematics Anxiety Scale for Children. *Measurement and Evaluation in Counseling and Development*, *34*(1), 14-26.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics Anxiety: What Have We Learned in 60 Years?. *Frontiers in Psychology*, *7*, 508.

Eden, C., Heine, A., & Jacobs, A. M. (2013). Mathematics anxiety and its development in the course of formal schooling—a review. *Psychology*, *4*(06), 27.

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*(3-4), 153-166.

Harari, R. R., Vukovic, R. K., & Bailey, S. P. (2013). Mathematics anxiety in young children: an exploratory study. *The journal of experimental education*, *81*(4), 538-555.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, 33-46.

Hunt, T. E., Bhardwa, J., & Sheffield, D. (2017). Mental arithmetic performance, physiological reactivity and mathematics anxiety amongst UK primary school children. *Learning and Individual Differences*, 57, 129–132.

Lai, Y., Zhu, X., Chen, Y., & Li, Y. (2015). Effects of Mathematics Anxiety and Mathematical Metacognition on Word Problem Solving in Children with and without Mathematical Learning Difficulties. *PLoS ONE*, *10*(6).

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and individual differences*, *19*(3), 355-365.

McLeod, D. B. (1994). Research on affect and mathematics learning in the JRME: 1970 to the present. *Journal for research in Mathematics Education*, *25*(6), 637-647.

Morony, S., Kleitman, S., Lee, Y. P., & Stankov, L. (2013). Predicting achievement: Confidence vs self-efficacy, anxiety, and self-concept in Confucian and European countries. *International Journal of Educational Research*, *58*, 79-96.

Piaget, J., Inhelder, B., & Szeminka, A. (1960). *The child conception of geometry* (EA Lurnzer, Trans). Nueva York.

Picos, A. P., Alonso, S. H., Saez, A. M., & del Rincón, T. O. (2013). Causas y consecuencias de la ansiedad matemática mediante un modelo de ecuaciones estructurales. *Enseñanza de las ciencias: revista de investigación y experiencias didácticas*, *31*(2).

Price, J. A. B. (2015). *Children's Mathematics Anxiety and Its Effect on Their Conceptual Understanding of Arithmetic and Their Arithmetic Fluency* (Doctoral dissertation, Faculty of Graduate Studies and Research, University of Regina).

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development*, *14*(2), 187-202.

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions*, *6*(1), 1-13.

Vukovic, R. K., Roberts, S. O., & Green Wright, L. (2013). From parental involvement to children's mathematical performance: The role of mathematics anxiety. *Early Education & Development*, *24*(4), 446-467.

Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary educational psychology*, *38*(1), 1-10.

Wu, S. S., Barth, M., Amin, H., Malcarne, V., & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in psychology, 3* (162), 1-11. doi: 10.3389/fpsyg.2012.00162

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science*, *23*(5), 492-501.