



Investigating the structural relationship between math anxiety, Gray's biological model of personality, and test anxiety through assessing the self-efficacy mediating role among junior girl students of Urmia City high schools, Iran

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Original Article

Abstract

BACKGROUND: Test anxiety as a common educational phenomenon is closely related to the academic performance and achievement, and even the future performance of millions of students. Math anxiety is considered as one of the possible contributing factors to test anxiety. The present study aimed to determine the relationship between test anxiety, math anxiety, and Gray's biological model of personality through assessing the self-efficacy mediating role among girl students studying in junior year in Urmia City high schools, Iran.

METHODS: This was a descriptive-analytical study with structural equation modeling (SEM) as study design. The statistical population included all girl students studying in the junior year of Urmia City high schools in the academic year of 2016; out of which 315 were selected using multistage cluster sampling method. The data were collected using Spielberger's test anxiety inventory (TAI), Chiu and Henry's mathematics anxiety scale for children (MASC), Sherer et al.'s general self-efficacy scale (SGSES), and behavioral inhibition/activation system (BIS/BAS) scale. Linear structural relations (LISREL) software was used for data analysis.

RESULTS: Math anxiety affected test anxiety both directly (33%) and indirectly (7%), and had a direct effect on self-efficacy (23%). BIS had an indirect effect on test anxiety (8%), while directly influenced self-efficacy (8%) and math anxiety (25%); and BAS had an indirect effect on test anxiety (12%) ($P < 0.01$).

CONCLUSION: These results suggest that the performance of students can be improved by increasing their self-efficacy and decreasing their test anxiety level. Accordingly, it is essential that educational authorities, and particularly teachers, do their best to improve students' academic achievement by adopting appropriate strategies and reducing their test anxiety.

KEYWORDS: Test Anxiety Scale, Mathematics, Self-Efficacy

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Introduction

Test anxiety as a common educational phenomenon is closely related to the academic performance and achievement and even the future performance of millions of students.¹

Despite the fact that small amounts of anxiety regarding the school and doing homework assignments provoke responsibility, scheduling, and further study in the students, it is found that the main reason behind the academic failure of most of the students is not the learning disability or low IQ, but rather the high level of test anxiety which affects memory

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function and the ability to focus, and makes it difficult to recall relevant information, and does not allow the student's intelligence and educational competency to flourish perfectly.² Test anxiety is a general term referring to some type of anxiety or specific social anxiety, which makes people call their abilities into question and makes them uncertain about their competencies, which results in a reduced ability to cope with conditions like a test in which individuals are assessed.³ Test anxiety is one of the most common and acute problems students encounter during educational course, which in many cases, hinders their proper assessment by teachers through interfering with students' academic performance.³ Spielberger et al. proposed worry and excitement as two components of test anxiety. Math anxiety is considered as one of the possible contributing factors to test anxiety.⁴

Math anxiety is defined as one's inability to deal with quantitative situations, including those involving numbers, and in general mathematics.⁵ Anxiety, in general, and math anxiety, in particular, can increase the distraction and invasion of unrelated thoughts and distort individuals' perceptions of mathematical phenomena and topics by disrupting mental structures and information processing procedures.⁶ Math fear creates emotional and mental barriers that make it difficult to achieve progress in mathematics in the future. Accordingly, the student chooses a fatalistic attitude and expects to get a poor grade on the math exam. This condition is gradually converts into a defective cycle and a pleasurable prediction, such that the mathematical performance is influenced by the math anxiety.⁷ The study conducted by Cargnelutti et al. on third grade students showed that math anxiety was significantly related to math performance.⁸

Another possible contributing factor to test anxiety is brain-behavioral systems that have received a lot of attention in the recent years.⁹

Gray has proposed a biological model of personality involving three brain-behavioral systems. According to Gray, these brain-behavioral systems are the basis of individual differences, and the activation of each of them calls for different emotional responses, such as fear and anxiety.¹⁰ The first system is the behavioral activation system (BAS) that responds to conditional stimuli of reward and signals of relief from punishment. The activity and increased sensitivity of this system triggers positive emotions, approach, and active avoidance.¹¹ The second system is the behavioral inhibition system (BIS) which responds to conditional stimuli of punishment and signals of lack of award as well as novel stimuli and intrinsic fear stimuli. This system's activity induces the emotional state of anxiety and behavioral inhibition, passive avoidance, silence, increased attention and arousal.¹¹ The third system is the fight-flight system (FFS) that is structurally related to the amygdala and hypothalamus and is sensitive to irritant stimuli. Human studies have emphasized on the role of these systems in the onset of clinical problems. The results of these studies indicate that the high activity of the activation and inhibition systems contributes to the emergence of various disorders.¹² BIS and BAS have been assessed in terms of several psychological components including self-regulation, interpersonal relationships, group performance, and pathological, psychological, and motivational factors.¹³ Slobodskaya believes that BIS and BAS are strong predictor variables for the anxiety problems of children and adolescents.¹⁴

Self-efficacy, which is the mediator variable in this study, is defined as one's beliefs about his/her capabilities to accomplish planned levels of performance, and to progress and control events that have significant effects on his/her life.^{15,16} From Bandura's point of view, self-efficacy is the most fundamental human mechanism for managing and controlling the events that influence one's life.¹⁷ Bandura has

suggested four information sources for self-efficacy including 1) prior performance, 2) succession modeling, 3) verbal persuasion, and 4) emotional-physiological stimulation. These sources of self-efficacy affect one's behavior if this information is selected, interpreted, and eventually integrated into self-efficacy beliefs.¹⁸ The studies indicate that self-confidence, as one of the components of self-efficacy, is the most significant intrapersonal component that is related to test anxiety.¹⁹ There is a linear relationship between test anxiety and one's performance at the exam which predicts that those with low anxiety benefit from the stressful conditions of the exam, while those with high anxiety profit from more relaxed exam situations. The results of a study carried out by Mirsamiei and Ebrahimi Ghavam revealed a negative and statistically significant relationship between students' self-efficacy and their test anxiety.²⁰

Math anxiety, as some form of discomfort springing up in response to situations like math activities, is accompanied by threats to self-esteem, anxiety and panic, stress, helplessness, fear, distress and sadness, embarrassment, debility, and lack of concentration which implies the need for further research in this field. Thus, given the importance of the abovementioned items as well as the research background, the main subject of this study is whether test anxiety can be predicted by BIS/BAS and math anxiety with self-efficacy as an intermediate parameter.

Materials and Methods

The statistical population included all girl students (a total number of 1750 students) studying in junior year of high schools in Urmia, Iran, in the academic year of 2016, out of which 315 subjects were selected according to Krejcie and Morgan's table using multistage cluster sampling method. At first, 8 schools (2 northern, 2 southern, 2 eastern, and 2 western schools) were selected randomly from 18 girls' high schools located in Urmia,

and afterwards 2 classes (each class with 20 students) were chosen from each high school and the questionnaires were distributed among students and filled out after obtaining informed consent from them. Pearson correlation and structural equations were employed to analyze the data using linear structural relations (LISREL) software.

Spielberger's test anxiety inventory (TAI):

This 32-item inventory was developed by Spielberger et al., in which each item is rated on a 3-point Likert scale (0 = very low, 1 = low, 2 = high, and 3 = very high). The total score of TAI varies between 0 and 96, with higher scores indicating more test anxiety.²¹ The reliability reported by Jadidi et al. for TAI was 0.86.²² In this study, the value of Cronbach's alpha used for reliability determination was 0.77.

Mathematics anxiety scale for children (MASC):

This scale was developed by Chiu and Henry²³ on the basis of the shortened version of Plake and Parker's Mathematics Anxiety Rating Scale (S-MARS) which can be used for children in grades of 8-12.²³ MASC consists of 22 short sentences rated on a 4-point Likert scale that specify math-related activities. The minimum and maximum scores on this scale are 22 and 88, respectively. To measure the validity of MASC, Chiu and Henry calculated its correlation using different tools. There was a high correlation (0.97) between this scale and MARS.²³ In this study, the Cronbach's alpha of this scale was 0.76.

General self-efficacy scale (GSES): This questionnaire, developed by Sherer et al., is composed of 17 items which are rated by the respondent on a 5-point Likert scale (totally disagree to totally agree).²⁴ GSES assesses three aspects of behavior including the willingness to initiate the behavior (1st, 4th, 14th, 15th items), willingness to make an effort to accomplish the assignment (3rd, 5th, 8th, 9th, 13th items) and persistence in the face of adversity and obstacles (2nd, 6th, 7th, 10th, 11th, 12th, 16th, 17th items). Asgharnejad et al. obtained a value of

0.88 for GSES reliability using the Cronbach's alpha coefficient.²⁵ In this study, the reliability of this scale was equal to 0.891.

BIS/BAS scale: BIS/BAS scale is a 20-item self-report questionnaire introduced by Carver and White, which has 3 subscales including reward responsiveness, drive, and fun seeking. Respondents are asked to rate each item on a 4-point Likert scale, with high scores indicating more sensitivity.²⁶ Mohammadi reported the values of 0.78, 0.69, 0.87, 0.74, and 0.65 for Cronbach's alpha coefficients related to total scale and subscales of BIS/BAS: reward responsiveness, drive, and fun seeking, respectively.²⁷ In this study, Cronbach's alpha which was employed to determine the reliability was 0.82.

Results

Before addressing the theoretical model test and in order to examine the relationship between the variables, descriptive indexes and correlation matrix of the studied variables are presented in table 1.

According to table 1, the mean and standard deviation (SD) of BAS, BIS, math anxiety, self-efficacy, and test anxiety were 19.55 ± 3.07 , 9.62 ± 1.72 , 58.14 ± 18.29 , 44.26 ± 11.52 , and 50.15 ± 11.60 , respectively. There was a statistically significant relationship between BAS and self-efficacy (0.31) ($P < 0.010$); but no significant relationship was observed between BAS and test anxiety (-0.10) and BAS and math anxiety (-0.060) ($P > 0.010$). In addition, BIS was significantly related to self-efficacy (-0.21) and test anxiety (0.15) ($P < 0.010$), but its relationship with math anxiety (0.19) was not statistically significant. Finally, statistically significant

relationships were found between math anxiety and self-efficacy (-0.21) and math anxiety and test anxiety (0.34), and self-efficacy was significantly correlated with test anxiety (-0.37) ($P < 0.010$).

In order to estimate students' test anxiety, the proposed conceptual model was examined by structural equation modeling (SEM) using maximum likelihood estimation (MLE) method. The MLE method requires not only the univariate normality, but also the multivariate normality. In this study, Mardia's standardized kurtosis coefficient was used to assess the multivariate normality. This value was obtained to be 0.36, which is less than 35, the value calculated by the formula of $p(p+2)$. The fitness indices were used to evaluate the model's fitness.

The Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), and Standardized Root Mean Squared Residual (SRMR) were considered as absolute fit indices; Comparative Fit Index (CFI), Normed Fit Index (NFI), and Non-Normed Fit Index (NNFI) were designated as relative fit indices, and chi-square to degree of freedom ratio (χ^2/df), Parsimonious Normed Fit Index (PNFI), and Root Mean Square Error of Approximation (RMSEA) were considered as parsimonious fit indices. According to our findings, the values of GFI, AGFI, CFI, NFI, NNFI indices which are 0.99, 0.98, 0.99, 0.98, and 0.99, respectively, all above 0.90.

The PNFI index value was 0.70, which was more than 0.60. The SRMR, RMSEA, and χ^2/df indices were 0.01, 0.01, and 0.82, which were below the acceptable limits of 0.05, 0.08, and 3, respectively. Therefore, since all fit indices were favorable, it could be concluded that the tested model fitted the collected data well.

Table 1. Correlation matrix, mean, and the standard deviation of studied variables

Variable	Mean \pm standard deviation	1	2	3	4	5
Behavioral activation	19.55 ± 3.07	1.00				
Behavioral inhibition	9.62 ± 1.72	-0.51*	1.00			
Math anxiety	58.14 ± 18.29	-0.06	0.11	1.00		
Self-efficacy	44.26 ± 11.52	0.31*	-0.21**	-0.21*	1.00	
Test anxiety	50.15 ± 11.60	-0.10	0.15*	0.34*	0.37*	1

* $P < 0.010$

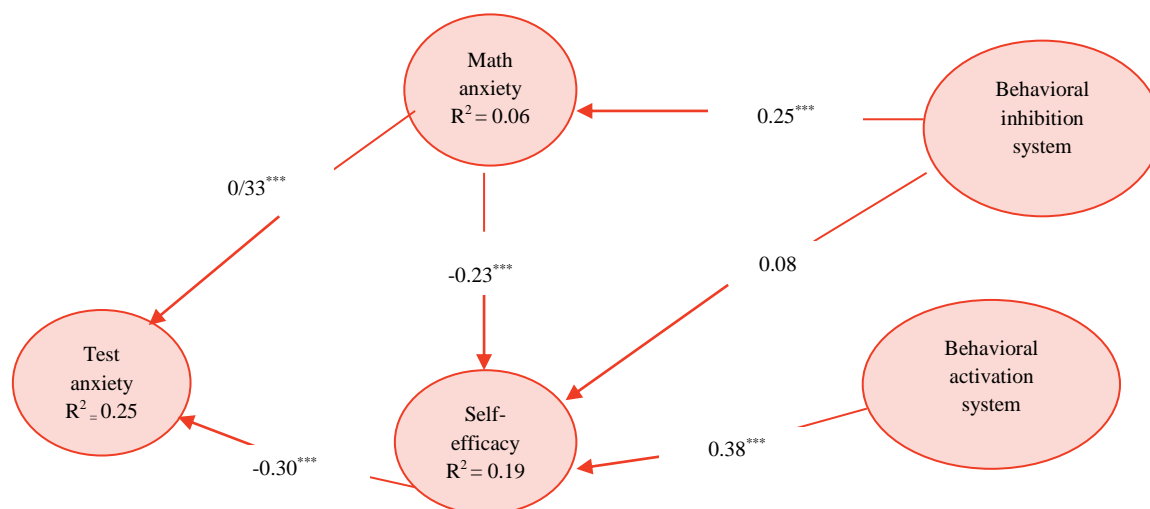


Figure 1. The diagram of the fitted model and the estimated parameters
 *** P < 0.001

The diagram of the fitted model and the estimated parameters are presented in figure 1. According to this figure, self-efficacy, math anxiety, and BIS/BAS explain 25% of the test anxiety changes. BIS and BAS predict 19% of self-efficacy variance, while the BIS predicts 6% of the changes in math anxiety. Table 2 shows the direct, indirect, and total effects and the explained variances of variables.

According to above table, the findings show that direct and indirect effects of anxiety on test anxiety are 0.33 and 0.07, respectively, which are statistically significant (P < 0.001); the direct effect of math anxiety on self-efficacy

(-0.23) is significant (P < 0.001); the indirect effects of BIS and BAS on the test anxiety are 0.08 (P < 0.010) and -0.12 (P < 0.001) which are significant; the direct effects of BIS and BAS on self-efficacy are 0.08 and 0.38, respectively, which only the latter is statistically significant (P < 0.001); finally, the direct effect of BIS on math anxiety is 0.25 which is significant (P < 0.001).

Discussion

The results revealed that math anxiety directly affected test anxiety, which is consistent with the findings of Rekabdar and

Table 2. The direct, indirect, and total effects and the explained variances of variables

Variable	Direct effect	Indirect effect	Total effect	Explained variance
On the test anxiety by				
Self-efficacy	-0.30**	-	-0.30**	0.25
Math anxiety	0.33**	0.07*	0.40**	
BIS	-	0.08*	0.08*	
BAS	-	-0.12*	-0.12*	
On the self-efficacy by				
Math anxiety	-0.23**	-	-0.23**	0.19
BIS	0.08	-0.06*	0.02	
BAS	0.38**	-	0.38**	
On the math anxiety by				
BIS	0.25**	-	0.25**	0.06

* P < 0.010, ** P < 0.001

BIS: Behavioral inhibition system; BAS: Behavioral activation system

Soleymani.²⁸ No discrepancy was found between the findings of this study and the results of the other studies. This finding can be explained by the fact that psychological pressures reduce one's effective behavior in face of different realities, especially when the requested assignments need more attention and focus.

Students, who get anxious during a math activity, cannot think properly and organize their own knowledge; therefore, they often intentionally put more effort into their activities; even though their efforts do not result in the significant learning of mathematical concepts, which ultimately make them desperate and depressed.

The study also showed that math anxiety indirectly affected test anxiety, which is in line with the findings of Zaki²⁹ and Ma and Xu.³⁰ In addition, a direct relationship was found between math anxiety and self-efficacy. This finding is consistent with the results of the studies by Schunk and Pajares³¹ and Cheung and Sun.³² To explain this finding, it should be noted that since Bandura has recognized self-efficacy as a cognitive intermediate parameter influencing one's thoughts and feelings,¹⁸ such an outcome is not unexpected; because once exposed to negative and stressful events, high self-efficacy helps individuals to manage those events and situations. An individual with test anxiety feels helpless and cannot take control of the exam. The results also demonstrated a negative relationship between test anxiety and self-efficacy. According to Mehrabizade *et al.*,³³ Bandura,¹⁸ the social theoretician, believes that test anxiety develops in a social context. The modeling and observational learning in early childhood is a part of this mechanism that affects test anxiety. Those with test anxiety have generally lower levels of self-efficacy and feel more helpless and incapable. This finding is in line with the results of the study conducted by Mehrabizade *et al.*, which indicated that test anxiety was negatively

correlated with self-efficacy and internal control place.³³ Moreover, Mirsamiei and Ebrahimi Ghavam, showed that there was a negative significant relationship between students' self-efficacy and test anxiety.²⁰ In fact, self-efficacy is very essential in improving one's performance.³⁴ The results also showed that BIS indirectly influenced test anxiety, which is consistent with the results of some other studies.^{35,36} Johnson *et al.*, who investigated the relationship between brain behavioral systems and psychological disorders, emphasized on the contribution of inhibition system in the symptoms of anxiety and depression.³⁷ In fact, the BIS responds to conditional stimuli of punishment and signals of lack of award as well as novel stimuli and intrinsic fear stimuli.¹⁰ This system's activity triggers the emotional state of anxiety and behavioral inhibition, passive avoidance, silence, increased attention, and arousal. The neuroanatomical basis of BIS is its highly activation during the anxiety experience.¹⁰ Hasking's study on adolescents showed that BAS and BIS were associated with more problem-solving strategies and inappropriate problem-solving strategies, respectively.³⁸

Based on the results, test anxiety is indirectly affected by the activation system. This finding can be explained by the fact that BAS is associated with the development of positive emotions and some dimensions of personality impulsivity, and an increase in its activity invokes positive emotions and attitude towards behavioral tendencies,¹⁰ which finally results in positive emotions like optimism and happiness. In Gray's theory, BAS is introduced with positive emotions and behavioral tendencies, such as extraversion and impulsivity, while BIS is connected to negative emotions and behavioral inclinations like fear, passivity, introversion, despair, depression, and anxiety.³⁹

Given the results, BIS directly influences self-efficacy which points to the fact that those

who are uncertain about their abilities evaluate themselves pessimistically and lose their ability to solve the problem, and their level of anxiety increases accordingly; and that is why many students are susceptible to depression.⁴⁰ Bandura et al. believe that skills can easily be influenced by self-doubt, and hence even highly susceptible ones cannot use much of their abilities once they do not believe much in themselves. Therefore, self-efficacy enables individuals to do extraordinary works using their own skills when faced with obstacles.¹⁵ The study carried out by Lee in East Asian countries showed that subjects with low self-efficacy and self-concept had high anxiety during the math test; however, they eventually got high scores. On the other hand, subjects from Western European countries like Finland, Sweden, and the Netherlands reported high math performance and low anxiety.⁴¹

The results also indicated that inhibition system had a direct effect of 25% on math anxiety which is significant at 99% confidence interval (CI). This finding is consistent with the results of Johnson et al. and Carver and Harmon-Jones studies.^{37,42} Finally, the study showed that self-efficacy was directly affected by the activation system, which is in line with the findings of Van Beek et al., Rawlings, and Seyed Mousavi et al.⁴³⁻⁴⁵ In general, it can be said that people who are over-anxious are susceptible to the more diseases. Anxiety is one of the psychological disorders that affects all people, including the youth and adolescents. When an individual is worried about his/her mental ability and performance in a test, this feeling diminishes his/her performance, which jeopardizes his/her adaptations and makes the individual to put a lot of energy into reaching balance.²⁰

Inaccessibility to boys' high schools and restricting the study to Urmia high schools are among the study limitations which confine its generalizability. It is suggested that such studies be carried out in different cities in both

male and female students using different affective variables.

Conclusion

Researchers believe that some kind of moderate anxiety is necessary for various activities like mathematical behavior. Math cannot stimulate the students' interest and motivate them to try their best as long as it is known as a boring and agonizing lesson. Therefore, this lesson should be taught not in a non-flexible and lecture-style form but by using various methods tailored to the students' learning style. This requires a targeted effort from the educational system. It is suggested that teachers use methods leading to self-efficacy improvement in students, which in turn decrease the level of test anxiety caused by low self-efficacy. It is also important for teachers to give positive feedbacks to their students, and employ methods that develop the strong sense of competence in an attempt to reduce the level of test anxiety caused by low self-efficacy and significantly decrease the sense of incompetence.

Conflict of Interests

Authors have no conflict of interests.

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