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# Physiological correlates of mathematical anxiety in resting state and during anticipation of math

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***Abstract***
**Introduction.** Math anxiety (MA) is a feeling of discomfort or fear during performing any kind of math related tasks. It is shown that MA affects performance in mathematics. People with high math anxiety have a moderate response in brain activity, not even to the task itself, but to the anticipation of math. Electrodermal activity and heart rate and heart rate variability are known to be sensitive indicators of stress. **Aim.** Our purpose was to investigate changes in physiological measures such as: electrodermal activity, heart rate and heart rate variability; during resting state and while anticipation of math in participants with different levels of math anxiety. **Materials and methods.** Our sample included 84 participants with high and low levels of math anxiety. Experimental procedure included recording of physiological measures during resting state, without specific instruction and during anticipation of math task, when they were informed that they will be performing calculation. **Results.** Study showed that heart rate was significantly higher during anticipation of math in all participants, with no regards to math anxiety level. However, a small effect was shown. Also it was found differences in amplitude of electrodermal activity in participants with different levels of math anxiety. **Conclusion.** Overall study suggests that heart rate is sensitive to such emotional state as anticipating math and electrodermal activity can be one of the indicators of math anxiety.
***Keywords:*** mathematical anxiety, physiological indicators, electrodermal activity, heart rate, heart rate variability

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# Физиологические корреляты математической тревожности в состоянии покоя и при ожидании решения математических задач

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***Аннотация***
**Введение.** Математическая тревожность (МТ) – это чувство дискомфорта или страха при выполнении любых математических задач. Показано, что МТ влияет на успеваемость по математике. Люди с высокой математической тревожностью имеют умеренную реакцию мозговой активности даже не на само задание, а на ожидание решения математических задач. Известно, что электрическая активность

кожи (ЭАК), частота сердечных сокращений (ЧСС) и вариабельность сердечного ритма являются чувствительными индикаторами стресса. **Цель.** Нашей целью было исследовать изменения физиологических показателей, таких как: электрическая активность кожи, частота сердечных сокращений и вариабельность сердечного ритма в состоянии покоя и при ожидании решения математических задач у участников с разным уровнем математической тревожности. **Материалы и методы.** В нашу выборку вошли 84 участника с высоким и низким уровнем математической тревожности. Экспериментальная процедура включала запись физиологических показателей в состоянии покоя, без специальных указаний и во время ожидания математических задач, когда участникам сообщалось, что далее они будут выполнять математические вычисления. **Результаты.** Исследование показало, что частота сердечных сокращений была значительно выше при ожидании решения математических задач у всех участников, независимо от уровня математической тревожности. Однако данный эффект был небольшой. Также были обнаружены различия в амплитуде электрической активности кожи у участников с разным уровнем математической тревожности. **Заключение.** Исследование показало, что частота сердечных сокращений чувствительна к такому эмоциональному состоянию, как ожидание решения математических задач, а изменение электрической активности кожи может выступать одним из индикаторов математической тревожности.

***Ключевые слова:*** математическая тревожность, физиологические показатели, электрическая активность кожи, частота сердечных сокращений, вариабельность сердечного ритма

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## Introduction

What makes the heart pant rapidly, feel exciting and break into perspiration? Everything that happens to us inevitably affects a plethora of physiological indicators, but this is not about the first date, but math anxiety or MA – the phenomenon with more than 60-years of study history. Basically it is associated with a negative emotional response to the necessity of using mathematical skills and can be triggered in everyday situations: from attending a math class to reading a cashier's receipt or recounting change in a store. Math anxiety is an unfavorable emotional reaction to mathematics or the prospect of doing mathematics [1], which is widely thought to be related with other types of anxiety such as test, state, and general anxiety [2, 3]. Yet at the same time recent studies let us treat MA as a separate construct from general anxiety despite relatively similar cognitive, brain and physiological manifestations [4]. Recent studies show a significant prevalence of the phenomenon: from 30 to 48 % of schoolchildren, and about 25 % of university students have a high or above average level of MA [5, 6].

Math anxiety negatively affects performance and success in mathematics. For example, people with a higher MA score on average have lower performance on math problems [7]. It is also associated with such long-term prospects in human life as education and employment, and also affects the level of development of the whole society, reducing the number of specialists in STEM [8]. Therefore, both teachers and scientists are in search of ways of eliminating negative effects by means of relevant emotion regulation strategies [9, 10].

A comprehensive investigation of the MA phenomenon, determining of the most and least affected groups, MA roots and limits can equip us with *“desirable remedy”* – targeted interventions which will make some individuals neutral towards math, others help to like it and for the rest not worry about negative feelings and only relieve anxiety [11]. Implementation of the regulation strategies which demonstrate effects, such as long-term interventions in real conditions of the educational process as well as psychotherapy-inspired interventions where face-to-face work with a high-skilled specialist is needed seems to be challenging in many aspects [10, 11]. With that in mind short-terms interventions are more attractive which is reflected in recent studies [12].

We presumed to go beyond and aim at not only studying the effects of short-term interventions on sample of Russian students but also evaluate physiological indicators during it. It is known that for students with high MA level, math doesn't just cause feelings of dislike or anxiety, it also affects physiological indicators such as heart rate, nervous system activation, and cortisol release [10]. This complex approach is reasonable as standard self-reporting surveys (AMAS, MARS, sMARS and etc.) [13] which are widely applicable for MA evaluation have several limitations such as:

- They require functioning self-inspection
- They can be manipulated consciously like in selection situations, but also unconsciously (social desirability effects).

Although psychophysiological studies are more difficult to conduct in contrast to questionnaires, they can contribute to a deeper and more comprehensive understanding of MA due to the dynamic assessment of objective indicators [9, 11]. Despite plenty of studies and ongoing large-scale research projects there is still no clear idea of what the neuro and physiological indicators of MA.

Studies showed significant brain response when anticipating an upcoming math task. In participants with high math anxiety, shown increasing activity in regions associated with visceral threat detection, and often the experience of pain itself (bilateral dorsal-posterior insula). Interestingly, this relation was not seen during math performance, suggesting that it is not that math itself hurts; rather, the anticipation of math is painful. This data suggest that pain network activation underlies the intuition that simply anticipating a dreaded event can feel painful [14]. These results give a reason to suggest that other physiological processes can differ in people with different levels of anxiety, during awaiting mathematical tasks.

**Aim**

This experimental study is aimed at investigating MA at the physiological level on the sample of Russian students.

***Overview of physiological indicators for present study***

The following physiological indicators have been selected for our study: Electrodermal activity (EDA), Heart Rate (HR), Heart Rate Variability (HRV). Electrodermal activity reflects the sympathetic nervous system's response via autonomic activation of eccrine sweat glands. Activation of sweat glands leads to variation in skin conductance which can then be measured. EDA can be distinguished to tonic, slow-changing, activity – Skin Conductance Level (SCL) and phasic activity, which reflects rapid response – Skin Conductance Response (SCR). Researchers are often interested in SRCs since these changes could be linked to particular stimuli and reflect the strength of sympathetic nervous system response [15]. Some SCRs, Nonspecific Skin Conductance Responses (NS-SCRs), occur in the absence of external stimulation. The lability of such responses could be considered a psychophysiological trait [16]. Evidence suggests that electrodermal lability vs. stability correlates with emotional expression and self-control [17, 18]. Some findings also suggest the link between NS-SCRs and anticipatory stress. For example, anticipatory SCRs are observed prior to decision-making and effortful cognitive control tasks [19, 20]. Not much studies have been published on psychophysiological responses using EDA measurement. One of the examples of such design is a recent study of Eidlin and Rubenstein where skin conductance response was monitored during the performance of math tasks and it was shown that MA levels were significantly related to physiological arousal [21].

Heart rate is the number of contractions or heart beats per minute (bpm) and the normal resting adult human heart rate is at the range of 60–100 bpm. Heart rate is regulated by sympathetic and parasympathetic input to the sinoatrial node. There are a lot of factors that influence HR: from gender to air temperature, bad habits and physical activity, age, and etc. As highlighted by Trotman and colleagues, personal perception of a situation as threatening or stressful, followed by increases in heart rate, can therefore lead to elevated feelings of anxiety [22]. Physiological manifestations of fear such as excessive sweating and blushing, trembling, palpitations, nausea come out of an increased autonomic arousal and heart rate [21].

Heart rate variability in comparison to heart rate measures fluctuations in the time intervals (or variability) between adjacent heartbeats [23] and represents a more sensitive indicator of stress [24]. HRV depends on the heart-brain interaction and dynamic non-linear autonomic nervous system processes [25]. There are linear and nonlinear algorithms to study these processes. The Time domain indexes are the first used indexes and simplest way to calculate HRV [26]. In this study we use the linear features in the time domain: Standard Deviation of RR intervals (SDNN), Mean Square of the Successive Differences (RMSSD)[1]. Its statistical robustness makes

[1] Mariani S., Migliorini M., Tacchino G., et al. Clinical state assessment in bipolar patients by means of HRV features obtained with a sensorized T-shirt. Annual International Conference of the IEEE Engi-

it well-suited for short-term time windows. RMSSD is more influenced by the Parasympathetic nervous system activity and hence is often used to estimate the vagally mediated fluctuations in HR. Reduced heart rate variability has not only been associated with a range of vascular diseases, but also with various mental disorders and cognitive impairments [23]. In recent years there has been considerable research interest in HRV method what is evidenced by a lot published studies, not only in medicine, but psychology, cognitive and neurosciences.

As of now, only a few studies explored the link between math anxiety and physiological arousal, which is mostly measured with electrodermal activity (EDA). For example, Strohmaier and colleagues [21, 27] revealed trait MA as a predictor of physiological arousal, reflected by SCRs frequency. The authors explored additional factors such as appraisals of control and perceived values and found their mediating role in the link between MA and physiology. In other words, those participants who felt a lack of control and assigned a high value to the math exam felt the most anxious.

Another study by Qu with a research team [28] revealed that skin conductance level (SCL) was negatively related to math anxiety scores during a five-minute anticipation period before the math exam but not during the exam itself. The authors also measured the heart rate of the participants and reported significant links between HR and MA scores towards the end of the 90-minute math exam.

Finally, a recent study by Eidlin Levy & Rubinsten [21] showed a significant correlation between physiological arousal and math anxiety. Physiological arousal was measured by event-related changes in SCRs amplitudes in response to complex numerical tasks. The authors also highlight the mediating role of math anxiety in the link between trait anxiety and physiological response.

***HRV and MA***

HRV indexed by respiratory sinus arrhythmia (RSA) mediated the link between MA and arithmetic speed. "Individuals with specific math anxiety showed lower RSA and longer reaction time than the other three groups in the arithmetic task". But the volume of sample was relatively small [29].

Despite the fact that HRV received a great deal of attention recently, association between this physiological indicator and MA has been neglected. So this grey area opens up prospects for a deeper understanding of math anxiety in physiological aspects and speaks well for the relevance of our experimental study.

**Materials and methods**

The study was conducted at the premises of the Laboratory for Cognitive Investigations and Behavioral Genetics of The National Research Tomsk State University (TSU). The study was approved by the TSU Ethics committee of interdisciplinary studies on April 2020 and final updated version received approval № 03042020-32/1 on April 2021.

*Participants*

The sample included students of various fields from different universities of Tomsk. Participants were prescreened for math anxiety on a first stage using an online testing platform https://www.1ka.si. Participants filled a consent form and then completed psychological testing. The Abbreviated Math Anxiety Scale (AMAS) was used to measure math anxiety [30]. Based on the results of the AMAS, were invited to participate in the physiological experiment. Basically it was supposed to test separately both the whole sample and extreme (High math anxiety (HMA) and Low math anxiety (LMA) groups, but later it was decided to invite all the participants to the second stage. At this point, we anonymized the personal data of the participants and used unique identification numbers. All participants provided signed informed consent that included information about specifics of the physiological experiment at the beginning of the study. At the end participants were compensated with a small reward in cash.

At the second stage of the study, psychophysiological data were collected. Totally there were 89 students invited to the laboratory.

In the laboratory, before the experiment, all participants were also presented with a second AMAS test and the correlation between these testing was $r = .72$, $p < .001$, which means testing are consistent. Therefore, it was taken the mean on AMAS testing between two measurements and based on a median score participants was divided into two groups: HMA and LMA.

neering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual International Conference. 2012. 2240–2243. DOI: 10.1109/EMBC.2012.6346408

Five participants from the low-anxiety group were removed from the analysis (due to being outliers in HR measures or EDA), the final sample included N = 84, age mean M = 19.91, (SD = 1.77), 26 male (31%). Therefor, 45 participants were identified as HMAs and 39 were identified as LMAs.

*Design and Experimental procedure*

On the psychophysiological stage of the experiment participants were suggested to: 1) fill out a consent form where procedure, potential risks and rights of participants were described; 2) take AMAS testing; 3) undergo electroencephalography (EEG) testing (*EEG data were not included in the scope of this study*[2]).

The experiment was designed with Inquisit Lab and included the following steps:

1. Upon installation of the sensors (EEG, EDA, PPG), participants were asked to minimize their movements and follow the instructions. The first instruction for the resting state condition was to look directly at the dark screen. The resting state parameters have been recorded for 3 min.
2. The next instruction informed participants about upcoming solving of the math tasks. They were asked to prepare for it while waiting. The first anticipation condition was also recorded for 3 min. Participant were informed about time limit.
3. During the first math test, the students were asked to solve as many items of the test as possible. Time limit was set for 10 min. It was allowed to use pen and paper for making notes during math tests. Participants were not able to skip exercise or return to the previous one.
4. Upon math tasks completing, participants were presented with either one of the math anxiety regulation exercises or 3-min. break in resting state.
5. For the second anticipation condition, the participants were again informed about an upcoming math test and were asked to prepare. Time of the recording was 3 min. Participant were informed about time limit.
6. At the final stage, the participants were presented with a second math test with a time limit of 10 minutes.

Overall time of the experiment was near 2.5 hours.

*Sociodemographic and psychological measures*

Sociodemographic test included questions about age, gender, and core educational modules. Psychological testing on that level included AMAS. Nine items of the AMAS [30] questionnaire describe the situations related to studying and being tested in math (e.g. "Taking an examination in a math course"). Items were translated into Russian and back-translated into English by the team of the Laboratory of Cognitive and Interdisciplinary Studies (Educational Centre Sirius). The questionnaire has high internal consistency (α = .90) and two-week test-retest reliability (r = .85). Strong convergent validity was evident between MARS-R and the AMAS (r = .85).

*Math Tasks*

Special battery to measure the variability in learning mathematics was developed for this study. It was based on the expertise of math educators. Math tasks for the experimental testing were taken from the Basic State Examination, which is compulsory at the end of the 9th grade of secondary school in Russia. Procedure was close to the real conditions for passing the exam. During the experiment all the participants were suggested to complete 2 similar blocks of assignments. Each block included 12 tasks aimed at testing arithmetic, calculation and logic skills as well as basic knowledge in algebra and geometry. To trigger MA time limitation factor was introduced, so 10 minutes were given for each block. Grading of the tasks was the following: 0 – incorrect or missing answer, 1 – correct answer.

*Physiological measures*

Initial data files contained both recordings of EEG channels and auxiliary EDA and PPG channels. These auxiliary channels were extracted using the Python package MNE (V. 0.23.0) [31].

***EDA***

EDA signal was band-pass filtered (0–0.5 Hz) [21] and resampled to 100 Hz. The signal was segmented into 3-min. conditions "Resting state", "Anticipation 1" and "Anticipation 2" using events from EEG recording annotations. Each segment was preprocessed and analyzed using functions of the NeuroKit2 bio signal processing Python package (V.0.1.3) [32].

During preprocessing raw EDA signal was cleaned from artifacts and then decomposed into tonic (Skin Conductance Level, SCL) and phasic (Skin Conductance Response, SCR) components of the signal. Based on the SCR component, the onsets, rise time, recovery and peaks of the signal were marked, as well as the amplitude of the signal. Then, we used interval-related analysis since we had long recordings of 3 minutes. For each of

[2] Cognitive data were collected also but they were not included for the analysis of this paper.

the conditions, analyzed EDA features included a number of SCR peaks that occurred during the interval and the mean amplitude of the peaks.

*Photoplethysmography (PPG)*

Same as EDA, the PPG signal was filtered (0.1–8 Hz) [33], resampled to 100 Hz and segmented into conditions. During preprocessing raw EDA signal was cleaned from artifacts and the heart rate was measured based on PPG peaks. As the result of interval-related analysis, the mean heart rate during conditions and HRV indexes were obtained. HRV indices were calculated based on PPG peaks. These indexes included: Standard Deviation of RR intervals (SDNN), measured in the unit of milliseconds (ms), Root Mean Square of the Successive Differences (between adjacent RR intervals) (RMSSD) [23].

The data collected during the mathematical test solving was not analyzed designingly, as they contained lots of artifacts caused by physical movements. Moreover, time for math tests completion was significantly differed in comparison with the conditions of resting state and anticipation (10 min. and 3 min. accordingly).

## Results

### *Behavioral measures*

The main goal of the study was to see if there are any differences physiological measures (EDA, HR, HRV) in different stages of experiment in different groups of math. Descriptive statistics were reviewed for math anxiety level of participants with high math anxiety (HMA) M = 23.96(4.52) and low math anxiety (LMA) M = 14.56(2.14).

Also was shown descriptive statistics of the math task performed by participants during math task. First math task: HMA group M=4(1.88) and LMA group M=4.95(2.16). Second math task: HMA group M=4.6(2.63) and LMA group M = 6.21(2.64).

### *Repeated measures ANOVA*

We applied repeated measures analysis of variance (RM ANOVA) to compare physiological measures during different stages of experiment – anticipation of the mathematical tasks and resting state in participants with high and low levels of mathematical anxiety. Before analyses were conducted, physiological data were transformed – heart rate variability measures were log transformed and electrodermal activity measures was square rooted. No transformation required to HR measurements, as normal distribution was shown.

While performing RM ANOVA, physiological indicators were taken as dependent variables and the factor of the measurement stage (state of rest and mathematical task anticipation time periods), the level of group mathematical anxiety (high and low), as well as their interaction were independent variables. After conducting repeated measures (RM) ANOVA, Tukey`s post tests were applied. Data processing and analyses were conducted using R and Python programming languages.

### *Statistics / Data Processing*

Data were processed and analyzed with a standard package of Python and R-Studio software. Descriptive statistics were examined for groups with different level of anxiety and repeated measures ANOVA was used to see the differences in physiological indicators on different stages of experiment.

### *Physiological measures*

***EDA.*** No significant differences in electrodermal activity (EDA) were revealed as well as in the number of EDA peaks. Were found significant differences in the amplitude of the peaks across high and low math anxiety groups ($F(1,82) = 4.20$, $p =. 044$, $\eta_g^2 = .04$) with lower values in HMA group. Post-hoc analysis was nonsignificant ($p = .08$). Descriptive statistics see in Table 1.

***HR.*** We found significant differences in mean heart rate only for stage variable ($F(1,82) = 69.38$, $p < .001$, $\eta_g^2 = .02$). Pulse was higher while anticipating mathematical tasks. According to a Tukey Post-hoc results revealed signifi-

**Table 1**

**Descriptive statistics for amplitude of EDA**

| Amplitude | MA level | n | mean | sd | min | max |
|---|---|---|---|---|---|---|
| SCR_Ampl_RS_H | H | 45 | 7.46 | 9.09 | 0 | 44.51 |
| SCR_Ampl_RS_L | L | 39 | 9.56 | 8.26 | 0 | 36.22 |
| SCR_Ampl_A_H | H | 45 | 7.47 | 6.85 | 0 | 25.21 |
| SCR_Ampl_A_L | L | 39 | 12.65 | 12.99 | 0.08 | 52.85 |

Note: RS – resting state, A – anticipating math task, H – high math anxiety, L – low math anxiety.

cant differences across stage condition in high ($t(82) = –6.15$, $p < .05$) and low ($t(82) = –5.15$, $p < .05$) math anxiety groups. Descriptive statistics can be seen in Table 2. No differences were found between the levels of MA.

***HRV.*** RMSDD index demonstrated significant differences only for stage condition ($F(1,82) = 4.67$, $p = .034$, $\eta_g^2 < .01$). The results are not significant according to Post-hoc results.

SDNN index demonstrated significant differences across stage condition ($F(1,82) = 70.58$, $p < .001$, $\eta_g^2 = .02$). The results are not significant according to Post-hoc results. However, all investigated HRV indicators showed decrease, both for HMA and LMA in the condition of anticipation of math tasks.

## Discussion

As it was declared to investigate changes in physiological indicators EDA, HR, and HRV at resting state and anticipation of math tasks among participants with different levels of math anxiety we based on the assumption that anticipation of math tasks is distressing or "painful" [14]. It gives the reason to believe that other physiological process can vary in individuals with different levels of anxiety while anticipating math tasks. It was supposed to get a response to the anticipation of tasks in changing the conductivity of the EDA, which leads to an increase in SCR during emotional arousal (in our case, caused by mathematics), that was shown in previous studies. [21, 27]. It was measured the average number of peaks and amplitude in our study. Only one EDA indicator (amplitude) showed effects for participants from groups of different MA levels. Despite the fact that we can only talk about a trend ($p = .08$), the effect itself was unexpected. Thus, an increase in the amplitude of SCR was shown in LMA group (12.65 ± 12.99), but not the HMA (7.47 ± 6.85). According to the literature data, higher SCR amplitude indices were observed in HMA than in the LMA group ($p = .037$) [21]. It is important to note, that the mean of the LMA group in our study was 12.65 ± 12.99.

Participants of this group had more emotional response on the condition of math anticipation. For now, it is difficult to say what these results are related to. It can be caused by both individual differences and the specifics of the participants division into groups by median (one sample included both participants with low and relatively high levels of MA). Moreover, we cannot exclude the option that participants assess themselves as low anxiety, but in the physiological manifestation of the EDA it does not look like this. These partially inconsistent results require further verification.

We also expected that the HR indicators would in anticipation of math tasks in a greater extent among participants with a high level of math anxiety. Based on the previous research a higher HR was found in a high MA group in comparison to a group of people with a lower MA during solving complex math tasks [28]. In our experimental study, HR increased for all participants. Heart rate increases significantly during stressful conditions [21], probably our participants may have experienced the emotional excitement associated with waiting for assignments (similar to an exam). Also, differences can be associated with the research procedure, and the tasks themselves (their complexity).

As for the HRV, there is few data regarding the study of mathematical anxiety. We could only assume that while anticipating for math tasks, the participants, who may be more emotional, will experience a decrease in these indicators. [23]. There is a trend of decreasing for SDNN and RMSDD indicators, but generally for the entire sample – all participants were in emotional stress before performing math tasks.

Thus, heart rate is sensitive to such an emotional state as the expectation of mathematics, and EDA can be one of the indicators of mathematical anxiety. To study HRV, it is necessary to include other parameters, as there is potential to

Table 2

**Descriptive statistics for pulse measures**

| Amplitude | MA level | n | mean | sd | min | max |
|---|---|---|---|---|---|---|
| SCR_Ampl_RS_H | H | 45 | 78.87 | 10.57 | 59.1 | 100.5 |
| SCR_Ampl_RS_L | L | 39 | 78.36 | 8.56 | 56.91 | 95.38 |
| SCR_Ampl_A_H | H | 45 | 81.91 | 10.86 | 62.86 | 104.97 |
| SCR_Ampl_A_L | L | 39 | 81.33 | 9.4 | 57.17 | 102.27 |

Note: RS – resting state, A – anticipating math task, H – high math anxiety, L – low math anxiety.

study in the light of MA, but so far very little data has been accumulated.

It is worth clarifying that in this work there are limitations associated with the volume of sample. So replication of the obtained results on a bigger sample is needed with specification in some measurements, for example, the level of test anxiety. Also other various factors that affect the results should be taken into account in more details.

## Conclusion

To sum up the study of math anxiety itself remains front and center, as it affects not only needs of daily life, but also refer to the choice of a further life prospects. To support those who are nervous about math is an important and challenging task both for school and university teachers, but also scientists and business, which is highly interested in top STEM-specialists.

The study of MA at the physiological level is underway, and the results on EDA and HR have already been accumulated. In our work, we have taken the first steps to study these indicators on a Russian sample. In general, MA studies with HRV are of great scientific interest, but it is important to detail the selection of HRV parameters as well as design of studies. The complex study of MA which combines behavioral, psychophysiological and neurophysiological methods can be successfully used to identify differences among individuals with high and low MA.

Additional parameters such as physiological and neurophysiological are relevant for the study of MA regulation and particular interventions, since these methods can more accurately explain differences in MA. We should note that the effects of MA can be not only negative. However, it is important to accumulate sufficient experimental experience to explain these differences. Currently, there is a particular interest in study of the physiological manifestations of MA, as can be seen from numerous scientific papers issued in 2021. Thus, all this gives hope for even deeper and detailed understanding of the math anxiety phenomenon.

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