**T.C.**
**FATIH UNIVERSITY**
**INSTITUTE OF BIOMEDICAL ENGINEERING**

# PSYCHOPHYSIOLOGICAL RESPONSE OF MATHEMATICS ANXIETY

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**MSc THESIS**
**BIOMEDICAL ENGINEERING PROGRAMME**

**İSTANBUL, JANURARY / 2016**

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**FATİH ÜNİVESİTESİ**
**BİYOMEDİKAL MÜHENDİSLİK ENSTİTÜSÜ**

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**MUHAMMAD AMMAR ALI**, an **MSc** student of Fatih University **Institute of Biomedical Engineering** student ID **520113015**, successfully defended the **thesis/dissertation** entitled "**Psychophysiological Response of Mathematics Anxiety**", which he/she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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_____

**Prof. Dr. Sadık KARA**

**Director**

**Date of Submission: 22 January 2016**

**Date of Defense : 27 January 2016**

***To my family,***

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January 2016 Muhammad Ammar ALI

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## LIST OF SYMBOLS

| | |
|---|---|
| μS | Micro-Siemens |
| η | Eta |
| ε | Epsilon |

## ABBREVIATIONS

MA : Math Anxiety
LMA : Low Math Anxiety
HMA : High Math Anxiety
ECG : Electrocardiogram
HR : Heart Rate
HRV : Heart Rate Variability
LF : Low Frequency
HF : High Frequency
LF/HF : Low Frequency power / High Frequency power
SDNN : Standard Deviation of RR intervals
EDA : Electrodermal Activity
SCR : Skin Conductance Response
SCL : Skin Conductance Level
μmho : Micromho
μS : Microsiemens
AR : Autoregressive
ANOVA: Analysis of Variance

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# SUMMARY

## PSYCHOPHYSIOLOGICAL RESPONSE OF MATHEMATICS ANXIETY

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Biomedical Engineering Programme

MSc. Thesis

Advisor: Prof. Dr. Sadık KARA

Co-Advisor: Asst. Prof. Dr. Osman Arda CIMEN

Math anxiety, as defined by Atkinson (1988) is "a sequence of cognitive, affective, and behavioral responses to a perceived self-esteem threat which occurs as a response to situations involving mathematics". The most common method of assessing math anxiety is using self-report questionnaires. These methods generally involve having the participants answer a series of questions without the intervention of the researcher. We measure the heart rate variability and electrodermal activity due to the fact that there have been no studies that we know of, that use these parameters to measure math anxiety in particular.

The hypothesis tested was that participants with higher math anxiety will have a higher electrodermal and cardiac response, in terms of SCR, HRV and LF/HF ratio. The subjects were 34 undergraduate students (15 males and 19 females) in the social sciences who have had little experience with mathematics in recent years.

MARS-SV translated to Turkish (Baloglu, 2010) was used. The BIOPAC MP150 system with the Bionomadix wireless ECG and GSR100C modules were used to acquire data.

Results suggest that high math anxious participants are more susceptible to a generally higher level of anxiety, making self-reports still reliant in assessing math anxiety.

**Keywords:** Math Anxiety, SCR, HRV, MARS-SV.

# ÖZET

## PSYCHOPHYSIOLOGICAL RESPONSE OF MATHEMATICS ANXIETY

Muhammad Ammar ALI

Biyomedikal Mühendisliği Programı

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Danışman: Prof. Dr. Sadık KARA

Eş-danışman: Yrd. Doç. Dr. Osman Arda ÇİMEN

Matematik kaygısı, Atkinson (1988) tarafından "matematik çözümleme içeren durumlarda algılanan benlik saygısına karşı tehdidin yarattığı, bilişsel, duygusal ve davranışsal tepki serisi" olarak tanımlanmaktadır. Öz rapor anketler matematik kaygısını değerlendirmek için en yaygın metoddur. Bu metod, genellikle katılımcıların bir soru serisini cevaplamaları ve araştırmacının müdahalesi olmaması ile gerçekleştirilir. Başka araştırmalar matematik kaygısını incelerken kalp hızı değişkenliği ve elektrodermal aktivite parametreleri kullanılmadığı için bu araştımada kullanılmışlardır.

Çalışmanın hipotezi, yüksek matematik kaygısı olan katılımcıların, SCR, HRV and LF/HF ratio açısından yüksek elektrodermal ve kalp tepkisi olacacağını test etmektedir. Katılımcılar son senelerde az matematik tecrübesi olan 34 önlisans sosyal bilimler öğrencisi (15 erkek ve 19 kadın) olarak seçilmiştir.

Çalışma için Türkçeye çevirilen MARS-SV (Baloğlu, 2010) kullanımıştır. Veri toplamak için BIOMAC MP150 sistemi ile Biomadix kablosuz ECG ve GSR100C modülleri kullanılmıştır.

Sonuçlar yüksek matematik kaygısı olan katılımcıların yüksek seviye kaygıya daha elverişli olduklarını ve öz raporlu anketler hala güvenilir bir matematik kaygısı ölçüsü olduğunu göstermektedir.

**Anahtar kelimeler:** Math Anxiety, SCR, HRV, MARS-SV.

# CHAPTER 1

# INTRODUCTION

## 1.1 Literature Survey

Math anxiety, as defined by Atkinson (1988), is "a sequence of cognitive, affective, and behavioral responses to a perceived self-esteem threat which occurs as a response to situations involving mathematics" [1]. The cause of this form of anxiety has not yet been established, whereas, its effects have been very clear. Unmanaged math anxiety could lead to an aversion to mathematics and compromise mathematical skill, and might affect the career paths of several students suffering from it [2]. Due to its prevalence, several methods of behavioral therapy for investigating math anxiety have been proposed and some have been shown to be effective.

Math anxiety shares correlations with test, general, trait and state anxiety with factors of 0.52, 0.35, 0.38 and 0.42 respectively [3]. A study by Dew, Galassi and Galassi (1984) showed that the constructs of math anxiety were more interconnected than those with test anxiety [4,5]. To further differentiate between the two Young, Wu, and Menon (2012) report that math anxiety activates brain regions associated with definite phobias and general anxiety disorders, making it a stimulus-specific anxiety. Math anxiety, in a non-traditional sense, functions as a learning disability that has negative consequences [6,7,8].

The most common method of assessing math anxiety is using self-report questionnaires [9]. These methods generally involve having the participants answer a series of questions without the intervention of the researcher. These methods, although popular, have inherent flaws such as over or underestimation of the experiences. The most popular of which was the Richardson and Suinn's mathematical anxiety rating scale, it was the first assessment instrument solely for math anxiety [10]. Due to its 98-item structure, and long testing time, it was later used as the foundation for several other revisions and newer tests. The MARS-SV (MARS-Short version) was developed by

Suinn and Winston (2003) in order to reduce the long assessment time of the original MARS [11].

The methods of brain imaging have also been used to acquire a more clear comprehending of the neural patterns of math anxiety, revealing that it extends beyond math competence; the mere anticipation of an arithmetic task is recorded with very similar brain patterns to physical pain in children [12]. Fear-related neural activity is also observed during math tasks for adults [6]. This change implicates age as an significant cause in the growth of the anxiety.

Individuals with high math anxiety tend to process their anxiety and perform the given math-related task simultaneously, which leads to a "dual task" nature and effectively taxing their working memory [6,13]. This effect, also known as an "affective drop" [8] affects their overall performance in the math related task [14]. However, this effect can be regulated by training these individuals in affective theraphy and perceptive command [15-17]. High leveled math fearful people also exhibit inefficient neural patterns in numerical tasks than low leveled math anxious individuals to arrive at comparable performance levels. [18,19].

The performance of math anxious individuals is directly correlated with the complexity of the given task [5]. The debilitating effect math anxiety has on math performance is generally observable in the higher and more complex levels of mathematics involving procedure rather than just basic arithmetic [14]. Recent event-related potential (ERP) that anxiety of math influences fundamental numerical working to simple arithmetic processing [20,21].

Math anxiety is known to develop with age [22]. The "seeds" of math anxiety take root at an early age in an individual, which lead to avoidance behavior resulting in reduced math competence. This process is claimed to develop during the early years of formal education [23,24], most likely starting in the initial years of middle school [14], and grow throughout one's lifetime. Vukovic, Kieffer, Bailey, and Harari (2013) report math anxiety to be a considerable factor in the mathematical performance of second grade students [25]. According to Hembree (1990), math anxiety increased by a correlation factor of 0.28 from grade school to college; peaking at the 9th to 10th grade,

which leads to avoidance of high level mathematics to simple arithmetic such as calculating the tip from a bill [3].

A gender-bias is also observed when assessing math anxiety, showing that females experience math anxiety more than males [3]. This however does not seem to affect their performance in mathematics, in comparison to their male counter parts. The possible reasons for this are either because females are more expressive about their anxiety or females cope with anxiety better [3, 26]. A research guided by Evans and Campbell (1997) reported that math anxiety reduced for females in all-female classrooms as opposed to coed classrooms. This indicates that anxiety might build up through females comparing themselves to males. Such a case can be explained by the perception of mathematics by the majority of females viewing mathematics as a male dominated field [27-30] which triggers a stereotype threat that affects math achievement [31,32].

Math anxiety has recently been negatively correlated to spatial ability [33,34]. This relationship suggests an insufficiency in understanding the basic elements of mathematics [35] as opposed to specific tasks such as arithmetic or algebra.

The origin of math anxiety has been chiefly related to environmental factors such as failure in mathematics [16,26,36]. More recent studies have focused on other causes such as genetics, an attentional bias, a low level of math ability, or differences in working memory capacity [37]. Teachers have been considered to be a significant factor in the transmission of math anxiety, Bekdemir (2010) observed that pre-service educators with increased math anxiety rendered bad knowledges in the math classroom [36]. This suggests that educators with inceased anxiety of math predisposed to transfer some of their negative attitudes to their students thus leading to more math anxiety. This same idea of "transferring" math anxiety is applicable if a parent with high math anxiety chooses to help their children with their homework or any other math related task. Genetics may also play a role in the origin of math anxiety as Wang et al. (2014) report that genetics accounted for about 40% of the variation in math anxiety, making certain individuals predisposed to the condition [38].

Heart Rate Variability (HRV; represented in RR intervals) refers to the differences in the beat-to-beat variations of the heart rate. It shows the dynamic between sympathetic

and parasympathetic activity in the heart [39,40]. Sympathetic activity is slower (few seconds) and tends to increase heart rate. The opposite holds true for parasympathetic activity; that is, it is faster (0.2 – 0.6 seconds) and decreases heart rate. The different nature of both these actions on the heart rate allows their independent activites to be monitored and quantitified. Sympathetic activity, classified as the low frequency (LF) component of HRV, ranges from 0.04 to 0.15 Hz. Whereas parasympathetic activity, classified as the high frequency (HF) component of HRV, ranges from 0.15 to 0.4 Hz [39]. The balance between both the activites is measured by the LF/HF power ratio. As a result of the interplay between the heart-brain interactions, HRV has been a reliable measure for cognitive performance [41-46]. It was reported by Thayer et al. (2009) that greater levels of heart rate variability directly correlated with a "better performance" in objectives requiring executive function. HRV has also shown to be a reliable indicator of affective states [42,47].

Electrodermal activity (EDA) or Galvanic Skin Response (GSR) refers to the changes of the electrical nature of the skin in response to sweat excretion [48]. These variations can be defined by tonic and phasic components. The tonic activity, the slower responding components of the signal are measured by Skin Conductance Level (SCL). The phasic activity reflects the faster changing elements of the overall EDA; this is measured by Skin Conductance Response (SCR). Both SCL and SCR are measured in microsiemens (μS) or micromho (μmho). The amplitude of a phasic SCR, representing a burst of sweat gland activation, is considered an expression of sympathetic activity [48].

## 1.2 **Purpose of the Thesis**

With so many different effects and dimensions of math anxiety being explored, this study replicated and elaborated on a previous study conducted by Faust (1992), namely the "Analysis of physiological reactivity in mathematics anxiety" [49]. Although there has been some research [50,51] that uses psychophysiological tools different than neurophysiological methods (i.e. fMRI and EEG) to investigate math anxiety, it has not been fully explored in a physiological pattern (i.e. HRV and EDA). Multiple studies have suggested physiology be more involved in the analysis of math anxiety [31, 38]

and further studies do not depend solely on self-report methods. This study has involved cardiac and electrodermal measures with relation to math anxiety.

## 1.3 **Hypothesis**

The hypothesis tested was that participants with higher math anxiety will have a higher electrodermal and cardiac response, validating the self-report methods previously used and establishing a more physical dimension to math anxiety research. A higher SCR, and LF/HF power ratio along with shorter RR intervals were all expected for participants with high math anxiety.

The motivations of this thesis are to understand a complicated and stimulus specific affect which might help in shaping the future of STEM enrollment and the field in general.

# CHAPTER 2

# METHODS AND MATERIALS

## 2.1 **Subjects**

The subjects were 34 undergraduate students (15 males and 19 females) in the social sciences who have had little experience with mathematics in recent years. 22 (11 males and 11 females) of which were selected for EDA analysis due to large artefact and outlier data. The participants were classified as high math anxious (HMA) or low math anxious (LMA) after a cluster analysis was performed on the Turkish translated MARS-SV results. This yielded 20 HMAs and 14 LMAs. 12 participants were removed from EDA analysis due to major artefact and outliers. Table 2.1 is the overall classification of participants in each sample.

Table 2.1 Classification of Participants

| **Classification of participants** | **HMA** | **LMA** |
|---|---|---|
| **HRV Sample** | 20 | 14 |
| **EDA Sample** | 10 | 12 |

It was hypothesized that if math anxiety presents a physiological response in terms of SCR it would be in the early stage of the presentation of the questions, therefore the SCRs were recorded within the first 1-3 seconds of the participant viewing the question as suggested by [52]. The minimum-amplitude measure for addition of SCRs was set to 0.01 μS.

## 2.2 **Instruments**

To properly classify the participants as math anxious the MARS-SV translated to Turkish (Baloglu, 2010) was used. The BIOPAC MP150 system, with the Bionomadix wireless ECG and GSR100C (with the TSD203 transducer) modules, was used at a sampling rate of 1000 Hz (1k Hz). AcqKnowledge 4.3 was used for acquisition. Kubios HRV (v2.2) [53] and Ledalab (v3.4.8) (www.ledalab.de) were used for analysis of the

ECG and EDA data, respectively. IBM SPSS Statistic 22 was used for statistical analysis.

### 2.2.1 BIOPAC MP150

The MP150 is a flexible, data acquisition device used simultaneously with BIOPAC's approved amplifiers and accessories. Figure 2.1 shows the front and back of the primary power module and essentially the MP150.


Figure 2.1 BIOPAC MP150

#### 2.2.1.1 BN-ECG2 Module

The BioNomadix system is a wireless, dual-channel physiological data acquiring platform. We used the BN-ECG2 to acquire data, as shown in Figure 2.2. It has dual channel ECG making it capable of 3 to 6 electrode configurations. Table 2.2 shows the further specifications of the BN-ECG module.


Figure 2.2 BN-ECG2 Module transmitter and receiver

Table 2.2 Specifications of BN-ECG

| | |
|---|---|
| **Bandlimits Max:** | 0.05 Hz to 150 Hz |
| **Factory preset:** | 1 Hz to 35 Hz |
| **Filter options:** | 0.05 or 1 Hz HP, 35 or 150 Hz LP |
| **Notch filter:** | 50/60 Hz user-controlled switch |
| **Noise Voltage (shorted inputs):** | 0.9 µV rms (bandwidth of 0.05 Hz to 150 Hz) |
| **Input Voltage Range:** | up to 10 mV P-P |
| **Output Voltage Range:** | ±10 V (receiver output) |
| **CMRR** | 90dB minimum at 50/60Hz |
| **CMII** | 1000 MΩ (50/60 Hz) |
| **Fixed Gain:** | 2,000 |

#### 2.2.1.2 GSR100C Module

The EDA100C electrodermal activity amplifier module (Shown in figure 2.3) is a single-channel, high-gain, differential amplifier that measures skin conductance. Its variable ranges and other specifications are listed in table 2.3. The TSD203 transducer was used with it.


Figure 2.3 GSR100C Module

Table 2.3 Specifications of GSR100C

| | |
|---|---|
| **Gain** | 20, 10, 5, 2 µS /volt |
| **INPUT SIGNAL RANGE** | |
| **Gain** | **Range (µS)** |
| 20 | 0 – 200 |
| 10 | 0 – 100 |
| 5 | 0 – 50 |
| 2 | 0 – 20 |
| **Low Pass Filter** | 1 Hz, 10 Hz |
| **High Pass Filter** | DC, 0.05 Hz, 0.5 Hz |
| **Sensitivity:** | 0.7 nS (with MP System) |
| **Excitation Voltage:** | 0.5 VDC (Constant Voltage) |
| **Output Voltage Range:** | 0-10 V nominal, ±10 V full (analog) |

The TSD203 transducer has 2 velcro straps with two Ag/AgCl 6 mm electrodes. It is usually connected to the 1st and 2nd fingers of the subjects's non-dominant hand, shown in figure 2.4.

Figure 2.4 TSD203 Transducer

Figure 2.5 shows all the necessary BIOPAC modules connected together and prepared for acquisition.


Figure 2.5 All modules attached

### 2.2.2 AcqKnowledge 4.3

AcqKnowledge 4.3 is an interactive, easy-to-use software that enables you to instantly view, measure, analyze and manipulate data. This program is used to acquire data, stimulation, triggering and analyses through pull-down menus and text dialogs. Figure 2.6 shows the graphical interface of the software during acquisition. Label 1-3 show the acquisition of ECG, skin temperature and electrodermal data respectively.

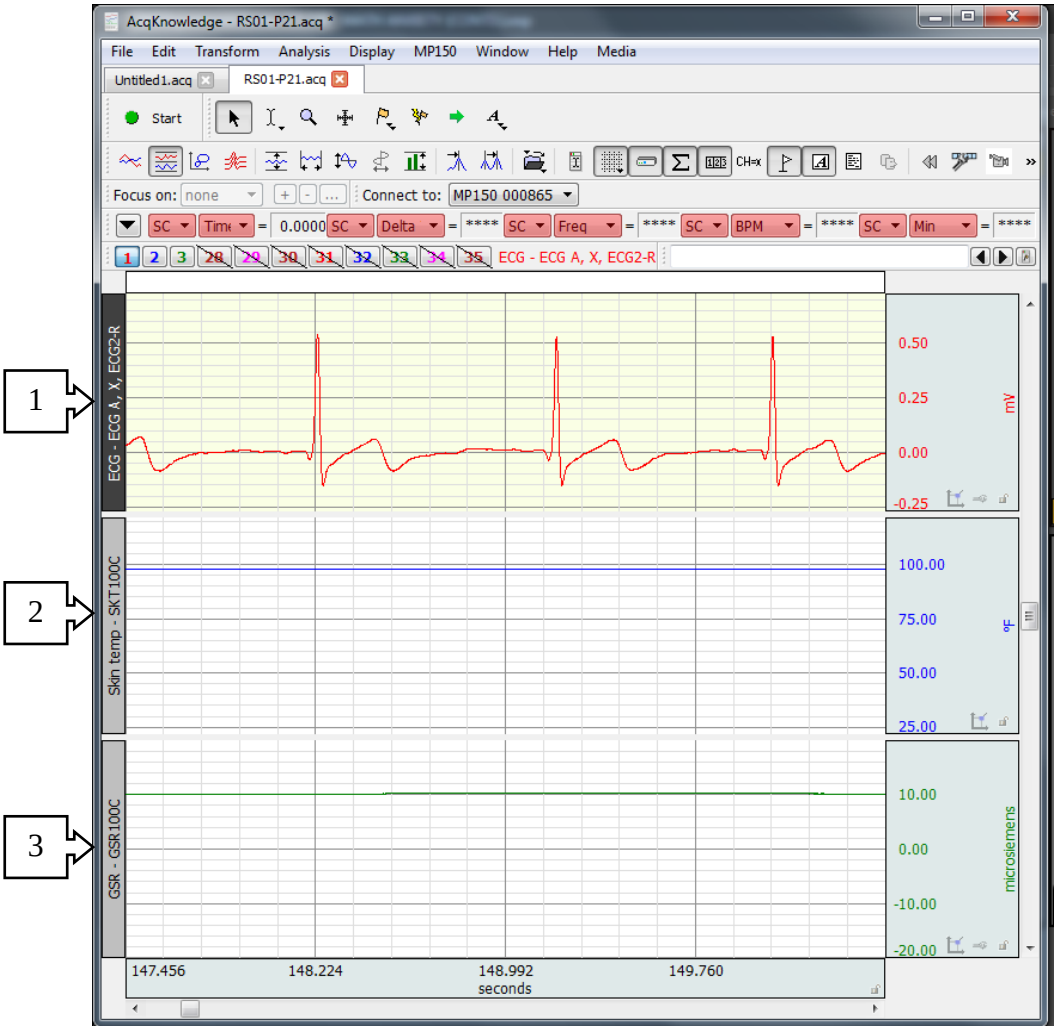


Figure 2.6 AcqKnowledge Graphical Interface

### 2.2.3 Ledalab(v3.4.8)

Ledalab is a Matlab-based software for the analysis of skin conductance data. It uses a continuous decomposition analysis (CDA) technique to seperate skin conductance (SC) data into two different continuous signals of tonic and phasic activity [48]. Figure 2.7 displays its interface and results. Label 1 shows the overall acquired skin conductance data. Label 2 shows a specific region of interest after the calculation. The grey section indicates the tonic activity whereas the blue indicates the phasic. The third label, label 3, is only the phasic activity of the overall EDA, acquired by subtracting the phasic elements from the overall data.

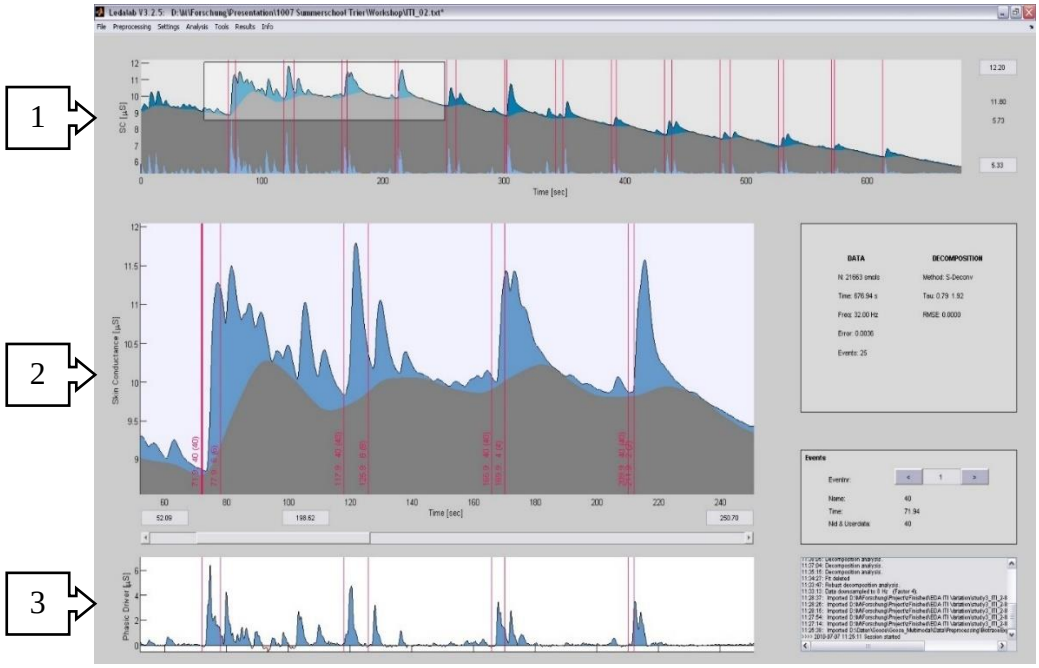


Figure 2.7 Ledalab Graphical Interface

### 2.2.4 Kubios HRV (v 2.2)

Kubios HRV, is a free open software developed using MATLAB® release 2012a (The MathWorks, Inc.). It was used to process the RR interval series as well as the LF/HF ratio. Adaptive filtering was used pre-processing. Time domain measures such as RR-interval and frequency domain measures such as LF/HF were calculated. Figure 2.8 is the graphic interface of the software. Label 1 shows the RR series options, showing artifact correction levels, detrending options and basic sample manipulation options. Label 2 is the data browser, showing the ECG data and the tachogram so visual correction can be done with ease. Label 3 highlights the various analysis options in the software which include selection frequency bands, interpolation rate, and spectrum estimation specifics such as window width and overlap for FFT and model order and factorization for AR. Label 4 shows the results in the time-domain, frequency-domain and nonlinear factors.

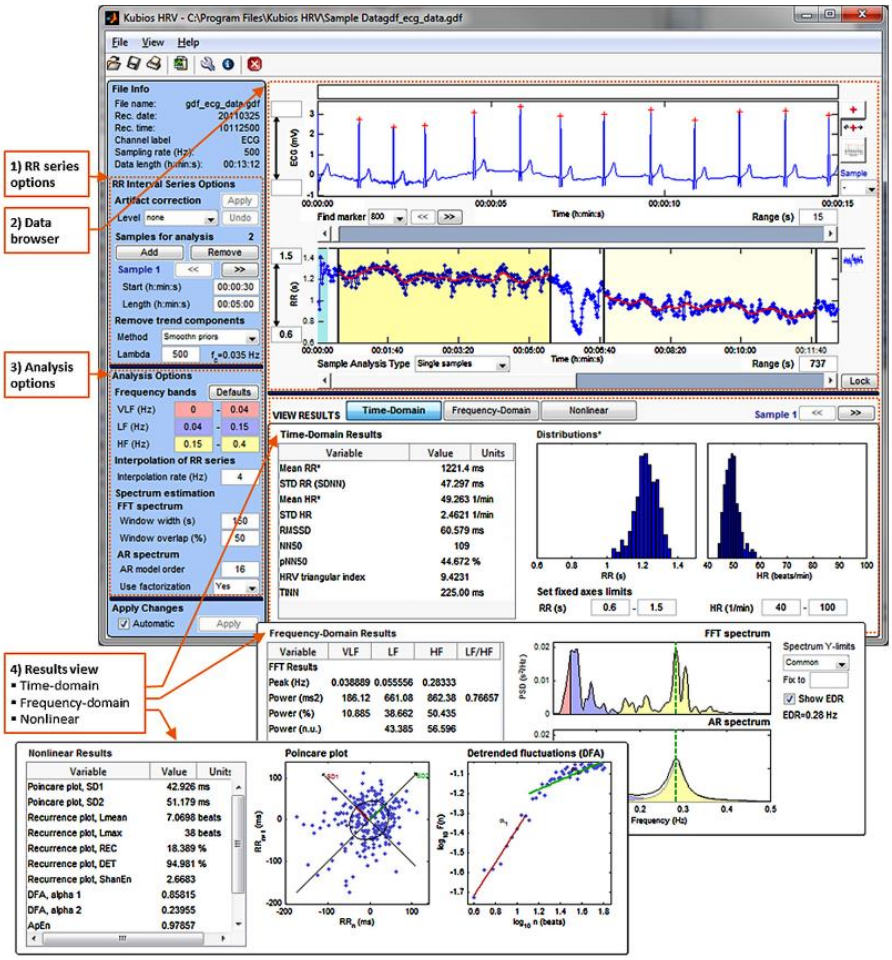


Figure 2.8 Kubios HRV Graphical Interface

### 2.2.5 MARS-SV

The MARS-SV is a 30-item math anxiety assessment questionnaire, using a five-point Likert scale (From 1 to 5). A Turkish translation was developed by Baloglu (2010) [54].

## 2.3 **Methodology**

In this study we measured the heart rate variability (HRV) of 34 undergraduate students as they took a mathematics test. The participants were first put through a 3-min resting baseline period with nothing on the screen (Referred to as B1). They were then presented with 4 comprehension questions, free from any mathematics (Referred to as the TEXT section). A second baseline period was introduced to remove any effects of the latent anxiety observed in the previous section (Referred to as the B2 section). 8

mathematics questions were then presented (Referred to as the MATH1 section). A third baseline (B3) followed the previous section but this one had classical Turkish music played in the background. Previous research suggests some effects of relaxing music on math anxiety and more specifically classical Turkish Music having some impact on human physiology [55, 56,57]. Therefore, we also wanted to investigate its effects in our study as well. 8 different mathematics questions, but with similar difficulty, were given in the final section (MATH2), thus concluding the experiment. This procedure is reflected in figure 2.9 with blocks representing each condition of the experiment.

This method had a total of 20 questions and 39 minutes' completion time. (3 minutes for each baseline, and 3 minutes for every two questions).

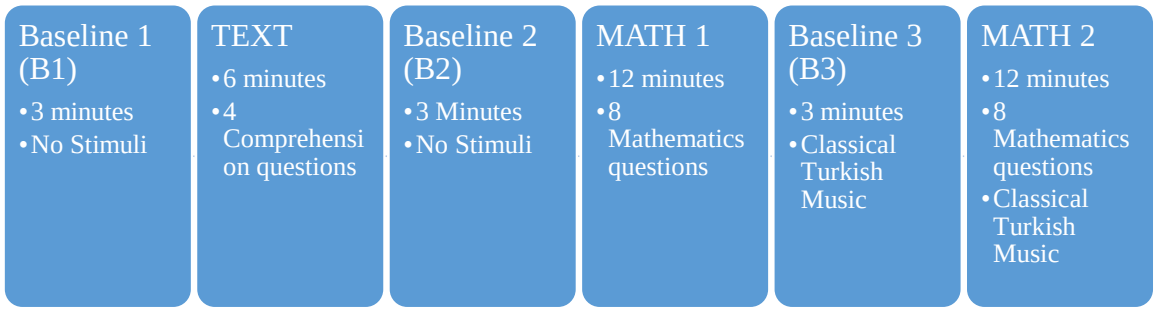


Figure 2.9 Block diagram of experiment

### 2.3.1 Laboratory Set Up

This section elaborates on the participants' experience and experimental set up before and during the examination. The participant was first introduced to the devices and their functions and the researcher answered any questions they had about the procedure. Once comfortably seated, the participant was asked to minimize movement, to reduce any artefact in the data and inform the researcher if any discomfort was felt during the process. The TSD203 transducer was then connected to the participants' index and middle finger of their non-dominant hand (See Figure 2.4) and the BN-ECG transmitter and electrodes were connected to the participants' chest.

All phones and devices were turned off during the examination to prevent any distractions or disturbances to the participant. A barrier was present between them to prevent any anxiety that might be triggered due to being observed.

A representation of the laboratory is shown in figure 2.10. The red figure represents the researcher and the purple one the participant. The questions were presented through the stimulus screen and a mouse was provided to answer the questions. The researcher's computer was used to acquire data as well as present the examination. Photographs of the actual arrangement are shown in figure 2.11 and 2.12.

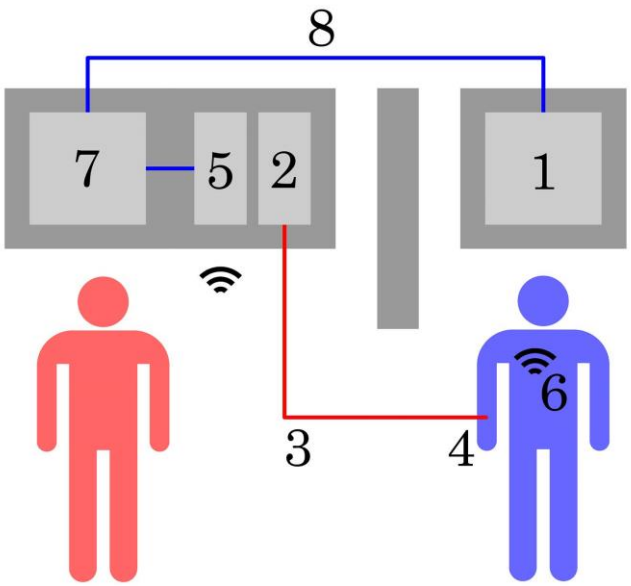


Figure 2.10 Block Representation of laboratory

1= Stimuli Screen; 2=GSR100C Module; 3= TSD203 Transducer; 4 = Connection at fingers; 5= BN-ECG2 Receiver module; 6= BN- ECG2 Transmitter module; 7= Control and acquisition PC; 8= Connection between PC and screen; Red figure= Researcher; Purple figure= Participant.

The area on the left in figure 2.11 shows the researchers area with the Biopac modules connected, the area on the right shows the participants section for the procedure.

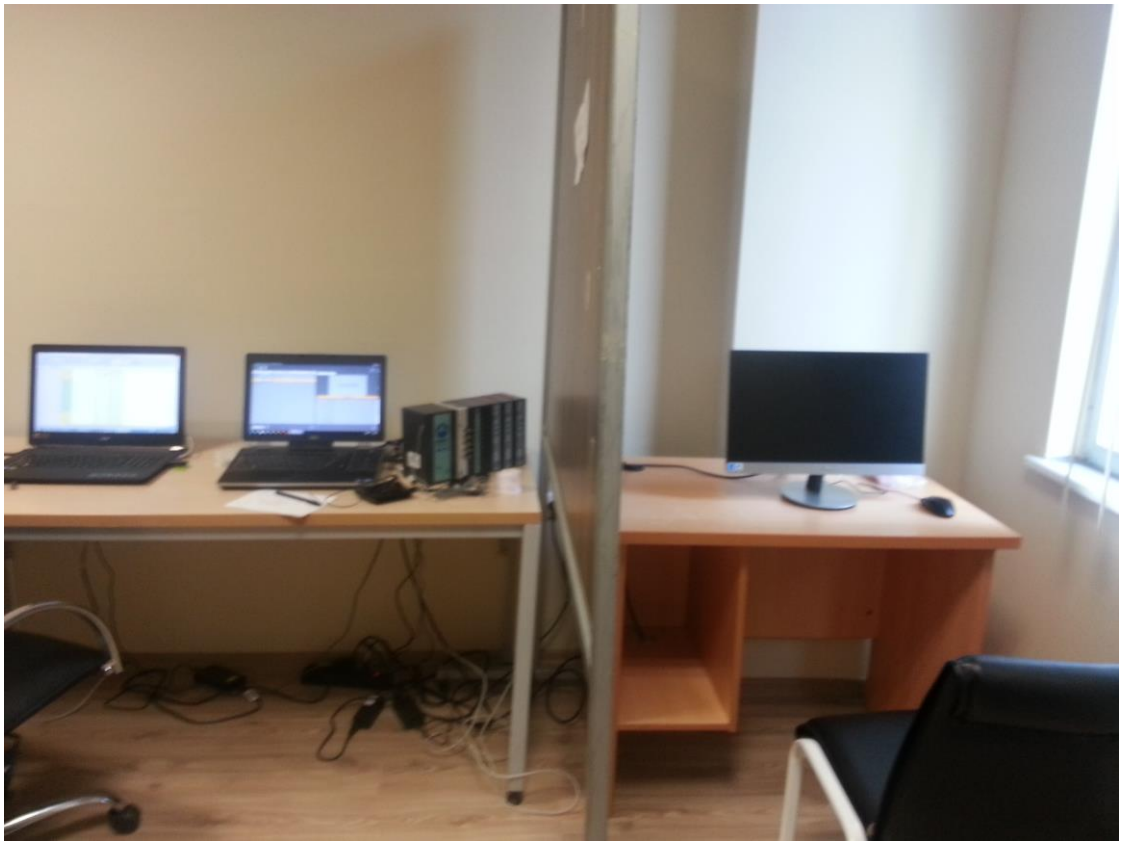

Figure 2.11 Picture of laboratory

Figure 2.12 shows the researchers and participants' desks during acquisition of data.

Figure 2.12 Left: Researchers desk; Right: Participant and Stimuli Screen

# CHAPTER 3

# RESULTS

The means of all the HMAs and LMAs were calculated for the RR Intervals, power of the LF/HF ratio, using an autoregressive (AR) model; and SCRs in all the phases of the experiment. Their means were first compared using an independent t-test to observe any major differences between the two groups. Afterwards, the repeated measures ANOVA test was used to compare any differences observed throughout the experimental period.

## 3.1 **Heart Rate Variability**

This section analyzes the RR Intervals and the LF/HF power of the participants throughout the experiment. Table 3.1 is a summary of the data. Figures 3.1 and 3.2 are bar chart representations and comparisons of the RR intervals and LF/HF, respectively, for HMAs and LMAs.

Table 3.1 Descriptive Statistics of HRV

| | **HMA (N = 20)** | | | | **LMA (N = 14)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **LF/HF (ms2)** | **Std. Dev.** | **RR (ms)** | **Std. Dev.** | **LF/HF (ms2)** | **Std. Dev.** | **RR (ms)** | **Std. Dev.** |
| **B1** | 3.24 | 0.35 | 740.01 | 108.42 | 1.94 | 0.42 | 802.05 | 124.70 |
| **TEXT** | 2.67 | 0.38 | 736.17 | 103.39 | 2.40 | 0.45 | 776.29 | 117.17 |
| **B2** | 3.36 | 0.39 | 742.48 | 91.61 | 2.44 | 0.46 | 808.81 | 111.32 |
| **MATH1** | 3.14 | 0.41 | 748.32 | 93.86 | 2.90 | 0.49 | 778.64 | 120.70 |
| **B3** | 3.70 | 0.53 | 769.60 | 91.02 | 3.11 | 0.64 | 805.42 | 110.16 |
| **MATH2** | 3.52 | 0.55 | 750.04 | 93.34 | 3.47 | 0.66 | 774.81 | 110.87 |

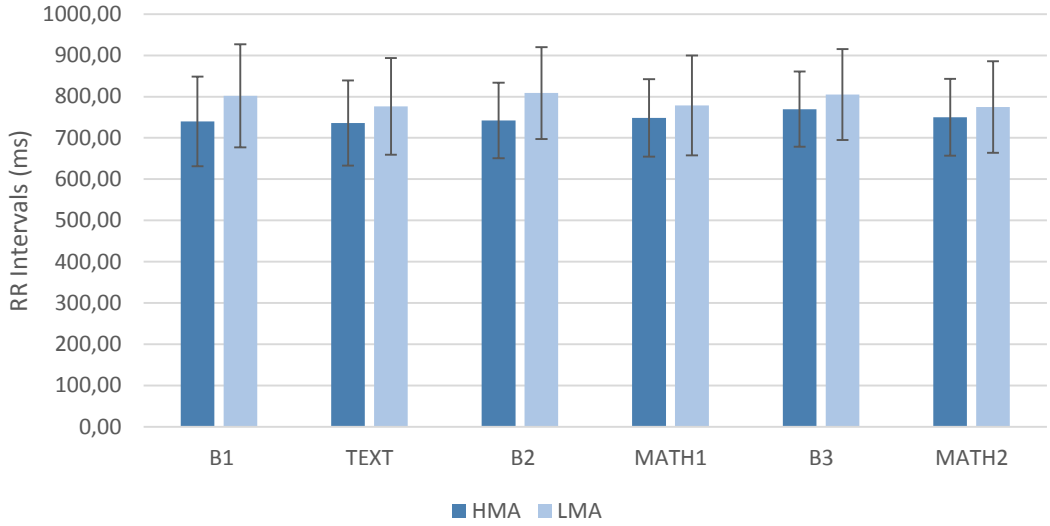


Figure 3.1 Comparison of RR Intervals

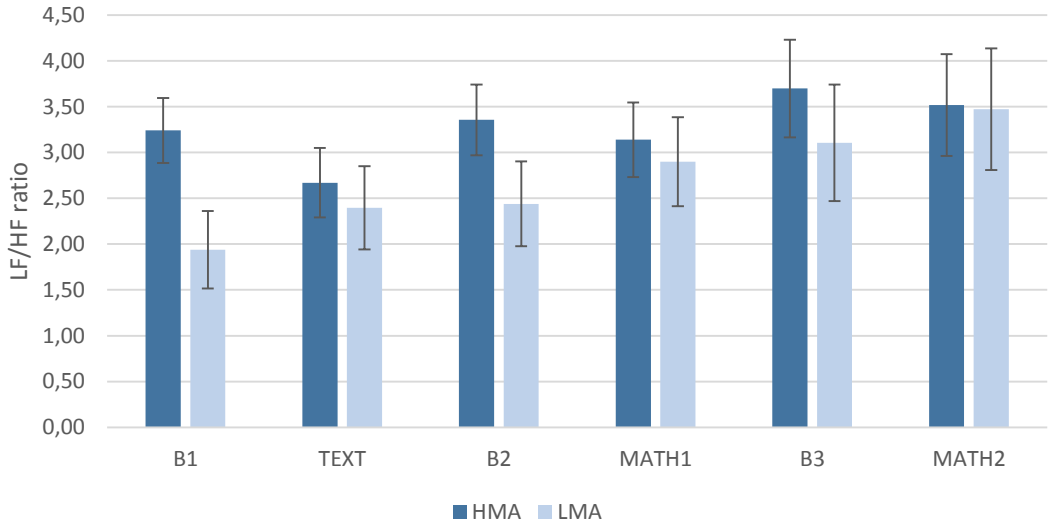


Figure 3.2 Comparison of LF/HF ratio

From the independent sample t-test, equal and unequal variances, it was seen that the HRV was not statistically different between those with high math anxiety and those with low math anxiety (For RR intervals, $p = 0.227$; For LF/HF power, $p = 0.310$).

Repeated measures ANOVA was used to analyze the different conditions. For RR intervals, mauchly's test of sphericity was violated ($\chi^2$ (14) = 66.792; $p < 0.05$). Therefore, Greenhouse-Geisser estimates were used to correct degrees of freedom

(ε=0.57). The result showed difference in HRV between HMA and LMA throughout the test (F (2.811, 89.938) = 3.736; $p < 0.05$; $\eta^2 = 0.1$).

For LF/HF power, mauchly's test of sphericity was violated ($\chi 2$ (14) = 34.405; $p < 0.05$). We used Huynh-Feldt estimates (ε=0.85). No significant difference was noted between HMAs and LMAs throughout the procedure (F (4.278, 136.097) = 1.048; p = 0.387).

Tables 3.2 and 3.3 show the differences for LMA and HMA, respectively, in terms of RR intervals through the various conditions and comparisons of all the conditions with each other.

Table 3.2 Significance of difference between LMAs' RR Intervals

| | **B1** | **TEXT** | **B2** | **MATH1** | **B3** | **MATH2** |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | **0.00** | x | | | | |
| **B2** | 0.43 | **0.00** | x | | | |
| **MATH1** | **0.01** | 0.74 | **0.00** | x | | |
| **B3** | 0.75 | **0.01** | 0.46 | **0.01** | x | |
| **MATH2** | **0.02** | 0.85 | **0.00** | 0.48 | **0.00** | **x** |

Table 3.3 Significance of difference between HMAs' RR Intervals

| | **B1** | **TEXT** | **B2** | **MATH1** | **B3** | **MATH2** |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | 0.55 | x | | | | |
| **B2** | 0.74 | 0.40 | x | | | |
| **MATH1** | 0.35 | 0.12 | 0.50 | x | | |
| **B3** | **0.02** | **0.01** | **0.01** | **0.02** | x | |
| **MATH2** | 0.38 | 0.22 | 0.49 | 0.73 | **0.02** | x |

It can be seen through Table 3.2, that LMAs have had more significant changes throughout the examination (B1 to TEXT, TEXT to B2, B2 to MATH1, MATH1 to B3 and B3 to MATH2, $p < 0.05$). There was also a significant difference observed between all the baseline periods (B1, B2 and B3) and all the test conditions (TEXT, MATH1 and MATH2). For high math anxious participants (Table 3.3) the significant differences were observed mostly when a condition was being compared to B3 and when moving from B3 to MATH2.

Tables 3.4 and 3.5 show the differences for LMA and HMA, respectively, in terms of LF/HF ratio throughout the various conditions and comparisons of all the conditions with each other.

Table 3.4 Significance of difference between LMAs' LF/HF ratio

| | **B1** | **TEXT** | **B2** | **MATH1** | **B3** | **MATH2** |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | 0.27 | x | | | | |
| **B2** | 0.14 | 0.87 | x | | | |
| **MATH1** | 0.06 | **0.01** | 0.23 | x | | |
| **B3** | **0.01** | **0.01** | 0.07 | 0.48 | x | |
| **MATH2** | **0.02** | **0.00** | **0.04** | 0.13 | 0.43 | x |

Table 3.5 Significance of difference between HMAs' LF/HF ratio

| | **B1** | **TEXT** | **B2** | **MATH1** | **B3** | **MATH2** |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | 0.16 | x | | | | |
| **B2** | 0.82 | 0.13 | x | | | |
| **MATH1** | 0.82 | 0.28 | 0.58 | x | | |
| **B3** | 0.46 | 0.11 | 0.42 | 0.29 | x | |
| **MATH2** | 0.62 | 0.06 | 0.77 | 0.22 | 0.75 | x |

Table 3.4 indicates that LMAs had differences between TEXT and MATH1, B3 and MATH2 conditions. B1 and B3 and MATH2 were also statistically different, and B2 and MATH2 were also different. There were no significant changes observed in the frequency domain in terms of LF/HF for HMAs from Table 3.5.

Although statistically insignificant, it is worthy of note that HMAs had generally more arousal in all conditions. An increase in the difference was particularly noticeable in all the baseline periods for both time and frequency domain.

Figures 3.3 and 3.4 show the changes in RR intervals and LF/HF ratio for both groups throughout the procedure and reflect the changes between the two groups' reactivity.

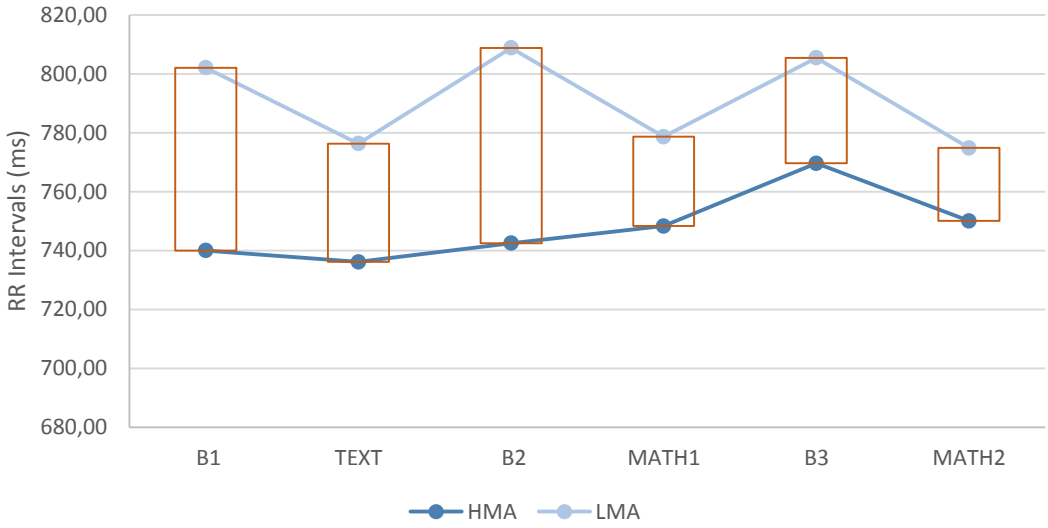


Figure 3.3 Changes in participants' RR intervals through examination

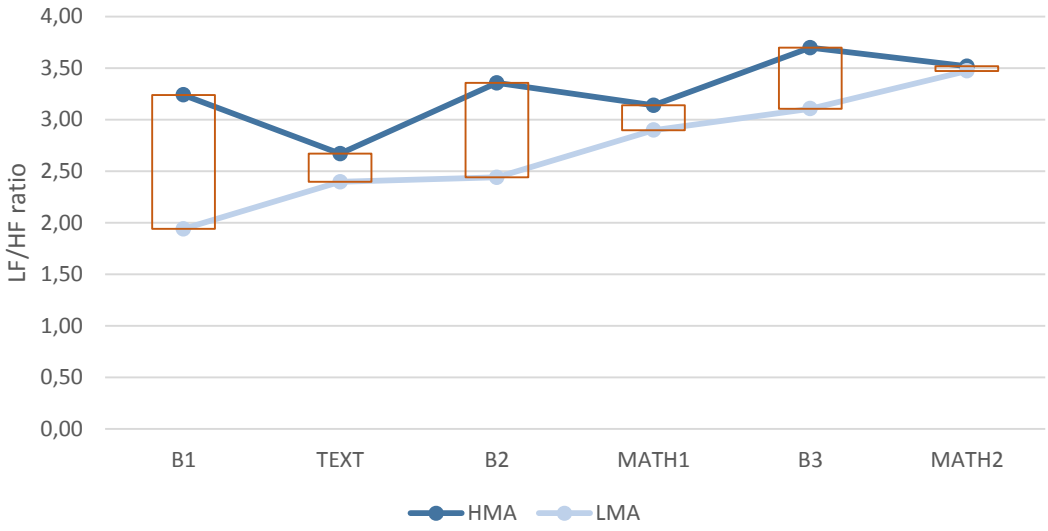


Figure 3.4 Changes in participants' LF/HF ratio through examination

## 3.2 **Skin Conductance Response**

This section analyzes the skin conductance response (SCR) of the participants throughout the experiment. Table 3.6 is a summary of the data. Figure 3.5 is a bar chart representation and comparison of the SCRs for HMAs and LMAs.

Table 3.6 Descriptive Statistics of SCR

| | HMA (N=10) | | LMA (N=12) | |
|---|---|---|---|---|
| | **Mean(μS)** | **Std. Error** | **Mean(μS)** | **Std. Error** |
| **B1** | .305 | .149 | .466 | .136 |
| **TEXT** | .651 | .154 | .438 | .141 |
| **B2** | .464 | .247 | .542 | .226 |
| **MATH1** | .437 | .141 | .418 | .128 |
| **B3** | .740 | .289 | .265 | .264 |
| **MATH2** | .518 | .126 | .541 | .115 |

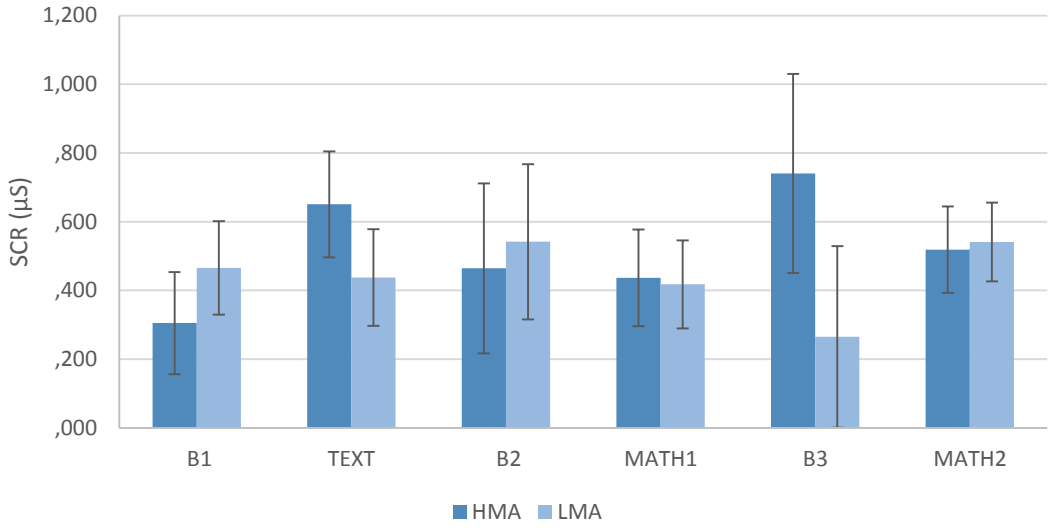


Figure 3.5 Comparison of SCRs

Repeated measures ANOVA was used to analyze the different conditions. Mauchly's Test of Sphericity was violated ($\chi 2$ (14) = 39.647; $p < 0.05$). Therefore, Greenhouse-Geisser estimates were used to correct degrees of freedom ($\varepsilon$=0.69). No significant difference in terms of SCR were noted between HMA and LMA throughout the test. (F (2.773, 55.45) = 1.452; p = 0.239).

Tables 3.7 and 3.8 show the differences for LMA and HMA, respectively, in terms SCRs through the various conditions and comparisons of all the conditions with each other.

Table 3.7 Significance of difference between HMAs' SCRs

| | B1 | TEXT | B2 | MATH1 | B3 | MATH2 |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | 0.14 | x | | | | |
| **B2** | 0.21 | 0.16 | x | | | |
| **MATH1** | 0.07 | 0.16 | 0.25 | x | | |
| **B3** | 0.31 | 0.34 | 0.34 | 0.29 | x | |
| **MATH2** | 0.07 | 0.14 | 0.19 | 0.09 | 0.24 | x |

Table 3.8 Significance of difference between LMAs' SCRs

| | B1 | TEXT | B2 | MATH1 | B3 | MATH2 |
|---|---|---|---|---|---|---|
| **B1** | x | | | | | |
| **TEXT** | 0.85 | x | | | | |
| **B2** | 0.79 | 0.63 | x | | | |
| **MATH1** | 0.74 | 0.84 | 0.52 | x | | |
| **B3** | 0.24 | 0.16 | 0.23 | 0.09 | x | |
| **MATH2** | 0.66 | 0.34 | 1.00 | 0.22 | **0.02** | x |

Figures 3.6 shows the changes in SCR for both groups throughout the procedure and reflect the changes between the two groups' reactivity.

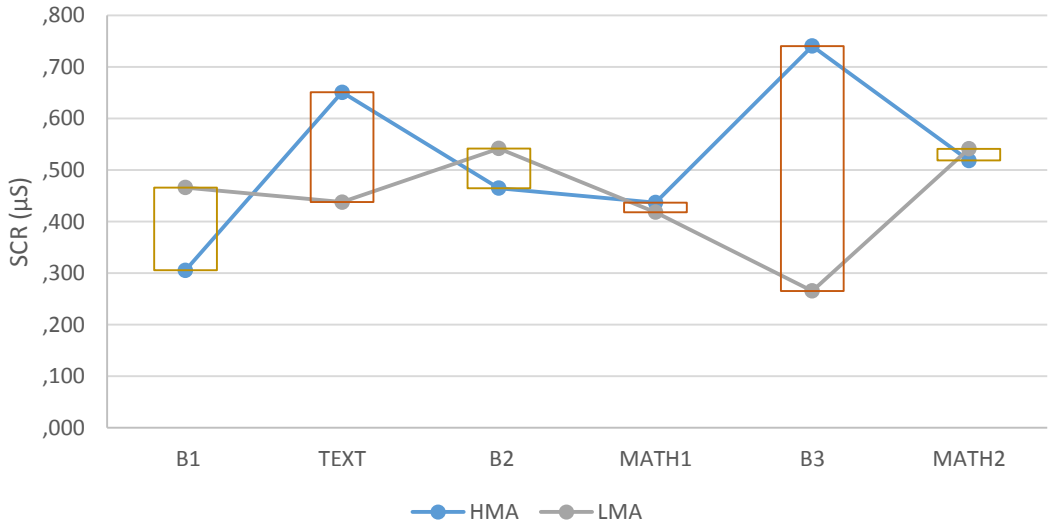


Figure 3.6 Changes in participants' SCRs through examination

Even though it is statistically insignificant it should be observed that high math anxious participants had higher arousal in the testing conditions TEXT and MATH1, in MATH2 however, there was minute difference observed which can be considered artefact.

# CHAPTER 4

## DISCUSSION

In this study we tested the dynamic among HRV, electrodermal activity and math anxiety. Math anxiety is usually gauged using self-report measures which are subject to certain criticisms. Since it has not been explored extensively in a physiological sense we tried to fill the gap in the literature.

Math anxiety has been known to have a stronger physiological response, and that is what we expected to find in the physiological sense. Lower HRV, higher LF/HF and higher EDA indicating higher anxiety and sympathetic activity [49, 58].

It was noted that there was no statistical difference between participants with high math anxiety and low math anxiety, this might indicate that math anxiety does not have a very strong physiological trigger or this might be due to the inherent test anxiety in the experimental situation, or perhaps the sample size was not large enough to notice any statistically viable differences.

However, high math anxious subjects (HMAs) had visibly lower heart rate variability, shorter RR intervals, throughout the examination period. This could be due to the inherent anxiety build of being told they were about to perform math tasks beforehand, thus increasing their cardiac responses before the experiment even began. Their LMA counter parts had a more viable baseline as there wasn't much of built up anxiety. A similar observation was made in Gan et al. (2015), when participants had already been aroused prior to any testing [55].

Subjects with lower math anxiety were noted to have more changes throughout the examination, that is to say they were more responsive than subjects with high math anxiety. The most difference between the two groups was noted during the three baseline periods, this suggests that the anticipation of the upcoming task increases the sympathetic response for high math anxious individuals, similar to [6, 12].

Although the level of arousal gradually increases throughout the procedure, the physiological difference between the groups reduced during testing conditions, but still

remained somewhat higher for the HMA group. This suggests that there might be some carry-over anxiety from the baseline period of the anticipation and difference in the coping mechanism employed by both groups to reduce that anxiety.

The Turkish classical music had an overall effect of the increase of heart rate variability in both HMA and LMAs. Although after the introduction of math the HRV fell again, regardless of music. This suggests that the Turkish classical music had an effect in the reduction of general anxiety but with math made LMAs susceptible to anxiety otherwise absent.

## CONCLUSIONS AND RECOMMENDATIONS

There have been some limitations of the present study. The participants were undergraduate students; in the future a younger sample size would help understand the emergence of physiological responses. Further research should also consider other sources of anxiety, such as hormonal gender differences and avoidance tendencies.

In conclusion, this study suggests that math anxiety in dimensions of self-reports, cardiovascular and electrodermal measurements are moderately correlated. Even though, there was no statistical difference between participants with high and low math anxiety, the stronger reactions in the HMAs suggest that they are more susceptible to levels of anxiety, making self-reports still reliant in assessing math anxiety. Although the relationship between physiology and self-reports regarding math anxiety need to be explored more thoroughly.

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# APPENDICES

## APPENDIX A – MARS - SV

This study used a 30-item Mathematics Anxiety Rating Scale-Short Version (MARS-SV). MARS-SV was a derivation from the 98-item Mathematics Anxiety Rating Scale (MARS) which was made by Suinn and Winston (2003). The short version of MARS was reviewed since the original instrument was a long and time consuming tool with several dimensions. The Mathematics Anxiety Rating Scale-Short Version (MARS-SV) was translated into Turkish by Baloğlu (2010) and this translation of the scale was used in this present study. The short and translated Mathematics Anxiety Rating Scale is a five-point Likert scale (from 1. not at all to 5. very much).

## A-1 Turkish Translation

1- "Hiç kaygılanmam," 2- "Çok az kaygılanırım," 3- "Kaygılanırım," 4- "Epeyce kaygılanırım" ve 5- "Aşırı derecede kaygılanırım"

| | | **Hiç kaygılanmam** | **Çok az kaygılanırım** | **Kaygılanırım** | **Epeyce kaygılanırım** | **Aşırı derecede kaygılanırım** |
|---|---|---|---|---|---|---|
| 1. | Bir matematik dersinin dönem sonu sınavına girmekten | 1 | 2 | 3 | 4 | 5 |
| 2. | Bir hafta öncesinden bir matematik sınavını düşündüğümde | 1 | 2 | 3 | 4 | 5 |
| 3. | Bir gün öncesinden bir matematik sınavını düşündüğümde | 1 | 2 | 3 | 4 | 5 |
| 4. | Bir saat öncesinden bir matematik sınavını düşündüğümde | 1 | 2 | 3 | 4 | 5 |
| 5. | Beş dakika öncesinden bir matematik sınavını düşündüğümde | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6. | İyi geçtiğini düşündüğüm bir matematik sınavının sonucunun ilan edilmesini beklerken | 1 | 2 | 3 | 4 | 5 |
| 7. | Karnemde yıl sonu matematik notumu gördüğümde | 1 | 2 | 3 | 4 | 5 |
| 8. | Mezun olabilmek için belli sayıda matematik dersini tamamlamak zorunda olduğumu fark ettiğimde | 1 | 2 | 3 | 4 | 5 |
| 9. | Matematik dersinde daha önceden haber verilmemiş quiz tipi bir sınava girdiğimde | 1 | 2 | 3 | 4 | 5 |
| 10. | Matematik sınavına çalışırken | 1 | 2 | 3 | 4 | 5 |
| 11. | Ö.S.S. gibi bir standart testin matematik bölümünü cevaplandırırken | 1 | 2 | 3 | 4 | 5 |
| 12. | Bir matematik dersinin ara sınavına girmekten | 1 | 2 | 3 | 4 | 5 |
| 13. | Ödevimi yapmak için matematik kitabımı elime aldığımda | 1 | 2 | 3 | 4 | 5 |
| 14. | Bir sonraki derse getirilmek üzere, içerisinde birçok zor matematik problemi bulunan bir ev ödevi verildiğinde | 1 | 2 | 3 | 4 | 5 |
| 15. | Bir matematik sınavı için çalışmaya hazırlanırken | 1 | 2 | 3 | 4 | 5 |
| 16. | Beş basamaklı bir sayıyı iki basamaklı bir sayıya bölme işlemini, kağıt-kalemle, tek başıma yaparken | 1 | 2 | 3 | 4 | 5 |
| 17. | Kağıt üzerinde 976+777 toplamasını yaparken | 1 | 2 | 3 | 4 | 5 |
| 18. | Alışverişten sonra kasa fişini okurken | 1 | 2 | 3 | 4 | 5 |
| 19. | 1 Türk Lirası'ndan daha pahalı bir malın KDV'sini hesaplarken | 1 | 2 | 3 | 4 | 5 |
| 20. | Aylık gelir ve giderlerimi hesaplarken | 1 | 2 | 3 | 4 | 5 |
| 21. | Benden kağıt üzerinde bir dizi toplama işlemi yapmam istendiğinde | 1 | 2 | 3 | 4 | 5 |
| 22. | Alt alta bir dizi sayıyı toplarken birinin beni izlemesinden | 1 | 2 | 3 | 4 | 5 |
| 23. | Bir yemek sonrasında, fazla ödeme yaptığımı düşündüğümde, hesabı yeniden toplarken | 1 | 2 | 3 | 4 | 5 |
| 24. | Bir dernekte aidatları toplayarak, toplanan miktarı takip etmekten sorumlu kişi olmaktan | 1 | 2 | 3 | 4 | 5 |
| 25. | Ehliyet sınavına çalışırken, gerekli rakamları ezberlerken (Örneğin: Farklı hızlarda giden araçların durmaları için gerekli minimum mesafeler gibi.) | 1 | 2 | 3 | 4 | 5 |
| 26. | Üyesi olduğum derneğe gelen aidatların ve dernek harcamalarının hesabını yapmaktan | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 27. | Hesap makinesi ile işlem yapan birini izlerken | 1 | 2 | 3 | 4 | 5 |
| 28. | Benden kağıt üzerinde bir dizi bölme işlemi yapmam istendiğinde | 1 | 2 | 3 | 4 | 5 |
| 29. | Benden kağıt üzerinde bir dizi çıkarma işlemi yapmam istendiğinde | 1 | 2 | 3 | 4 | 5 |
| 30. | Benden kağıt üzerinde bir dizi çarpma işlemi yapmam istendiğinde | 1 | 2 | 3 | 4 | 5 |

**A-2 Original Version**

In this scale, the questions refer to things and experiences that may cause fear or apprehension. Please describe how much fear is associated with each item by choosing 1- "Not at all," 2- "A little", 3- "A fair amount," 4- "Much" and 5- "Very much". Please work quickly but consider each item carefully and throughly.

| | | **Not at all** | **A little** | **A fair Amount** | **Much** | **Very Much** |
|---|---|---|---|---|---|---|
| 1 | Taking an examination (final) in a math course | 1 | 2 | 3 | 4 | 5 |
| 2 | Thinking about an upcoming math test 1 week before | 1 | 2 | 3 | 4 | 5 |
| 3 | Thinking about an upcoming math test 1 day before | 1 | 2 | 3 | 4 | 5 |
| 4 | Thinking about an upcoming math test 1 hour before | 1 | 2 | 3 | 4 | 5 |
| 5 | Thinking about an upcoming math test 5 minutes before | 1 | 2 | 3 | 4 | 5 |
| 6 | Waiting to get a math test returned in which you expected to do well. | 1 | 2 | 3 | 4 | 5 |
| 7 | Receiving your final math grade in the mail (report ) | 1 | 2 | 3 | 4 | 5 |
| 8 | Realizing that you have to take a certain number of math classes to fulfil the requirements for graduations. | 1 | 2 | 3 | 4 | 5 |
| 9 | Being given a "pop" quiz in a math class. | 1 | 2 | 3 | 4 | 5 |
| 10 | Studying for a math test | 1 | 2 | 3 | 4 | 5 |
| 11 | Taking the math section of a college entrance exam like LGS-LYS | 1 | 2 | 3 | 4 | 5 |
| 12 | Taking an examination (midterm) in a math course | 1 | 2 | 3 | 4 | 5 |
| 13 | Picking up a math textbook to begin working on a homework assignment. | 1 | 2 | 3 | 4 | 5 |
| 14 | Being given a homework assignment of many difficult problems which is due to next class meeting. | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | Getting ready to study for a math test. | 1 | 2 | 3 | 4 | 5 |
| 16 | Dividing a five digit number by a two digit number in private with pencil and paper | 1 | 2 | 3 | 4 | 5 |
| 17 | Adding up 976+777 on paper | 1 | 2 | 3 | 4 | 5 |
| 18 | Reading a cash register receipt after you purchase. | 1 | 2 | 3 | 4 | 5 |
| 19 | Figuring the sales tax (KDV) on a purchase that costs more than 1 Turkish Lira | 1 | 2 | 3 | 4 | 5 |
| 20 | Figuring out your monthly budget | 1 | 2 | 3 | 4 | 5 |
| 21 | Being given a set of numerical problems involving addition to solve on paper | 1 | 2 | 3 | 4 | 5 |
| 22 | Having someone watch you as you total up a column of figures | 1 | 2 | 3 | 4 | 5 |
| 23 | Totalling up a dinner that you think overcharged you. | 1 | 2 | 3 | 4 | 5 |
| 24 | Being responsible for collecting dues for an organization and keeping track of the amount | 1 | 2 | 3 | 4 | 5 |
| 25 | Studying for a driver's licence test and memorizing the figures involved such as the distances it takes to stop a car going at different speeds | 1 | 2 | 3 | 4 | 5 |
| 26 | Totalling up the dues received and the expenses of a club you belong to | 1 | 2 | 3 | 4 | 5 |
| 27 | Watching someone work with a calculator | 1 | 2 | 3 | 4 | 5 |
| 28 | Being given a set of division problems to solve on paper | 1 | 2 | 3 | 4 | 5 |
| 29 | Being given a set of subtraction problems to solve on paper | 1 | 2 | 3 | 4 | 5 |
| 30 | Being given a set of multiplication problems to solve on paper | 1 | 2 | 3 | 4 | 5 |

# APPENDIX B – Presented Stimuli

## B-1 Baseline (B1)

Şimdi ilk olarak size Sözel Sorulardan oluşmuş kısa bir test uygulanacaktır.

Test sırasında 2 farklı metin okumanız istenecek ve her metin ile ilgili olarak 2 soru yanıtlamanızı rica ediyoruz.

Toplamda bu bölüm kapsamında 4 soru yanıtlamış olacaksınız. Lütfen olabildiğince bütün soruları doğru olarak yanıtlamaya çalışınız. Bu bölüm için size ayrılmış toplam süre 6 dakikadır.

## B-2 Comprehension questions (TEXT)

Dünya, milyonlarca insanı ekran karşısına çeken ve gelmiş geçmiş en iyi televizyon dizilerinden biri olarak kabul edilen "Lost" un sonunu büyük bir merakla bekliyor. Tamamen kurguya dayalı, ıssız bir adada geçen bu diziye, sürekli yeni karakterler eklenerek, ölen karakterler hikâyeye yeniden alınarak ve karakterlerin hikâyeleri geçmiş, şimdi ve gelecekte birbiri içinde işlenerek dizinin temeli olan merak ögesi sürekli canlı tutuluyor. Kendi kültürünü yansıtan yapımları beğenip yabancı dizi izleme alışkanlığı olmayanlar, popüler kültürü sevenler, yeni medya araçlarını sonuna kadar kullanmayı bilen yeni kuşak, bilim kurgu ve mitoloji meraklıları "Lost" dizisinin izleyici kitlesini oluşturuyor.

1- Bu parçaya göre, "Lost" dizisinin izlenme oranının yüksek olmasında, özelliklerinden hangileri etkilidir?

I. karakterlerdeki çeşitlilik ve değişim,

II. hikâyenin ıssız bir adada geçmesi,

III. karakterleri canlandıran oyuncuların tanınmamış olması,

IV. hikâyede farklı zaman dilimlerinin iç içe geçmesi

A) I ve II

B) I ve III

C) I ve IV

D) II ve III

E) III ve IV+

2-Bu parçaya göre, aşağıdakilerden hangisinin "Lost" dizisi izleyicisi olması beklenmez?

A) Çağdaş bilimin verileriyle düş gücünden yararlanılarak oluşturulan ürünlerden hoşlananlar

B) Yaşanmış gerçek olayları izlemeyi sevenler

C) Evrenin doğuşuna ya da dinsel olaylara dayalı hikâyelere düşkünlüğü olanlar

D) Toplumun geniş kesimlerine seslenen gelişmelere ilgi duyanlar

E) Yerli yapımları izlemeyi sevenler

(I) Paganizmin yaygın olduğu devirlerde insanlar doğanın kutsal olduğuna, doğada gözlenen olayların da tanrıların yansıması ve işaretleri olduğuna inanırlardı. (II) Bu düşünceyle, bir hasat mevsimi verimli geçtiğinde, o mevsimin sonunda tanrılara şükranlarını sunmak için kurban adarlardı. (III) Ağustos ayı ortalarına denk gelen bir dönemde, tanrılara yakın oldukları düşüncesiyle kutsal kabul ettikleri yüksek dağların zirvesine çıkarlardı. (IV) Bu, bir sonraki sezonun hasat açısından nasıl olabileceğine dair bilginin de alınabileceği "uygun" bir zamandı. (V) Çünkü göksel mesaj olarak düşünülen gök taşı yağmurları özellikle ağustos ayı ortasında çok yoğun olurdu. (VI) Paganlar için mevsimlerin dönüm zamanları, ay ve güneşin safhaları da dinî törenlerin yapıldığı önemli zamanlardı.

3- Bu parçadaki numaralanmış cümlelerden hangisi kendinden önceki cümlede belirtilenlerin sonucudur?

A) II.

B) III.

C) IV.

D) V.

E) VI.

4- Bu parçanın anlatımında aşağıdakilerden hangisine başvurulmuştur?

A) Benzetmeye

B) Eleştiriye

C) Açıklamaya

D) Çağrışımlara

E) Kanıtlamaya

**B-3 Baseline 2 (B2)**

Sınavımızın ilk bölümüne tamamladınız, teşekkür ederiz.

Şimdi lütfen gözlerinizi 3 dakika kapalı tutarak ya da sakin bir şekilde oturarak dinleniniz.

3 dakika geçtiğinde bilgisayarın ekranı değişecektir.

Sınavımızın ikinci kısmı sayısal sorulardan oluşmaktadır.

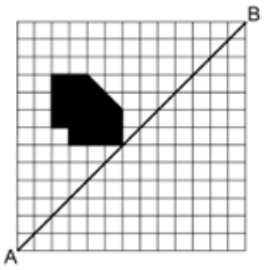
Sayısal bölümde şimdi size her biri 2 sorudan oluşmuş toplam 4 ekran gösterilecektir.

Her bir ekrandaki soruları çözmeniz için üçer dakika zaman verilecektir. Soruları çözerken kalem kâğıt kullanmanıza izin verilmeyecektir. Lütfen soruları çözerken ekrana bakmaya devam ediniz.

Lütfen olabildiğince bütün soruları doğru olarak yanıtlamaya çalışınız.

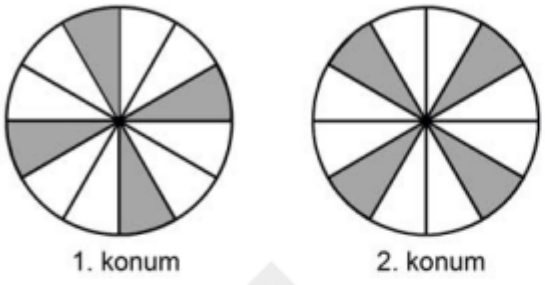
**B-4 Mathematics questions (MATH1)**

A1- Boyalı şeklin AB doğrultusuna göre simetriği aşağıdakilerden hangisidir?




A)  B)  C)  D)  E) 

A2- Merkezi etrafında dönebilen, 12 eş parçaya bölünmüş dairesel disk 1. konumdayken döndürülerek 2. konuma getirilmiştir. Buna göre, bu diske uygulanan döndürme işlemi aşağıdakilerden hangisi olamaz?




A) Saat yönünde 60 derece B) Saat yönünde 90 derece C) Saat yönünde 150 derece

D)Saat yönünün tersinde 30 derece E) Saat yönünün tersinde 120 derece

B1- Leblebinin 200 gramı 1,2TL olduğuna göre, 700 gramı kaç TL'dir?

A) 3,6B) 3,8C) 4D) 4,2E) 4,6

B2- Bir parça telin ucundan telin 1/5'i kesildiğinde telin orta noktası eski durumuna göre 4cm kayıyor. Buna göre, bu telin tamamı kaç cm'dir?

A) 35B) 40C) 45D) 50E) 55

C1- -2<x<4 olduğuna göre (-1+x) ifadesinin alabileceği en büyük tam sayı değeri kaçtır?

A) 0 B) 1 C) 2 D) 3 E) 5

C2- 0<x<1 olmak üzere,

a= 1/x

b= x2

c=x

olduğuna göre, aşağıdaki sıralamalardan hangisi doğrudur?

A) a<b<c B) a<c<b C) b<a<c D) b<c<a E) c<a<b

D1- Fonksiyon, A kümesinden B kümesine bir eşleşme olarak tanımlanır. Bu eşleşmenin 2 özelliği vardır:

1) A kümesinde boşta eleman kalmayacak.

2) A kümesindeki her eleman B kümesinden yalnızca bir elemanla eşleşecek.

Buna göre aşağıdaki durumlardan hangisi bir fonksiyon ifade etmez?

A) Tüm dişi denizatlarının hayatları boyunca sadece bir eşle üremesi
B) Her akıllı telefonun IOS, Android gibi bir yazılıma sahip olması
C) Bir dans kulübündeki tüm kadınların gece boyu bir kişi ile dans etmesi

D) Bazı ülkelerdeki erkeklerin birden fazla eşe sahip olması

E) Her çocuğun bir tane biyolojik annesinin olması

D2- **Deney**: Sonuçların kümesi belli olan, ancak hangi sonucun ortaya çıkacağı önceden söylenemeyen bir işleme denir.

**Örnek uzay**: Bir deneyin tüm farklı sonuçlarının oluşturduğu kümeye o deneyin örnek uzayı denir.

**Çıktı**: Örnek uzayın elemanlarından her birine yani bir deneyde elde edilebilecek sonuçların her birine çıktı denir.

**Olay**: Örnek uzayın her alt kümesine olay denir.

**Olasılık değeri**; Uygun sonuçların sayısının tüm sonuçların sayısına bölünmesi ile bulunur.

Bu bilgiler ışığında aşağıdaki soruyu cevaplayınız.

1, 2, 3, 4 ve 5 rakamları eş büyüklükte pinpon toplarına yazılarak içi görünmeyen bir torba içine atılıyor. Torbadan rastgele bir top çekiliyor. Çekilen topun üzerinde yazılı olan rakamın 4 sayısı dışında bir sayı olma olasılığıyla ile ilgili hangisi yanlıştır?

A) Deney: Torbadan üstünde rakamlar olan top çekme B) Örnek uzay; E = {1,2,3,4,5}
C) Çıktı: 1,2,3,4,5 D) Olay = {1,2,3,5} E) İstenilen olasılık değeri 3/5'tir.

**B-5 Baseline with music (B3)**

Sınavımızın üçüncü kısmı da sayısal sorulardan oluşmaktadır.

Bu bölümde şimdi size her biri 2 sorudan oluşmuş toplam 4 ekran gösterilecektir.

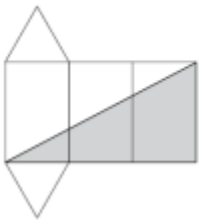
Her bir ekrandaki soruları çözmeniz için üçer dakika zaman verilecektir. Soruları çözerken kalem kağıt kullanmanıza izin verilmeyecektir. Lütfen soruları çözerken ekrana bakmaya devam ediniz.

Lütfen olabildiğince bütün soruları doğru olarak yanıtlamaya çalışınız.

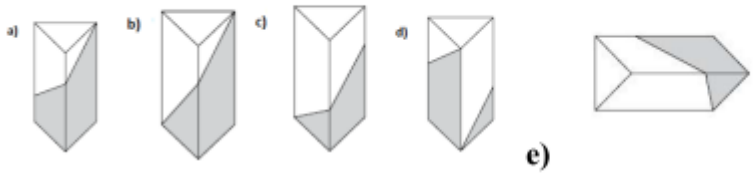
Bu bölüme geçmeden önce 3 dakika sakin bir şekilde oturarak dinlenmenizi rica ediyoruz.

**B-6 Mathematics questions with music (MATH2)**

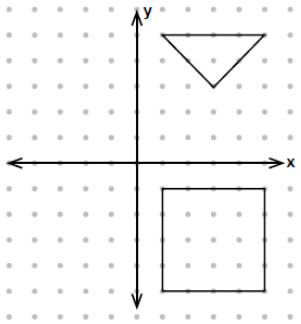
E1-

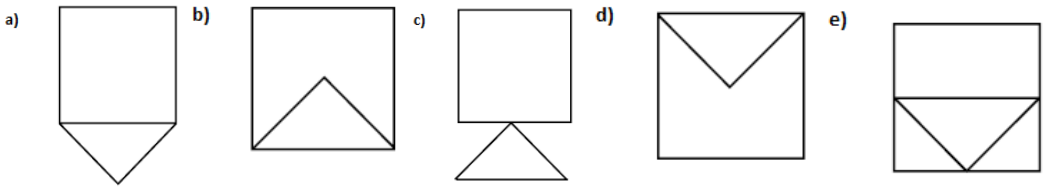


Bir üçgen prizmanın açılımı olan kartonun tek tarafı şekildeki gibi boyanıyor. Bu karton, boyalı kısmı dışarda kalacak şekilde kapatıldığında elde edilen üçgen prizmanın görünümü aşağıdakilerden hangisi olamaz?




E.2- Şekildeki üçgen x eksenine göre yansıtıldığında kare ile birlikte oluşan şekil aşağıdakilerden hangisidir?




F1.-Alanı $100m^2$ olan kare şeklindeki bir bahçenin etrafına 10m aralıklarla birer ağaç dikilecektir. Kaç tane ağaca ihtiyaç vardır?

a)10

b)8

c)6

d)4

e)2

F2- Bir alışveriş merkezinde asansöre binen bir kişi bulunduğu kattan 5 kat aşağıya indiğinde -2. katta olduğunu görmüştür. Buna göre, bu kişi asansöre hangi katta binmiştir?

a)7

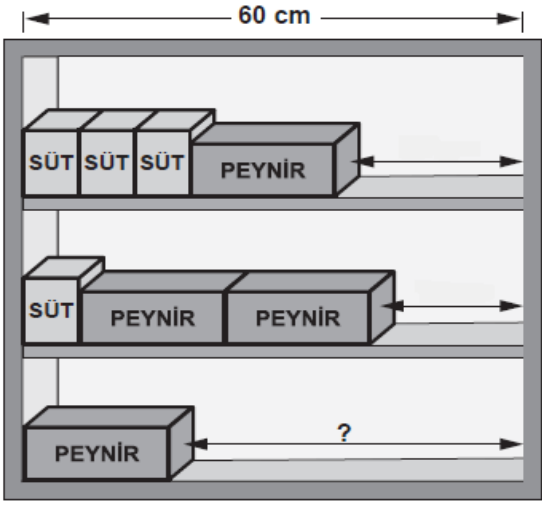
b)5

c)3

d)2

e)1

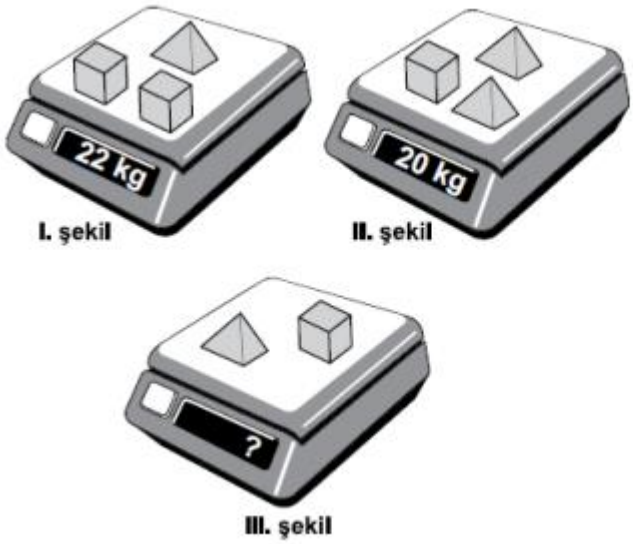
G1-




Aşağıdaki şekil, birbirine özdeş olan süt ve peynir paketlerinin 60 cm uzunluğundaki bir rafa 3 farklı biçimde dizilişini göstermektedir. İlk iki raf diziminde boşta kalan raf uzunlukları 10 cm olduğuna göre 3. rafta boşta kalan raf uzunluğu kaç cm'dir?

a) 10
b) 20
c) 30
d) 40
e) 50

G.2-




Aşağıdaki şekillerde özdeş küpler ve özdeş piramitlerin kütleleri ölçülmektedir. I ve II. şekildeki ölçümlere göre III. şekildeki ölçüm kaç kilogramdır?

a) 12
b) 14
c) 16
d) 18
e) 20

H1- Küme; iyi tanımlanmış, birbirinden farklı nesneler topluluğudur. Bu tanıma göre aşağıdaki sorunun cevabını bulunuz.Aşağıdakilerden hangisinin veya hangilerinin küme belirtmediğini bulunuz.

I.Güzel kızlar

II. Yeşil gözlü öğrenciler

III. Kolay sorular

A) Yalnız III B) Yalnız II C) Yalnız I D) Yalnız I ve III E) Yalnız II ve III

H2.

Bağımsız Olay: Bir olayın gerçekleşip gerçekleşmediği diğer bir olayın gerçekleşmesine bağlı değil ise yani bir olayın sonucu diğer olayın sonucunu etkilemiyorsa böyle olaylara bağımsız olaylar denir. <p>

Bağımlı Olay: Bir olayın gerçekleşip gerçekleşmediği diğer bir olayın gerçekleşmesine bağlı ise yani bir olayın sonucu diğer olayın sonucunu etkiliyorsa böyle olaylara bağımlı olaylar denir. <p>

Buna göre; aşağıdaki olaylardan bağımlı ve bağımsız olanları belirleyiniz. <p>

I.Aynı anda atılan madeni para ile zardan, paranın tura zarın çift sayı gelmesi<br>

II.Bir üniversitede bütünleme sınavına sadece finale giren öğrencilerin alınması<br>

III.Bir üniversite öğrencisinin aynı dersten 2. kez kalması<br>

IV.Aynı anda havaya atılan iki zarın üst yüzeylerine gelen sayıların toplamının 5'ten büyük olması

a)I ve II bağımsız, III ve IV bağımlı

b)I ve II bağımsız, III bağımlı, IV hakkında kesin bir şey söylenemez

c)I, III ve IV bağımsız; II bağımlı

d)II ve IV bağımlı, I ve III bağımsız

e)II ve III bağımsız, II bağımlı, IV hakkında kesin bir şey söylenemez.