T.C.
FATIH UNIVERSITY
INSTITUTE OF BIOMEDICAL ENGINEERING

EVALUATION OF PHYSICAL RESPONCES OF HEALTY SUBJECTS USING BY CLASSICAL TURKISH MUSIC MODES

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MSc THESIS
BIOMEDICAL ENGINEERING PROGRAMME

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İSTANBUL, 29 AUGUST / 2014

T.C.
FATİH ÜNİVESİTESİ
BİYOMEDİKAL MÜHENDİSLİK ENSTİTÜSÜ

TÜRK MÜZİĞİ MAKAMLARININ SAĞLIKLI İNSANLAR ÜZERİNDE FİZİKSEL ETKİLERİNİN DEĞERLENDİRİLMESİ

ESRA ERCİYAS

YÜKSEK LİSANS
BİYOMEDİKAL MÜHENDİSLİĞİ PROGRAMI

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FATIH UNIVERSITY

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Esra KUTLU ERCİYAS, a **M.Sc.** Student of Fatih University **Institute of Biomedical Engineering** student ID 520112016 successfully defended the **thesis** entitled '**Evaluation of Physical Responses of Healthy Subject Using by Classical Turkish Music Modes**., which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission: 23 August 2014

Date of Defense: 29 August 2014

To my beloved family and husband,

ACKNOWLEDGEMENTS

I would like to thank to my estimable supervisor Prof. Dr. Sadık KARA for his advices, his patience and encouragement during thesis. His guidance about a lot of topic to motivate me was really helpful to finish my thesis. I also would like to precious my co-advisor Assist. Prof. Dr. Saime Akdemir Akar for her assistance, patience and encouragement during thesis, she was always available for my questions. They were positive and gave generously of their time and vast knowledge.

Finally but significantly, I would like to thank my beloved husband who supported me every single moment with his generous kindness against to stress of my experiments.

August 2014 Esra ERCİYAS

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LIST OF SYMBOLS

Hz	Hertz
$\delta(t)$	Impulse function
μ	Mean
σ	Standard Deviation
Σ	Sum
V	Voltage
L (z)	Low Pass Filter
H (z)	High Pass Filter

ABBREVATIONS

ANS : Autonomic Nervous System
BVP : Blood Volume Pulse
CT : Continuous-Time
DWT : Discrete Wavelet Transform
DFT : Discrete Fourier Transform
DT : Discrete-Time
DTFT : Discrete-Time Fourier Transform
DF : Degree of freedom
EEG : Electroencephalography
EDA : Electro dermal Activity
EDR : Electro dermal Response
FFT : Fast Fourier Transform
GSR : Galvanic Skin Response
HF : High Frequency
HRV : Heart Rate Variability
LH : Low Frequency
M1 : Music 1 (Kuçek makam)
M2 : Music 2(Rast makam)
PSD : Power Spectral Density
PSD : Power Spectral Density
R1 : Resting 1
R2 : Resting 2
R3 : Resting 3
SC : Skin Conductance
SCL : Skin Conductance Level
SCR : Skin Conductance Response
SNS : Sympathetic Nervous System
STFT : Short Time Fourier Transform
Std. dev.: Standard Deviation

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SUMMARY

EVALUATION OF PHYSICAL RESPONCES OF HEALTY SUBJECT USING BY CLASSICAL TURKISH MUSIC MODES

Esra ERCİYAS

Biomedical Engineering Programme

MSc Thesis

Advisor: Prof. Dr. Sadık KARA

Co-Advisor: Assist Prof. Dr. Saime AKDEMİR AKAR

Listening music has many positive effects on listeners. It has been known since early time. Music therapy has been used to decrease pain, calm patients and even treat depression. Music also effects in a person's duty performance, it can change emotional state and give more motivation to the listener. The purpose of this study to evaluate effects of some Turkish modes on healthy subject. Mode is a system of melody types used in Turkish classical music. Each mode has a different impact on a person. Responds and emotions against to music can change according to person nationality, cultural difference, age, gender, etc... In This study, galvanic skin response, skin temperature, blood volume pulse signals were recorded from healthy Turkish and foreign people during resting, calm and auditory stimulation periods. Recorded signals were analyzed with signal processing method and the results were compared to show effect of music.

Keywords: music modes, Turkish classical music, galvanic skin response, blood volume pulse, skin temperature, power spectral density.

ÖZET

TÜRK MÜZİĞİ MAKAMLARININ SAĞLIKLI İNSANLAR ÜZERİNDE FİZİKSEL ETKİLERİNİN DEĞERLENDİRİLMESİ

Esra ERCİYAS

Biyomedikal Mühendisliği Programı

Yüksek Lisans

Danışman: Prof. Dr. Sadık KARA

Eş-danışman: Yrd.Doç. Dr. Saime AKDEMİR AKAR

Müziğin dinleyenler üzerinde birçok olumlu etkisinin olduğu bilinmektedir.Müzik ayrıca bir tedavi dalı olarak da kullanılmaktadır.Müzik terapisi acıyı azaltmak, hastaları sakinleştirmek hatta depresyonu yenmek için kullanılabilmektedir.Müzik, dinleyenlerin motivasyonunu artırarak kişisel performanslarını da etkilemektedir Bu çalışmanın amacı türk müziğinin farklı makamlarının sağlıklı insanlar üzerindeki etkilerinin incelenmesidir. Makam, Türk müziğinde eserlerin ses dizilerini ve dizi özelliklerini ifade eden terimdir. Her makam kişiler üzerinde farklı etkilere sahiptir.Müziğe karşı verilen tepkiler ve duygular kişinin uyruğuna,kültürel farklılığına yaşına ve cinsiyetine göre farklılık göstermektedir. Bu çalışmada deri iletkenliği yanıtı,vücut sıcaklığı ve kan hacmi sinyalleri sağlıklı türk insanları ve yabancı katılımcılardan alınarak kaydedilmiştir.Kaydedilen sinyaller sinyal işleme metoduyla incelenmiş ve müziğin etkisini görmek için sonuçlar karşılaştırılmıştır.

Anahtar kelimeler: müzik makamları, klasik türk müziği, galvanik deri iletkenliği,kan hacim nabzı,deri sıcaklığı, güç spektral yoğunluğu.

CHAPTER 1

INTRODUCTION

1.1 Purpose of the Thesis

Listening music has many positive effects on listeners. It has been known since early time. It affects the heartbeat, pulse rate and blood pressure, electroencephalogram, galvanic skin response etc...The human heartbeat is particularly accommodated to sound and music [1]. Music Therapy is a developed related healthcare profession that uses music to answer to physical, biological, cognitive, social, emotional and spiritual needs of all ages. Human can be stimulated by music. It opens up channels of self-expression and provides relaxing. Music can improve muscular energy, molecular energy, and affect heart rate, help to show feeling easily, provide rapid recovery and healing after any surgery, and support thinking, and creativity [2]. The effectiveness of music therapy is based on transference and self-expression, not musical skills or ability [3]. Music used in treatment of many diseases, such as; depression, Alzheimer disease, cancer, Parkinson's disease.

Every country has their special music types such as classical Turkish music. Classical Turkish music has a large and varied system of mode called as makam. The purpose of this study to evaluate effects of some Turkish modes on people. In this study we analyzed effect of 2 makam types in Turkish classical music upon Turkish and Foreign subjects.

1.2 Literature Survey

Many researches have been done before about effect of music on people. Various study show use, music tempo can cause people to bite faster while eating [4] and music can help people to make better at their task performance [5] .Sometimes music can occasion a negative effect on performance while students working , it cause to disorganize their concentration [6].

According to the Robyn Armon et al. music tempos affect the some organ systems after physical exertion. They worked about blood pressure, heart rate and skin conductance.

When listening the rock music with fast tempo heart rates were 120-130 beats per minute on average. When listening to classical music with slow tempo heart rates were 50-60 beats per minute on average. According to results heart rate increase when listening rock music, namely participant had a higher heart rate also heart rate decreases when listening classic music. Additionally, according to their result Participants had higher systolic blood pressures while listening to classical music than rock. Their result galvanic skin response was not affected by music tempo [1]. According to Karageorghis, Drew and Terry study music also helped to increase grip strength. They determined that both male and female young participant showed significantly higher grip strength after listening to fast music and compared with slow music and non- music result[7] . Music can help to calm the anxiety that dental diseased patients experience by helping them relax during the operations [8].In the Edworthy and Waring experiment, fast tempo music of 120-130 beats per minute increases anxiety and increases blood pressure and heart rate, but slow tempo music of 50-60 beats per minute has the opposite effect on the body [9].Several studies suggest that music has a lot of effects on participants at the physiological level. According to Trappes (2010) study , music increases learning ability and memory through different interconnected processes in the brain.[10] Oldham et al. (1995) obtained a significant, positive effect on performance, organization satisfaction and state of mind when personal headphone playing music were used in an office situation[11]. Dannenbaum (1945) found that people are less able to detect geometric faults while they are listening music [12] and Kirkpatrick (1943) detected that music blocks work demanding mental concentration [13]. According to sky chaffin et al. experiment; Music can provide blood pressure recovery from stress. They hypothesized that listening to music would decrease post-stress blood pressure elevations. In their experiment, participant performed a mental arithmetic task for 3 minutes, then participant rested for ten minutes meanwhile participant listened music which selected by him/her. They selected randomly one of three music type (classical, jazz or pop music). İn their experiment participants blood pressure and heart rate were monitored during baseline, stressor and recovery periods [14].Result of their experiment; pop music affected cardiovascular system.it caused higher heart beat but classical music had opposite effect. Cardiovascular responses to stress can be altered, and reduced. Beckett studied of music effect upon heart rate during walking. There are three music situations; without music, continuous music, and intermittent music.

The results from this performance showed that music could help to increase recovery heart rate [15]. Other studies found that music did not affect heart rate. Boutcher and Trenske (1990) obtained that there were no significant differences in the heart rate of the university student after exercising on a cycle ergometer with or without music [16]. Szabo et al. (1999) realized no difference in the heart rate among college students after exercising with by no music, slow music, fast music, slow-to-fast music, and fast-to-slow music [17].

In another experiment researcher worked about effect of Turkish classical music on blood pressure in elderly hypertensive patients. Their objectives were to research whether Turkish classical music has positive effects on blood pressures and anxiety levels in elderly hypertensive patients [18]. When we examined these experiments results, obtained different effect of music on heart rate, in some studies music changes heart rate, and occasionally there is no significant difference.

1.2 Hypothesis

Each Turkish music modes is effective on people in different type. Some of music modes give a fear, some give happiness. Music modes can change blood volume pulse (BVP), galvanic skin response (GSR), brain waves, heart rate (HR), body temperature. Kuçek is a Turkish classical music mode and according to philosopher Farabi this mode gives to people distresses and sadness. Rast makam is another classical music mode which gives to people happiness. We hope to see these changes in our recorded data and statistical result.

CHAPTER 2

2.1 Music

Music is a complex mixture of melody, rhythm, harmony, chord, timbre, and silence in a particular structure [19].The formation, performance, significance, and definition of music changes according to culture and social environment. To many people in different cultures, music is an important part of theirs daily life. Music is performed for many causes, for example, pleasure, entertainment, religious or ceremonial aims. Music has some positive effect and important for life because, music lifts up your soul and releases it, it helps you express yourself in ways that you can't with normal talking, it helps relaxing. People can explain their sadness, enjoyment, excitement and other emotions with by music. Also music increases learning ability and memory through different interconnected processes in the brain [20].

2.2 History of music therapy

Human being has looked for cures to their diseases for centuries. They have discovered causes of some diseases and tried different treatment methods within their own cultural boundaries [21]. The human beings added music to these treatment methods. Treatment with music has been applied in different cultures and different times especially in psychological and brain diseases. Music has been used in treatment as a part of magic, religion rational thought according to morals and beliefs of the communities. The therapist, who tries to become a bridge between the magical power of music and patients, has been considered to be a magician, priest physician, or music specialist in centuries. Human beings have used music not only as a means of communication but also cure for psychological a disorder, which has created music therapy.

Music therapy is a treatment method practiced by arranging psychological effects of musical sounds and melodies according to various psychological disorders. Music appeals to depth of human soul much more in comparison with the other artistic branches. Therefore, it is more effective than other. Music, the most expressive way of fine arts, has been dealt with as a special treatment method under the name of ‘‘music therapy ‘’ especially in the last 40-50 years. Spiritual relaxation and excitement through music which was evaluated and applied by the old civilizations and religions has taken a scientific and methodological position.

One of the first people who wanted to use music therapy in the clinics is the famous French neurologist, Philippe Pinel. After Pinel, various doctors put forward and advocated treatment with music in medicine in the 18Th centuries [22]. The profession of music therapy is the United States began to develop during the First World War. Music was used as an intervention to address traumatic war injuries and relieve the pain.

Music’s therapeutic effects on psychological disorders known since ancient time. In ottoman, music therapy had lived one of the most brilliant period. In the middle Ages and western countries, some mentally ill were subjected to severe inhuman torture. According to them, evil spirit entered to body or brain and affected him/her. In contrast, Darüşşifa (mental hospital) was built by sultan Beyazıd 2 in Edirne and mental patients were being treated with by music in Darüşşifa [23].

2.3 Music modes (makams)

Classical Turkish music has a large and varied system of modes called as makam .In Turkish music , there are more than 600 modes but today only around 20 modes are commonly used [24]. According to Farabi each mode has different effect on people.

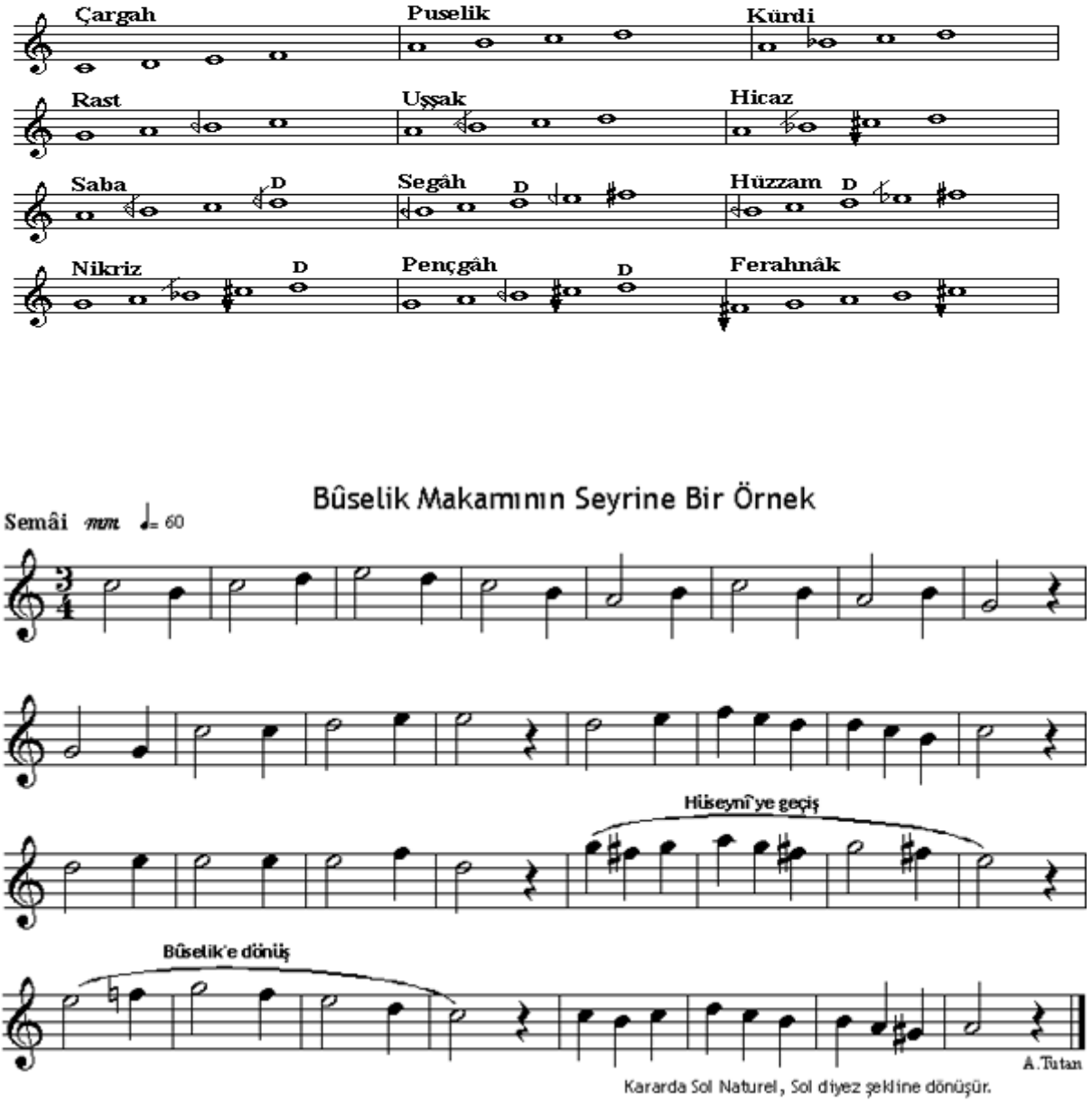

Figure 2.1 Makam Types [35]

2.3.1 Some modes (makams) effects.

Büzürk mode: gives a person fear.

Rehavi mode: gives a person the idea of eternity.

Isfahan mode: gives a person the capacity of action, the sense of security.

Rast mode: gives a person happiness and comfort.

Neva mode: gives a person pleasure

Uşşak mode: gives a person the laughter.

Saba mode: gives a person bravery, power.

Hicaz mode: gives a person humility.

Buselik mode: gives a person strength.

Hüseyni mode: gives a person serenity [25].

Farabi say the effects of the modes of Turkish music according to the times they were effective:

Rehavi mode: impressive at pre-dawn.

Hüseyni mode: impressive at dawn.

Rast mode: impressive in early morning.

Buselik mode: impressive in mid-morning.

Zirgüle mode: impressive toward noon.

Uşşak mode: impressive at noon.

Hicaz mode: impressive in the afternoon.

Irak mode: impressive in late afternoon.

Isfahan mode: impressive at dusk.

Neva mode: impressive in the evening.

Büzürk mode: impressive in late evening [26]

2.4 Effect of modes on various diseases

Many Turkish scientists had worked with music therapy method. İbni sina, Farabi, Razi, Gevrekzade hasan efendi are the most important examples for history of music therapy. Gevrekzade hasan efendi had mentioned effects of music modes upon different child diseases in his book ‘’Neticetül-fikriye ve Tedbir-i veladet-ül bikriye’’

Some of examples from his book

Rast mode; It is effective in diseases that goes along with stroke.

Irak mode; It is effective in meningitis and bad temper.

Isfahan mode; Gives clarity of mind, gives your heart relief, protects against inflammatory diseases.

Zirefgend mode; This mode is effective in cases of curvature, stroke, back pain, joint pain.

Rehavi mode; Effective on headache, epistaxis, upper respiratory tract disease.

Zengüle mode; Zengüle mode used in heart diseases, liver diseases, heartburn, and brain disorder. It is effective in getting rid of mental illness.

Hicaz mode; Used in tenesmus also used in treatment of sexual problems.

Buselik mode; Effective on eyes and hip pain, reduce the intensity of thought in the brain.

Uşşak mode; If child listen this makam in daytime, it gives spaciousness them. İf mature people listen it, reduce their foot pain.

Hüseyni mode; Gives spacioousness, effective on hepetitis and heart inflammation, eliminate heartburn.

Neva mode; It convert bad and distressed ideas to joy and calmness [27].

2.5 The hospitals where music therapy was used in Turkish Islamic civilization

- Nurettin zengi hospital-damascus(1154)
- Kayseri gevher nesibe hospital (1205-06)
- Divriği hospital(1228-29)
- Amasya hospital(1308-09)
- Fatih hospital (1470)
- Suleymaniye medical school and hospital(1557)
- Enderun school(1478)
- Edirne medical school and hospital(1488)[28]

Figure 2.2 Examples of Şifahane pictures [36]

Figure 2.3 Examples of Şifahane pictures [36]

2.6 Effects of musics upon heart rate and gsr

İn Trappe's experiment some participants have anxiety, pain, stress, depressive syndromes. These subjects listened classical music and music caused both heart rate and blood pressure to decrease [29]. This same study suggested that hip hop and rap music with fast tempos, cause negative effects on subjects by increasing their blood pressure and heart rate but GSR was not affected from these experiments.

Uppal and Datta (1990) studied on junior high school girls to see whether music had an effect on increasing heart rate during exercising. The results of the study show that music was significantly impressive at increasing heart rate [30]. According to another experiment, Coutts (1965) determined that male university students, exercising on exercise bike in three conditions (fast, slow, and no music), had no difference in heart rate among the these three conditions [31].

CHAPTER 3

MATERIALS AND METHODS

In this chapter we will mention about subjects information, the procedure of research, the physiological signals that used in the research, the measurement system used in the experiment and signal processing methods.

3.1.Characteristics of subjects

In this experiment subjects were selected from university students and 15 Turkish 15 Foreign subjects results were used for analyzing.

Table 3.1 Characteristics and self-report measures of participants

Variables	Turkish	Foreign
Number	15	15
Male/Female	7/8	9/6
Age	18-40	18-40
Dominant hand	All right-handed	All right –handed
Smoker/non smoker	4/11	3/12

Table 3.2 Exclusion criteria for subjects

Any medication	Pathological, endocrinological, cardiovascular disorders	
Musician	Substance abuse disorders (including alcohol abuse)	
Hear losing	Pregnant and lactating female	Physical exercises

Subjects are selected from Fatih university students and personals. Subjects should not use any medication because medicines affect brain, heart and cardiovascular system [32]. Also they should not do exercise. When subject do exercise, heart rate is rises, and sweating occurs. This situation affects results accuracy. Another exclusion criterion is pregnant and lactating female. In pregnancy period, some hormonal changing occurs in female body [33]. These changing affect female body in different way. Heart rate changes, body temperature changes, also even EEG results are effected [34].

3.2 Procedure and Auditory Stimuli

Subjects listened music in the sitting position. Their status was eyes closed and in relaxed position, did not move until end of the recording. Study room was silence and dark (light closed). The auditory stimulus was listened with earphones.

TABLE 3.3 Total length of signal recording

2 minute	2 minute	2 minute	2 minute	2 minute
Resting period Silence	Music (Kuçek mode)	Resting period Silence	Music (Rast mode)	Resting period Silence

10 minutes recording

Signals were recorded simultaneously during 10 minutes from each subject. First period was resting and silence period with 2 minutes duration. Second period was first auditory stimuli period (Kuçek mode) during 2 minutes. Again 2 minutes silence and resting and next step was music period (Rast mode) during two min. Last step was 2 minute resting period .Kuçek Mode music name was Turkish Ottoman Kanun Taksim. Rast Mode music name was

Darıldın mı Cicim Bana. According to Farabi, kuçek mode gives sadness to people and rast mode gives happiness and comfort. We have selected these modes to see opposite effect of them. (GSR), (PPG) and (ST) signals were recorded during 10 minutes from each subject.

3.3 Physiological Signals and Data Recording system

BIOPAC System Inc. MP150WSW data acquisition system was used to record GSR, PPG and Skin temperature signals. (Figure 3.1) [37]

Table 3.4 Signal conditioning module compatibility [38]

CO2100C	EGG100C	HLT100C	PPG100C
DA100C	EMG100C	LDF100C	RSP100C
EBI100C	EOG100C	MCE100C	SKT100C
ECG100C	ERS100C	O2100C	STM100C
EEG100C	GSR100C	OXY100C/E	TEL100C

Figure 3.1 BIOPAC MP150WSW data acquisition system [37]

3.3.1 Galvanic Skin Response (GSR)

Galvanic skin response is a method of measuring the electrical conductance of the skin, also known as skin conductance (SC), electro dermal response (EDR), psychogalvanic reflex (PGR), skin conductance response (SCR) or skin conductance level (SCL) [39]. Affective stimuli cause changing on the skin. Emotional change is regulated by sweat gland. Sweat glands activation and secretions are controlled by sympathetic nervous system (SNS) [40]. SNS is one of the branches of automatic nervous system (ANS). Parasympathetic nervous system (PNS) is another part of ANS. it works coordinately with SNS (Figure 3.2). SNS works in stressful events and increases heart rate, blood pressure, urinary bladder, breathing .PNS works in resting time, decreases heart rate, blood pressure, breathing, relaxes muscle. We measure galvanic skin response when PNS and SNS activation [41].

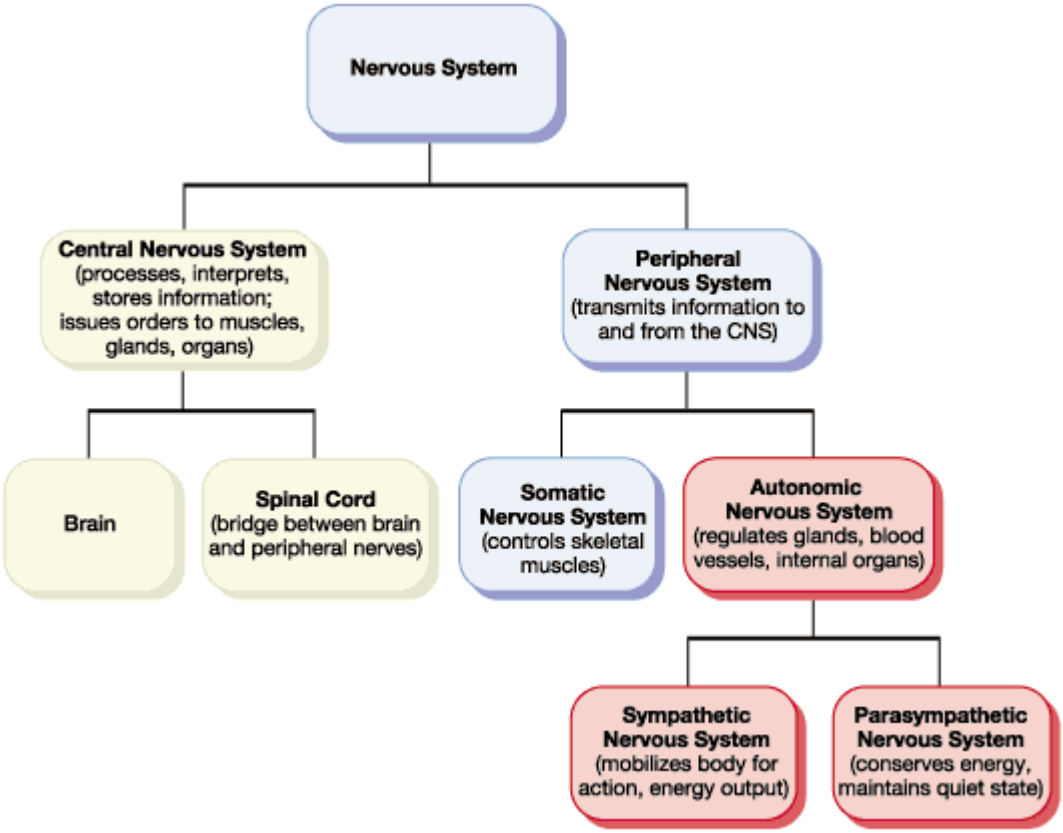

Figure 3.2 Human nervous system [42]

GSR100C amplifier (Figure 3.3(a)) uses 0.5VDC constant voltage and TSD100C Ag-AgCl non-polarizable electrodes (Figure3.3 (b)) to measure GSR signal.

Figure 3.3a) TSD203 TSD203 transducer [43]

Figure 3.3 b) Galvanic Skin Response Amplifier GSR100C[44]

Table 3.5 EDA100C Specifications

Input conductance range			
DC	0.05 Hz	*Minimum Resistance*	*Sensitivity*
0 to 200 µS/V	±200 µS/V	5,000 Ω	20 µS/V
0 to 100 µS/V	±100 µS/V	10,000 Ω	10 µS/V
0 to 50 µS/V	±50 µS/V	20,000 Ω	5 µS/V
0 to 20 µS/V	±20 µS/V	50,000 Ω	2 µS/V

TABLE 3.6 Electrical specification of GSR 100 C device

Gain	20, 10, 5, 2 micro-mhos/volt
High pass filter	DC, 0.005 Hz, 0.5 Hz
Low-pass filter	1Hz, 10 Hz,
Sensitivity	0.7 nano-mhos
Output Range	0-10V nominal ±10V full

3.3.2 Skin Temperature (ST)

Skin is one of several organ systems serving in maintaining a core temperature of someone's body[45]. The body keeps its core temperature constant at about 37 C [46]. Temperature sensors in the skin and internal organs control inner temperature and transmit signals to the hypothalamus, a region of the brain[47]. The temperature-regulating centers are located in the Preoptic Area of hypothalamus[48].This area contains neurons and receives input from temperature receptors in the skin. Preoptic neurons compare and integrate central and peripheral thermal information [49].

Figure 3.4 a) Skin Temperature amplifier SKT100C [50] ,Figure 3.4 b) skin temperature transducer TSD202B[51]

BIOPAC SKT100C skin temperature amplifier (Figure 3.4(a)) and TSD202B ST transducer (Figure 3.4(b))were used for record of skin temperature signal. Finger probe is connected to patients hand . The gain was set at 5 °F/V and the sampling rate was 200 Hz. The SKT100C operating temperature range is 40°F to 140°F (5°C to 60°C) [52].

Table 3.7 Electrical specificications of SKT100C amplifier

Gain	5, 2, 1, 0.5 °F/V
Output Range	Output Range ±10 V (analog)
Low-pass filter	1 Hz, 10 Hz,
High-pass filter	DC, 0.005 Hz, 0.5 Hz
Sensitivity	180 micro °F (100 micro °C)

3.3.3 Blood Volume Pulse (BVP)

Blood volume pulse is a signal that is obtained by blood volume changes in the micro vascular layer of tissue due to blood pulsation of the heart beat.Blood volume change measured by a photoplethysmography method. The Blood volume pulse sensor shines infrared light through the finger and surrounding tissues and measures the amount of light reflected by the skin[53]. The PPG100C Pulse Plethysmogram Amplifier and transducer are noninvasive and simple method records the pulse pressure wave and provides an pointer of blood pressure, blood density from subject. PPG signals give information about heart rate and heart rate variability (HRV).Detection of PPG signals used PPG100C photoplethysmogram amplifier modul (figure3.5(a)) and TSD200 photoplethysmogram transducer (Figure 3.5 (b)). The gain was set at 100 and sampling freqency was 200 Hz. PPG signal low pass filtered at 10 Hz and high pass filtered at 0.05 Hz.

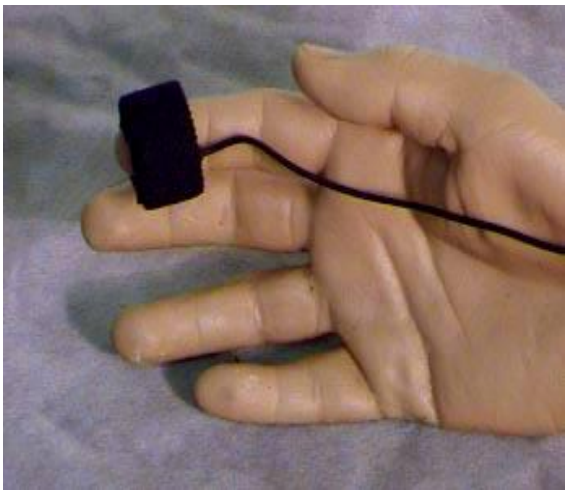

Figure 3.5 a) Photoplethysmogram amplifier PPG100C and

b) photoplethysmogram transducer TSD 200

Table 3.8 PPG100C SPECIFICATIONS [54]

Gain	10, 20, 50, 100
Output Range	±10 V
High-pass filter	DC, 0.005 Hz, 0.5 Hz
Low-pass filter	3 Hz, 10 Hz,
Signal Source:	TSD200 Pulse Transducer
Excitation Voltage	6.0 V

Heart rate varıabılıty

Time interval between heartbeats.

- Low frequency (LF) (LF, 0.04–0.145 Hz) Affected(sympathetic,paasympathetic)
- High frequency (HF) (0,15 Hz- 0,40 Hz) Affected (parasympathetic)
- LF/HF = Sympathovagal Balance

3.4 Signal Processing

3.4.1 Fourier Transform

Fourier transform is the mathematichal tool to connect the time domain and frequency domain and is important in mathematics, engineering, and the physical sciences. Fourier series make use of the orthogonality relationships of sine and cosinus functions[55]. Discrete-time fourier transform (DTFT) , Discrete Fourier transform , Fast fourier transform, Continious time (CT) fourier transform, Continious time (CT) fourier series are types of fourier transform are used in different field. Fourier transform and inverse of fourier transform is given in Eq.(3.1) and Eq.(3.2) [56]

$$S(jw) = \int_{-\infty}^{\infty} s(t) e^{-i\omega t} dt \tag{3.1}$$

$$s(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S(j\omega) e^{i\omega t} d\omega \tag{3.2}$$

Discrete-time Fourier transform (DTFT) plays an important role in signal processing applications, discrete-time signal processing algorithms and systems analysis, design, performing linear filtering, correlation analysis and spectral analysis. DTFT is Eq.is given (3.3) [57]

$$S(e^{j\omega'}) = \sum_{n=-\infty}^{\infty} s[n] e^{-j\omega' n} \tag{3.3}$$

3.4.2 Power spectral density(PSD)

Power spectral density(PSD) is an method which displays the strength of the energy as a function of frequency. Put another way, it shows at which frequencies energy are strong and at which frequencies energy are weak. The PSD is deterministic, and for certain types of random signals is independent of time[58].

Power Spectral Density Definition

The PSD is defined as the DTFT of the covariance sequence:

$$\phi(\omega) = \sum_{k=-\infty}^{\infty} r(k)e^{-i\omega k} \tag{3.4}$$

The inverse transform, which recovers *{r(k)}* from given *$\phi(\omega)$,is*

$$r(k) = \frac{1}{2\pi}\int_{-\pi}^{\pi} \phi(\omega)e^{i\omega k}d\omega \tag{3.5}$$

Verified that ;

$$\frac{1}{2\pi}\int_{-\pi}^{\pi} \phi(\omega)e^{i\omega k}d\omega = \sum_{p=-\infty}^{\infty} r(p)\left[\frac{1}{2\pi}\int_{-\pi}^{\pi} e^{i\omega(k-p)}d\omega\right] = r(k) \tag{3.6}$$

Why you can need with power spectral density function?

PSD is a very useful method if you want to identify oscillatory signals in your time series data and want to know their amplitude [59]. PSD is used different areas, for example:

W78hen we look to some random signals, you can not understand them. Therefor, it is hard to find similarty just by looking to random signals examples results. But when calculated power spectral density of each signals,can be found similarity between signals. There are parametric and non parametric method to calculate PSD.

Spectral estimators methods types:

1.Non-parametric (classical) methods

2.Parametric (non-classical) methods

3.4.2.1 Non parametric method:

Start by thinking the autocorrelation sequence from a given data. The power spectrum then is estimated via Fourier transform of an estimated autocorrelation.[60]

3.4.2.1.1 The Periodogram

The periodogram is the one of the ways to estimate power spectral density. It is found by estimating autocorrelation.

Autocorrelation equation is :

$$r_x(k) = \lim_{N\to\infty}\left\{\frac{1}{2N+1}\sum_{n=-N}^{N} x_{n+k}{x_k}^*\right\} \tag{3.7}$$

Autocorrelation can be estimated, if xn is avaliable for interval [0, N-1] is modified as

$$\widehat{r_x}(k) = \frac{1}{N}\sum_{n=0}^{N-1-k} x_{n+k}{x_k}^* \qquad k = 0, 1, \dots, N-1 \tag{3.8}$$

The periodogram is predicted by taking DTFT of the autocorrelation.

$$\widehat{P_{per}}(e^{jw}) = \sum_{k=-N+1}^{N-1} \widehat{r_k}\,(k)e^{-jk\omega} \tag{3.9}$$

The periodogram is found by taking the Fourier transform of autocorrelation and the convolution theorem:

$$\widehat{P_{per}}(e^{jw}) = \frac{1}{N}X_N(e^{j\omega})X_N^*(e^{j\omega}) = \frac{1}{N}\left|X_N(e^{j\omega})\right|^2 \tag{3.10}$$

3.4.2.1.2 Welch method

An improved estimator of the PSD is the one proposed by welch and used to estimate power spectrum. Contents of Method is dividing the time series data into segments, calculating a modified periodogram of each segment, and last step averaging the PSD estimates.

Data segment are given;

$$y_j(t) = y((j-1)K + t), \qquad \begin{matrix} t & = & 1, \ldots, M \\ j & = & 1, \ldots, S \end{matrix} \tag{3.11}$$

The windowed periodogram corresponding to yj(t) is computed as;

$$\hat{\phi}_j(\omega) = \frac{1}{MP} \left| \sum_{t=1}^{M} v(t) y_j(t) e^{-i\omega t} \right|^2 \tag{3.12}$$

P describes power of the temporal window {υ(t)};

$$P = \frac{1}{M} \sum_{t=1}^{M} |v(t)|^2 \tag{3.13}$$

WP is calculated by averaging windowed periodogram

$$\hat{\phi}_W(\omega) = \frac{1}{S} \sum_{j=1}^{S} \hat{\phi}_j(\omega) \tag{3.14}$$

3.4.2.2 Parametric (non-classical) methods:

The reviewed process is replaced by an appropriate model with known spectrum.

3.5 Statiscal Analiysis

İndependet Sample Student's t-test and paired t-test was used for statiscal anlysis of the recorded signals.

3.5.1 The Student's t-test3

Any statistical test that uses the t-distribution can be called a t-test. T-test is the most commonly used method in hypothesis testing**.** T-test compares the means of two groups and decides differences are random or statistically significant. Also it is known small sampling theory. Can be studied with small samples in t –test. For this reason, Great convenience for researchers.

The t -distribution (figure 3.6) [61] is probability distribution that used to predict the mean of a normally distributed population when the sample size is small.

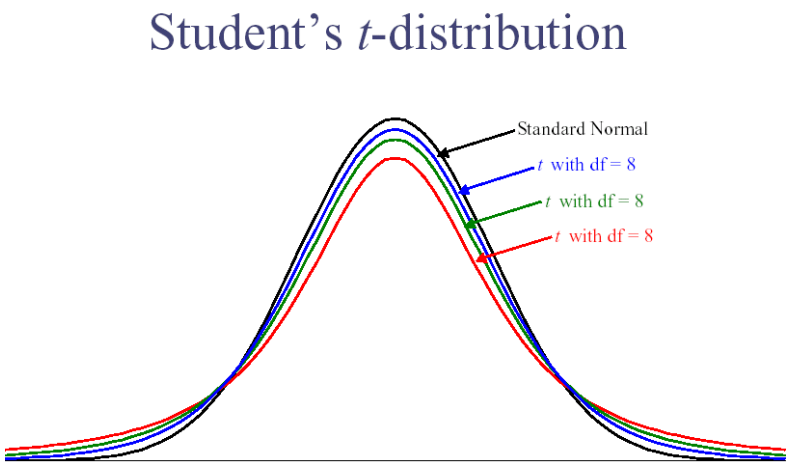

Figure 3.6 t-distribution

There is one parameter in t distribution,which called the degree of freedom (df),DF=n-1.

3.5.1.1 The Independent Sample Student's t-test

The independent sample student's t-test is used when compared two unpaired group or significantly different from each other.In this test, we compare the observed diversity between the two sample means to the expectation that there is no diversity in the population. Sample size from the two groups may or may not be equal to each other.

t-Test: Two-Sample Assuming Equal Variances

We need to calculate the pooled standard deviation of the two samples. The pooled standard deviation works by way of weighted average of the variance of the two samples.Pooled Standart dev. can be calculated by

$$s_p{}^2 = \frac{(n_1 - 1){s_1}^2 + (n_2 - 1){s_2}^2}{n_1 + n_2 - 2} \tag{3.15}$$

Where n1+n2-2 is the df (degree of freedom). Now we can get T value by

$$T = \frac{\overline{X} - \overline{Y}}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \tag{3.16}$$

t-Test: Two-Sample Assuming Unequal Variances

n1 and n2 from two normal populations are independent and sample sizes less than 30. Now we can calculate t value by

$$T = \frac{\overline{X} - \overline{Y}}{\sqrt{\frac{S_X^2}{n_1} + \frac{S_Y^2}{n_2}}} \tag{3.17}$$

3.5.1.2 Paired Sample Student's t –test

Paired t- test used to compare variables when data in each sample set are related in a special way. Also this test is generally used when measurements are taken from the same subject before and after some application. Considers the variation within each group and obtain a t value (Eq.3.18)

$$t = \frac{\frac{\sum d}{N}}{\sqrt{\frac{\sum d^2 - \frac{(\sum d)^2}{N}}{N(N-1)}}} \tag{3.18}$$

CHAPTER 4

RESULTS

In this part, skin temperature, skin conductance and blood volume pulse signals that were collected from both Turkish and foreign subjects and analyzed. For signal processing, algorithms in MATLAB® (v. 7.8.0 R2009a) software was used and statistical analysis is made by the SPSS® software. After analysis and signal processing steps, results are examined in detailed. BIOPAC® Software Interface used to record Skin temperature, PPG and Galvanic Skin Response signals which taken from healthy subjects. **Figure 4.1** shows BIOPAC Software screenshots during data collection from subjects. First channel is GSR, second channel is PPG, and Third channel is SC.

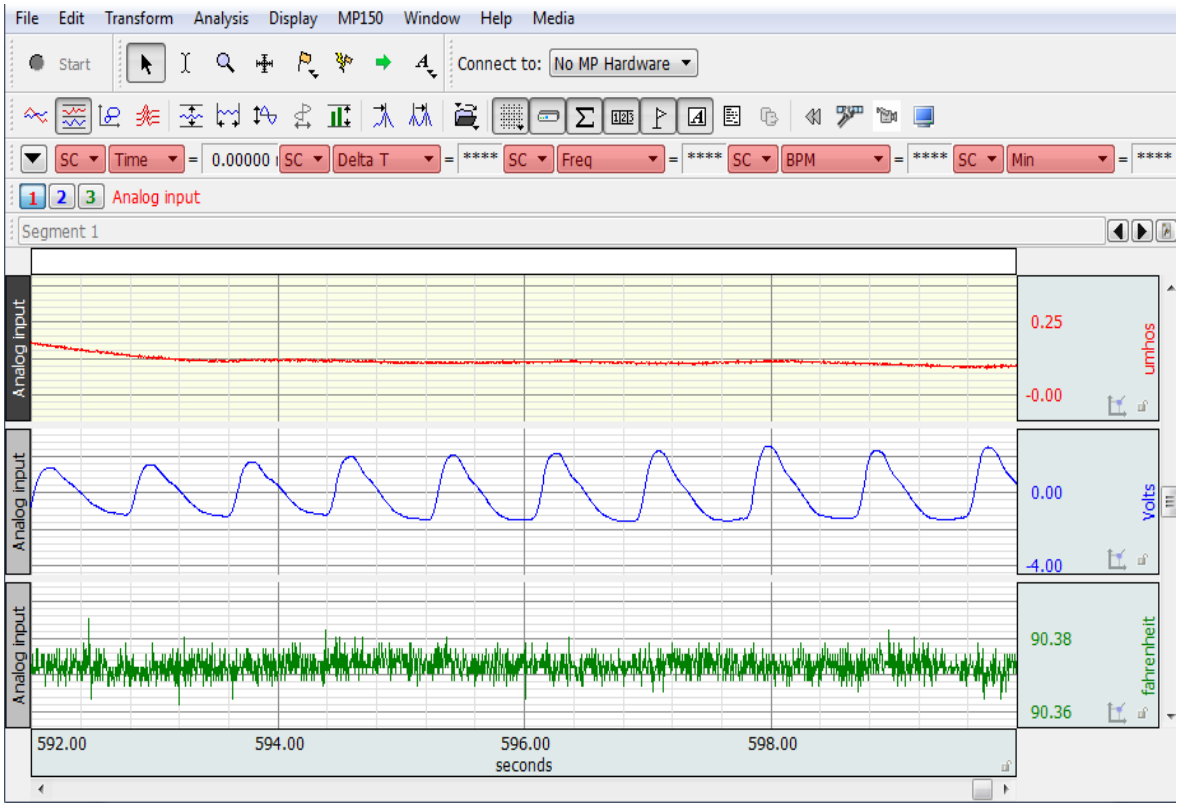

Figure 4.1 BIOPAC Software Interface screenshot while recording data

4.1 Skin Temperature

Skin temperature analysis was executed for both Turkish subjects and Foreign subjects for all periods of the record. ST measurement screenshot given figure(4.2) Descriptive statistical information about mean and standard deviation is given in Table (4.1) Figure 4.3 shows the change in Skin temperature both the Turkish and Foreign subjects all periods.

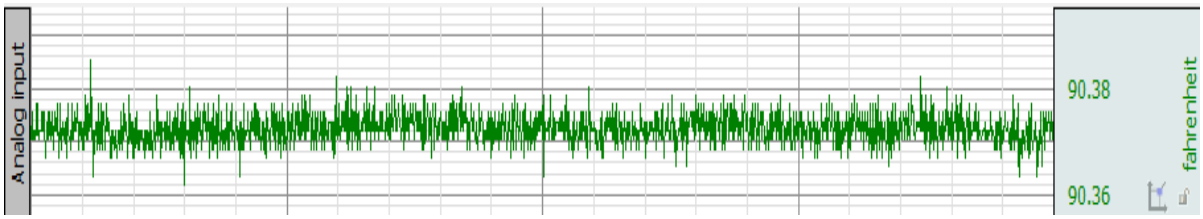

Figure 4.2 Screenshot part of Skin temperature measurement signal during total recording in each group

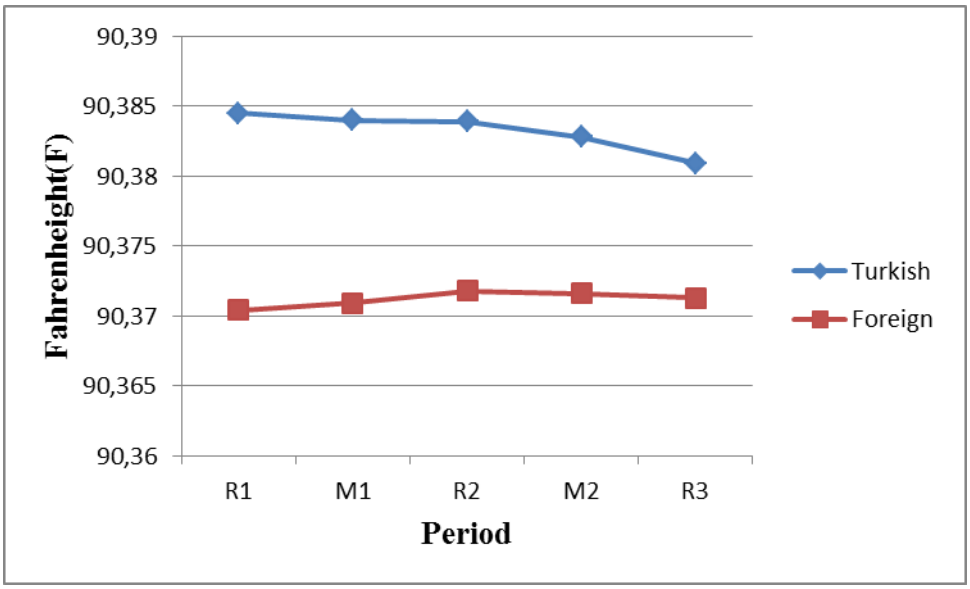

Figure 4.3 Change in skin temperature at different periods. R1 is first resting period, M1 is music period, R2 is second resting period, M2 scond music period and R3 is third resting period.

Table 4.1 Descriptive statistics about skin temperature in the Turkish and Foreign subjects

	Turkish subject		**Foreign subject**	
Period	**Mean (F)**	**Standart dev.**	**Mean (F)**	**Standart dev.**
R1	90.3845	0.0019	90.3704	0.0023
M1	90.384	0.0020	90.3709	0.0023
R2	90.3839	0.0020	90.3718	0.0022
M2	90.3828	0.0021	90.3716	0.0023
R3	90.3809	0.0018	90.3713	0.0027

Our results showed that the highest ST was in R1 period and the lowest ST was at R3 period in Turkish subjects. In foreign subjects,the highest ST was recorded in R2 period and the lowest ST was observed at R1 period. Turkish subjects mean ST was higher than foreign subjects in all periods.

The Turkish and Forein subjects were compared in its group with SPSS® programme, paired sample Student's t-test. The level of confidence interval was 95% thus the significant difference between groups was accepted when p value smaller than 0.05. In our results showed that there is significant difference between (M1) and (R1) periods (p=0,072) only in Turkish subjects. Statiscal results showed Table 4.2 and Table 4.3.

Table 4.2 Comparison of skin temperature between the different periods in Turkish subjects

Turkish	**R1-M1**	**M1-R2**	**R2-M2**	**M2-R3**	**R1-R2**	**R2-R3**	**M1-M2**
Mean	0,00394	0,00059	0,00107	0,00456	0,00389	0,00327	0,00118
Std.dev.	0,00783	0,00827	0,00619	0,00456	0,00542	0,01353	0,00864
P value	0,0072	0,785	0,512	0,346	0,256	0,365	0,604

Table 4.3 Comparison of skin temperature between the different periods in Foreign subjects

Foreign	**R1-M1**	**M1-R2**	**R2-M2**	**M2-R3**	**R1-R2**	**R2-R3**	**M1-M2**
Mean	0,00325	0,0023	0,00105	0,00060	0,00195	0,00165	0,00132
Std.dev	0,00754	0,00881	0,00451	0,00207	0,00906	0,00655	0,00438
P value	0,1176	0,316	0,384	0,281	0,419	0,347	0,262

The comparing between Turkish and Foreign groups were performed by SPSS statistical programme, independent sample Student's t test and results are given in Table 4.4

Table 4.4 Comparing of skin temperature between the Foreign and Turkish group

Periods	**R1**	**M1**	**R2**	**M2**	**R3**
Mean diff	0,00034	0,00032	0,00031	0,00027	0,00021
Std. err. Diff	0,0008	0,0007	0,0005	0,0007	0,0008
P value	0,0531	0,052	0,054	0,060	0,062

Significant differences was not observed in any periods after comparing by independent sample students t test.

4.2 Galvanic Skin Response

Galvanic skin responce measured in all periods. Measurement continued during 10 minutes(600 sec.).

Figure 4.4.a)

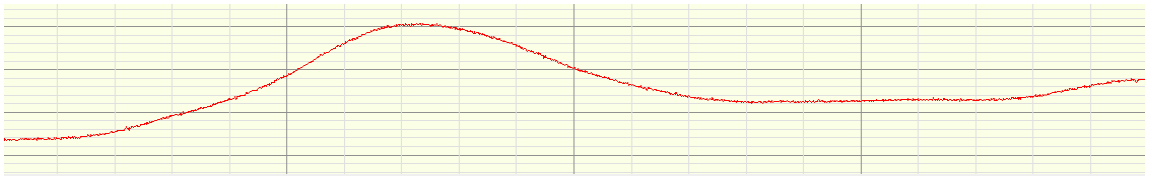

Figure 4.4 b)

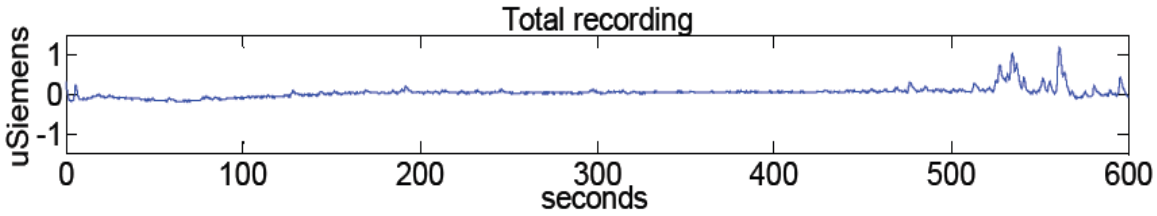

Figure 4.4 a) and Figure 4.4 b) Shows change in galvanic skin response during the signals recording.

Paired sample Student's t-test were applied to analyze the difference between periods. 95% confidence level was taken , also significant difference was approved when p value is less than 0.05.There are significant difference observed between R1-M1 (P= 0,004), M1-R2 (P=0,033) , R2-M2 (P=0,0438) , M2-R3(P=0,0421) R2-R3 (P=0,0402), M1-M2 (P=0,0494) periods in Turkish group.In Foreign group,significant difference is observed in R1-M1(P=0,003), R2-M2(P=0,049),M2-R3 (P=0,024),M1-M2(0,0494) periods in Table 4.5. Histogram presentation of SC datas is in Figure 4.5. The results of this comparison are written in Table 4.6. Mean and standard deviation of SC analysis results of Turkish and Foreign group in all periods was showed in Table 4.7. And also Figure 4.6 and Figure 4.7 shows SC changing in two group.

Table 4.5 Comparison of skin conductance between periods in the Turkish and Foreign group

	Turkish Group		**Foreign Group**	
Periods	**Mean ± (SD) (µSiemens)**	**P value**	**Mean ± (SD) (µSiemens**	**P value**
R1-M1	0,003859 ± (0,07673)	0,004	0,01576 ± (0,01669)	0,003
M1-R2	0,00884 ± (0,07211)	0,033	0,00067 ± (0,01584)	0,112
R2-M2	0,00304 ± (0,02366)	0,0438	0,01682 ± (0,03071)	0,049
M2-R3	0,00297 ± (0 ,02280)	0,0421	0,01153 ± (0,01768)	0,024
R1-R2	0,02395 ± (0,03127)	0,510	0,01509 ± (0,01868)	
R1-R3	0,02975 ± (0,03284)	0,0594	0,02037 ± (0,02565)	0,008
M1-M2	0,00481 ± (0,07106)	0,0494	0,01615 ± (0,02976)	0,041
R2-R3	0,00580 ± (0,03197)	0,0402	0,00529 ± (0,02282)	0,385

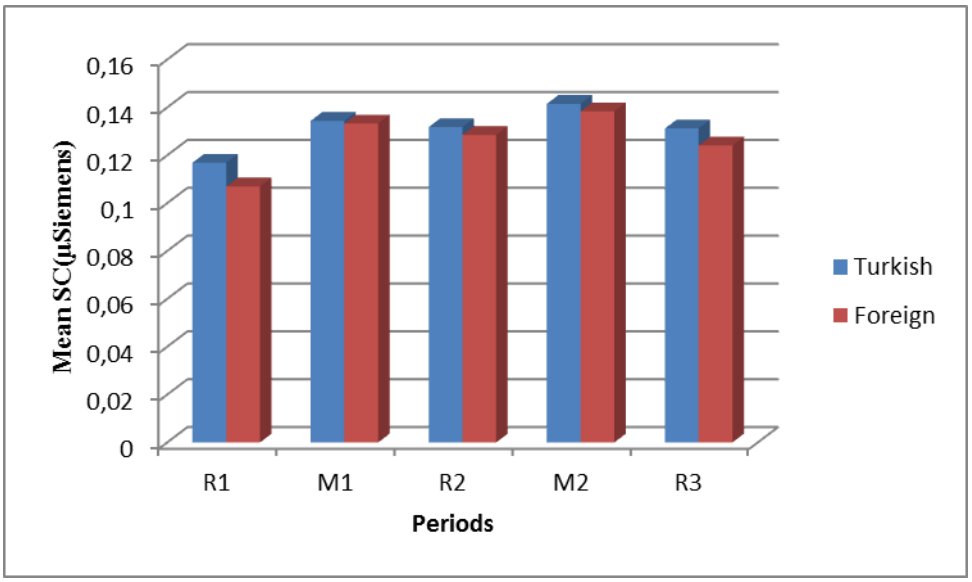

Figure 4.5 Skin conductance graphics of the Turkish and Foreign groups in periods

Independent sample Student's t-test was used to compare between Turkish and Foreign group.Highest SC value of Turkish group is observed in M2 period, same result is observed in foreign group. Lowest SC value of Turkish group is recorded in R1 period and same result is observed in foreign group.

Table 4.6 Statistics about skin in the Turkish and Foreign group

	Turkish Group		**Foreign Group**	
Period	**Mean (µSiemens)**	**Standard Deviation**	**Mean (µSiemens)**	**Standard Deviation**
R1	0,1169	0,01541	0,1070	0,01852
M1	0,1344	0,01804	0,1332	0,07453
R2	0,1318	0,02320	0,1285	0,03006
M2	0,1415	0,03819	0,1384	0,02692
R3	0,1312	0,01665	0,1241	0,02322

Table 4.7 Comparison of skin conductance between the turkish and foreign group

Periods	**R1**	**M1**	**R2**	**M2**	**R3**
Mean Diff.	0,00995	0,00877	0,00332	0,00311	0,00714
Std. Err. Diff.	0,00622	0,01980	0,00332	0,01206	0,00738
P value	0,121	0,664	0,738	0,336	0,341

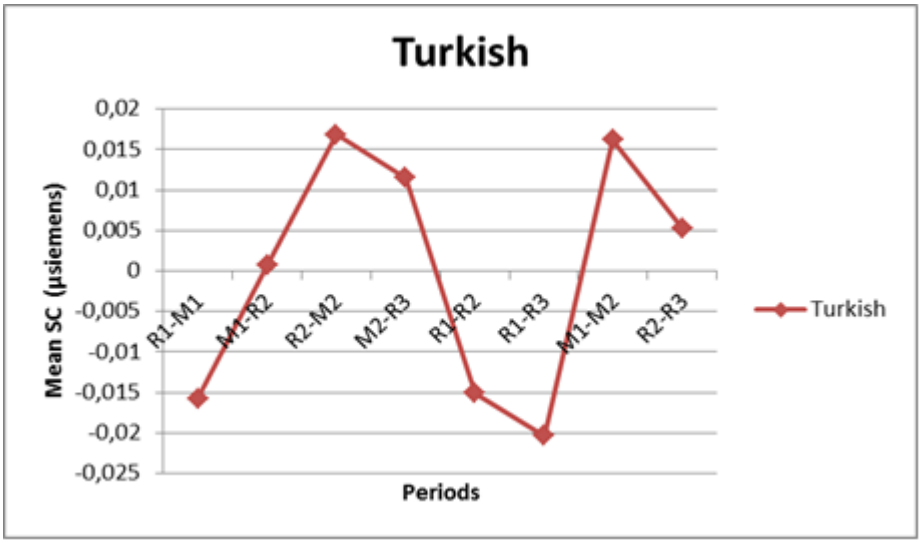

Figure 4.6 Change in skin conductance for Turkish group

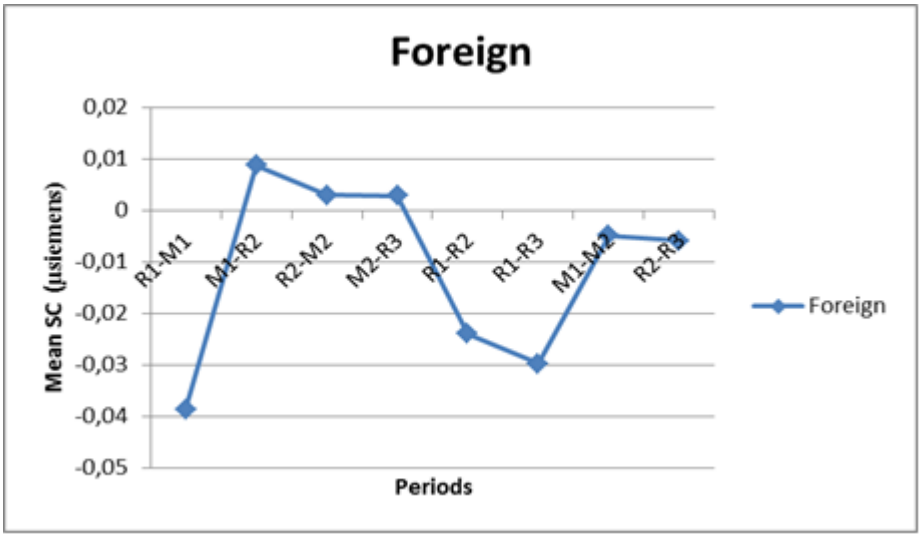

Figure 4.7 Change in skin conductance for Foreign group

4.3 Blood Volume Pulse

PPG signals give information about heart rate and heart rate variability (HRV) by MATLAB software algorithm. Maximum and minimum heart rates are given in (Table 4.8) . (Figure 4.8) shows change of blood volume pulse during recording.

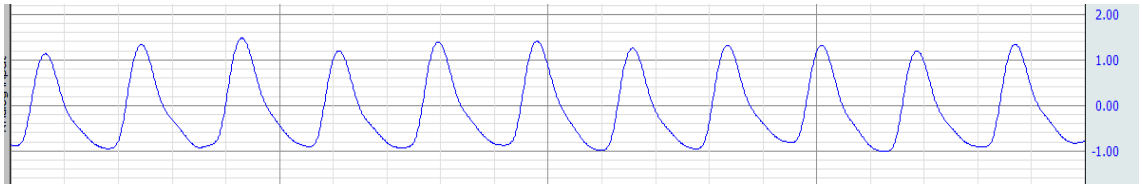

Figure 4.8 Changing blood volume pulse during the signals recording.

Table 4.8 Maximum and minimum peaks of PPG signals of the Turkish and Foreign group

		Turkish group			**Foreign group**		
Heart Rate		**Mean**		**Standard dv.**	**Mean**		**Standard dv.**
R1	**Max.**	98.7	89.25	15,17	91.2	85.5	19.9
	Min	79.8		15.02	80		18.6
M1	**Max**	90.2	85.1	18.6	88.5	82.75	24.8
	Min	80		16.9	77		24.3
R2	**Max**	83	75.25	16.3	74.5	73.7	22.03
	Min	67.5		16	72.9		21.9
M2	**Max**	102.9	93.95	16.5	97.8	85.55	23.7
	Min	85		16.1	73.3		23
R3	**Max**	87.6	78.5	13.5	84.3	78.1	22
	Min	69.4		13.2	71.9		21.8

The maximum heart rate is obtained during M2 period both Turkish and Foreign group.Minimum heart rate is detected in R2 period in turkish group and R3 Period in foreign group.Heart rate was higher in all periods for Turkish group.In turkish group heart rate is decreased while pass from R1 to M1 period and increase R2 to M2 periods and also decreased while while pass from M1 to R2 and M2 to R3 periods.Same results are observed in foreign group. Comparison between periods in both heart beats of the Turkish and Foreign group is given in Table 4.9.

Table 4.9 Comparison of heartbeat between periods in the Turkish and Foreign group (mean / standard deviation)

Heart Beat	**Turkish Group**		**Foreign Group**	
Periods	**Mean / SD**	**P value**	**Mean / SD**	**P value**
R1-M1	3.5 / 14.774	0,002	10.2 / 13.54	0.074
M1-R2	2.69 / 12.459	0,056	6.35 / 12.89	0.562
R2-M2	4.56 / 11.32	0,062	4.57 / 9.67	0.623
M2-R3	7.69 / 16.76	0.125	1.35 / 18.49	0.0314
M1-M2	4.54 / 10.89	0.342	12.6 / 13.7	0.0387
R1-R2	1.78 / 12.65	0.071	18.54 / 23.67	0.236
R1-R3	3.2 / 18.65	0.063	16.4 / 12.83	0.631
R2-R3	2.25 / 13.43	0.276	7.83 / 13.09	0.592
M1-R3	0.43 / 9.56	0.257	7.23 / 10.11	0.0621
R1-M2	8.76 / 9.16	0.416	4.215 / 21.25	0.634

Paired sample Student's t-test was used for comparison of the periods both Turkish and foreign group. The confidence level was select at 95% and significant difference was accepted when ($p < 0.05$). According to Table 4.9 there was a significant difference observed between R1-M1 periods in Turkish group. In Foreign group there was a significant difference observed between M2-R3, M1-M2 periods ($p<0.005$).Power spectral density was analyzed by Welch's periodogram algorithm. Power, maximum amplitude and frequency for both Turkish and Foreign group are showed in Table 4.10.

Table 4.10 Mean and standard deviation of HRV components (Power, Frequency, Maximum amplitude) between the Turkish and Foreign subjects

	Turkish group			**Foreign group**		
Period	**Power (Watt)**	**Frequency (Hz)**	**Maximum Amplitude (Volt)**	**Power (Watt)**	**Frequency (Hz)**	**Maximum Amplitude (Volt)**
R1	0.5284± 0.0007	0.1347± 0.1235	0.5608± 0.02743	0.5245± 0.0004	0.1297± 0.1326	0.4257± 0.0456
M1	0.6326± 0.0004	0.2214± 0.1585	0.6238± 0.0349	0.4831± 0.0006	0.1309± 0.1482	0.4536± 0.0241
R2	0.5962± 0.0012	0.2315± 0.1372	0.6126± 0.0283	0.5843± 0.0007	0.2118± 0.1162	0.6237± 0.03131
M2	0.6208± 0.0006	0.2104± 0.1383	0.8341± 0.03672	0.5769± 0.0005	0.2406± 0.1582	0.6421± 0.03212
R3	0.6204± 0.0007	0.4184± 0.1672	0.7248± 0.04133	0.6073± 0.0006	0.3145± 0.1594	0.4592± 0.04168

Power spectrum of Turkish groups is given in Figure 4.9 and foreign group Figure 4.10. The histogram of means of both groups is shown in Figure 4.11.

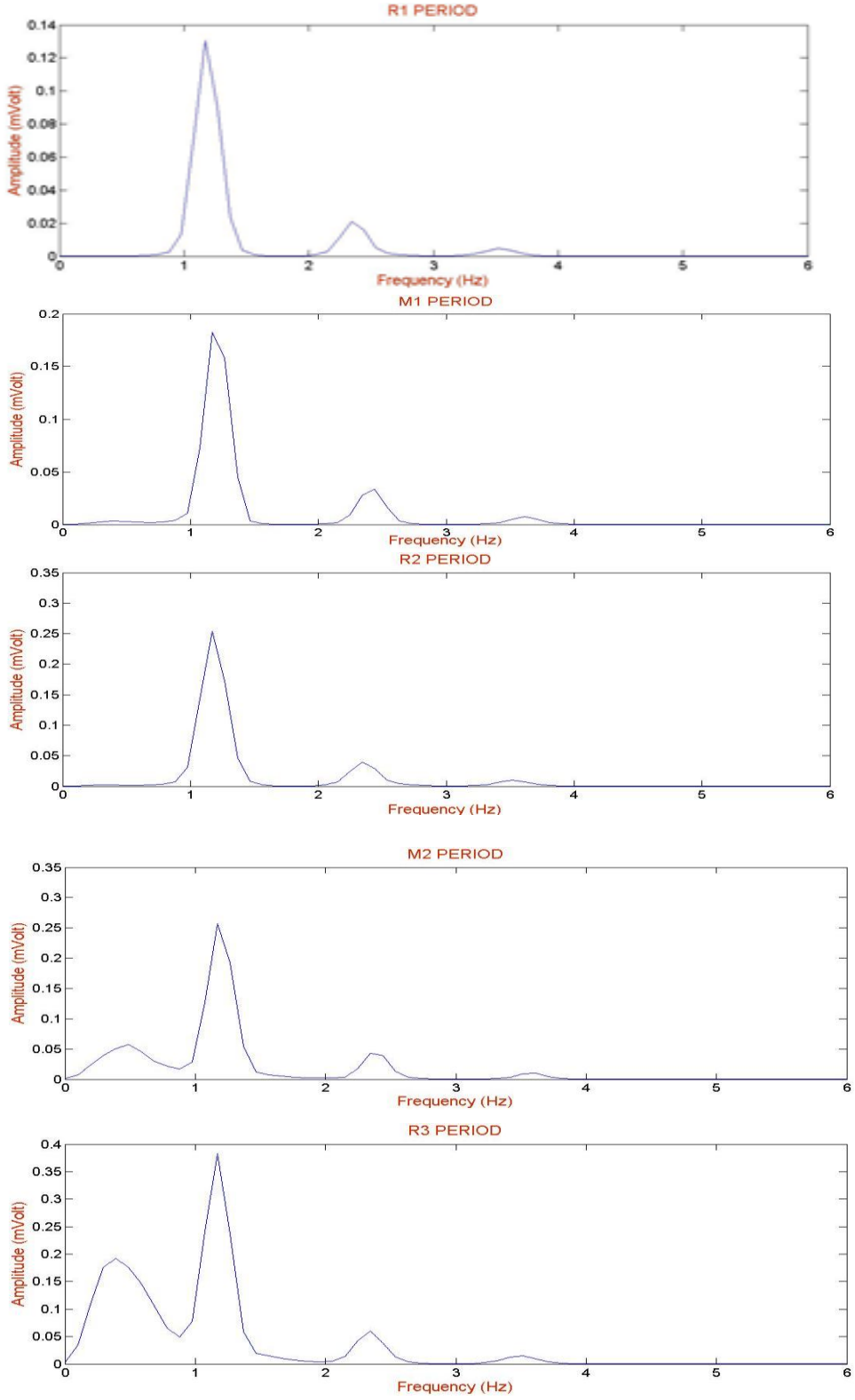

Figure 4.9 Power spectrum of the Turkish group at different periods.

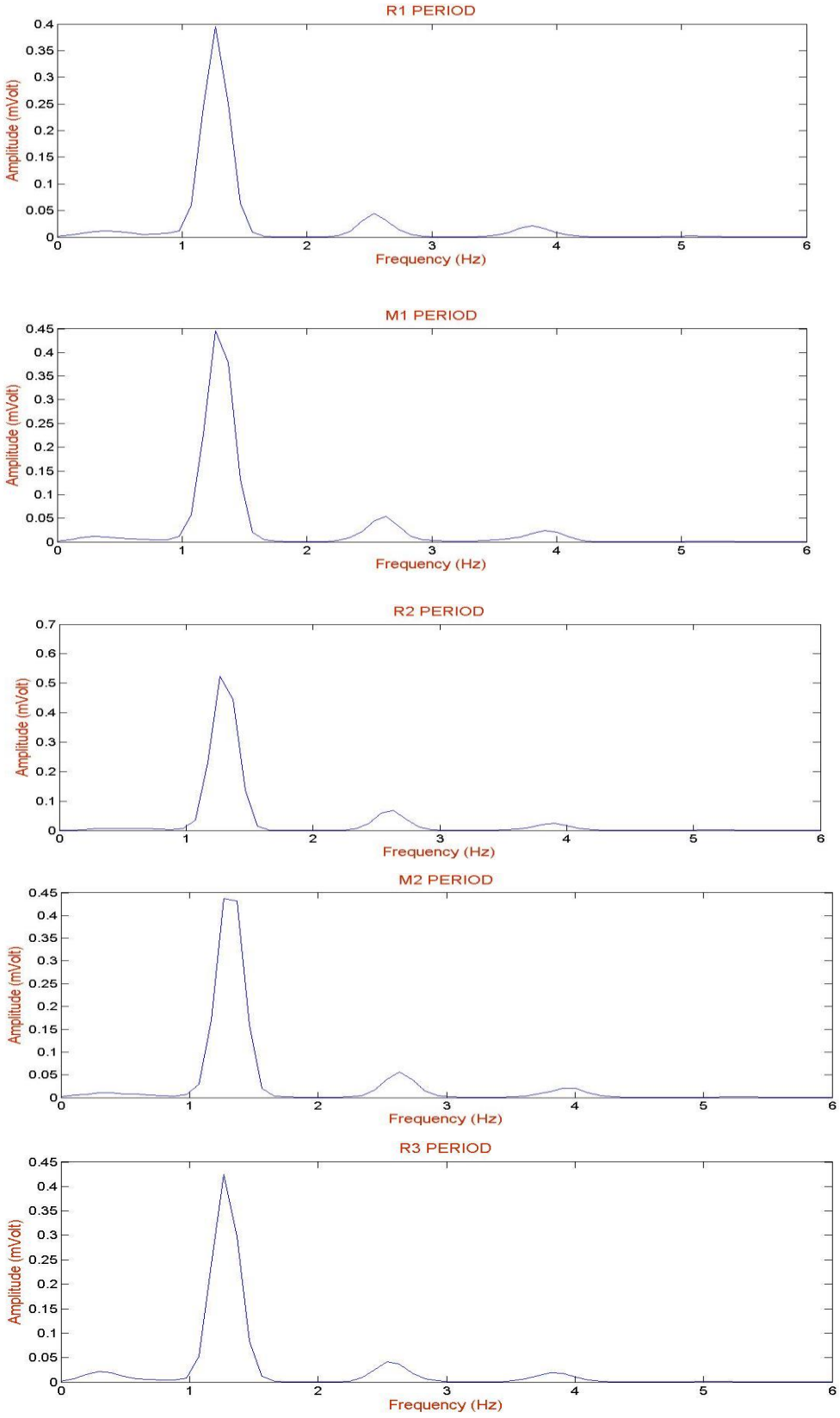

Figure 4.10 Power spectrum of the foreign group at different periods.

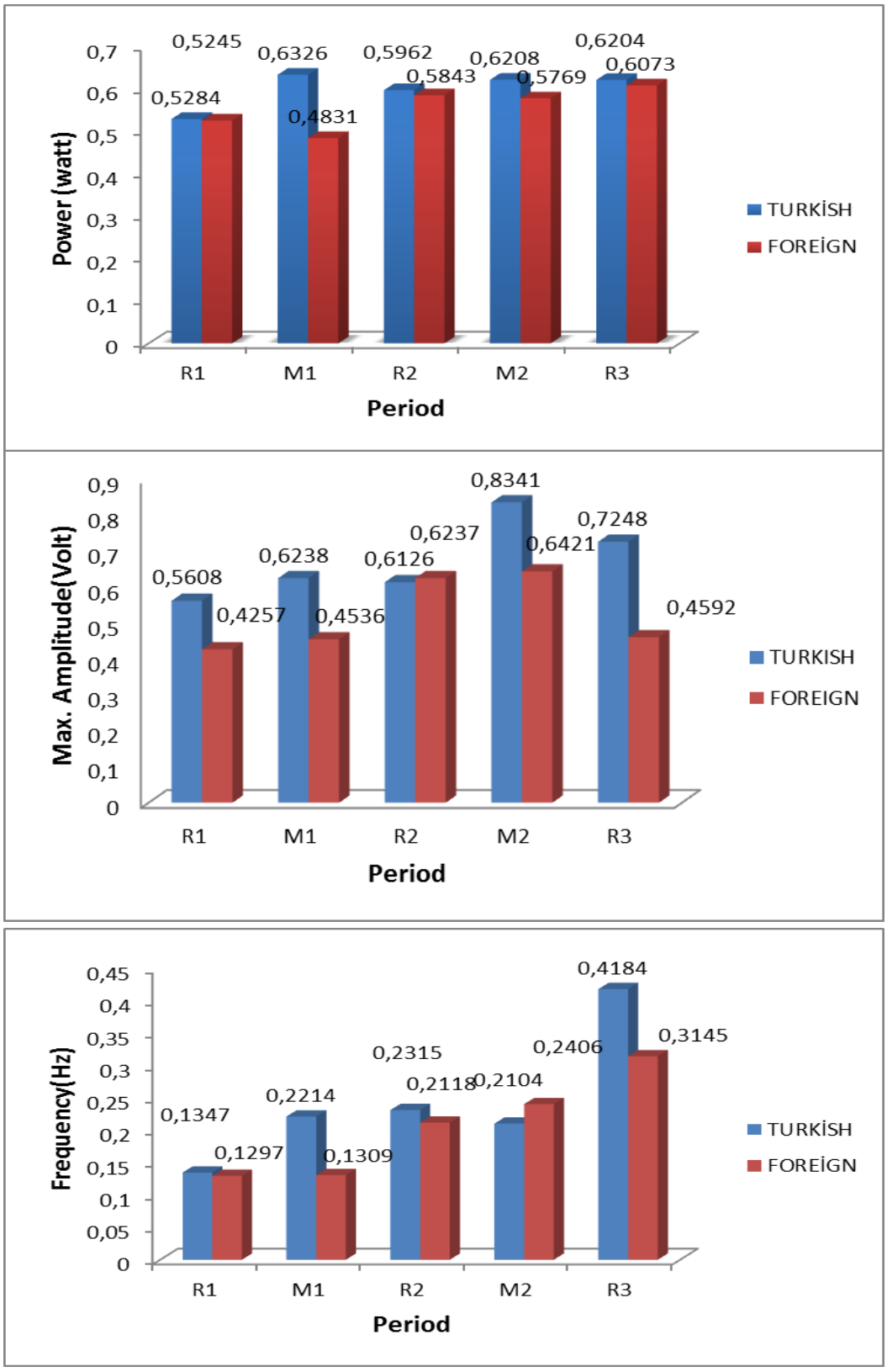

Figure 4.11 Power (a), Maximum amplitude (b) Frequency (c) of the Turkish and Foreign group

According the **Figure 4.11 and Table 4.10,** in Turkish group, the power is increased from R1 to M1 period and then it is regressed lowest value in R1 and highest value in M1 period. After that, it is increased in M2 and decreased from M2 to R3 period. In foreign group, the power is decreased from R1 to M1 period, and it is regressed lowest value in M1 period, and then is increased from M1 to R2 period, last reached the highest value in R3 period. In each period Turkish group's power value higher than foreign group's. Maximum amplitude is increased from R1 to M1 period and regressed lowest value in R1 period. Maximum amplitude had a highest value in M2 period and is decreased from M2 to R3 period in Turkish group. Foreign group had a lowest Maximum amplitude value in R1 period and is increased from R1 to M2 period and is reached highest value M2 period. Max amplitude was higher R1, M1, M2, R3 period for Turkish group. Frequency was highest value in R3 period and lowest value in R1 period both Turkish and Foreign group. Frequency is increased from R1 to R2 period and from M2 to R3 period in Turkish group. Frequency is decreased only from R2 to M2 period. İn foreign group, frequency is increased from R1 to R3 Period.

Paired sample Student's t-test was applied for comparison of the periods between them. The confidence level was 95% and difference is accepted significant when p value is smaller than 0.05.

There is significant difference in power between R1-M1, R1-R3, M1-R2, and M2-R3 periods. For frequency the difference is observed in R1-M1, M1-R2, and M1-R3. For max. amplitude, there is significant difference is R1-M1, M1-R2, and R2-M2 periods in Turkish group.

Significant difference is found in power between R1-M1, R1-R3, M1-M2, and M2-R3 periods. There is significant difference in frequency between R1-M1, R1-R2, M1-R2 and for Maximum amplitude there is significant difference is observed in R1-M1, R1-M2, R2-R3 periods in foreign group.

Table 4.11 Comparison of components of HRV; power, maximum amplitude and frequency between periods in the Turkish group

	Power (Watt)		**Frequency (Hz)**		**Maximum Amplitude (Volt)**	
	Mean ± SD	**p value**	**Mean ± SD**	**p value**	**Mean ± SD**	**p value**
R1-M1	0.152351 ± 0.0004	0.0013	0.163584 ±0.0836	0.0022	0.062245 ±0.1030	0.0012
R1-R2	0.146427 ± 0.0005	0.0724	0.15247 ±0.0745	0.231	0.05347 ±0.2384	0.0621
R1-M2	0.02374 ± 0.0003	0.128	0.00452 ±0.0423	0.061	0.036748 ±0.0736	0.0629
R1-R3	0.03526 ± 0.0007	0.0017	0.09168 ±0.0561	0.271	0.00024 ±0.0534	0.324
M1-R2	0.17309 ±0.0010	0.00395	0.08264 ±0.1281	0.000	0.06358 ±0.0427	0.0234
M1-M2	0.03956 ±0.0008	0.545	0.07261 ±0.0415	0.0561	0.04946 ±0.00536	0.317
M1-R3	0.003475 ±0.0007	0.126	0.16285 ±0.0416	0.0023	0.04629 ±0.0453	0.072
R2-M2	0.01437 ±0.00035	0.630	0.17288 ±0.0427	0.176	0.05638 ±0.0579	0.0025
R2-R3	0.03725 ±0.0004	0.183	0.0925 ±0.0792	0.2618	0.0738 ±0.0683	0.146
M2-R3	0.000372 ±0.0005	0.00360	0.08362 ±0.0626	0.163	0.08248 ±0.0546	0.191

Table 4.12 Comparison of components of HRV; power, maximum amplitude and Frequency between periods in the foreign group

	Power (Watt)		**Frequency (Hz)**		**Maximum Amplitude (Volt)**	
	Mean ± SD	**p value**	**Mean ± SD**	**p value**	**Mean ± SD**	**p value**
R1-M1	0.007456 ±0.0063	0.0021	0.153674 ±0.0845	0.0172	0.02184 ±0.045	0.00421
R1-R2	0.003264 ±0.0056	0.142	0.08128 ±0.0713	0.000	0.01936 ±0.0013	0.0613
R1-M2	0.00946 ±0.0043	0.526	0.09267 ±0.0052	0.0723	0.03529 ±0.0142	0.0031
R1-R3	0.005362 ±0.009453	0.000	0.0835 ±0.0783	0.0513	0.03805 ± 0.010	0.213
M1-R2	0.000463 ±0.00647	0.0653	0.15245 ±0.00213	0.0021	0.02371 ±0.00325	0.0553
M1-M2	0.00392 ±0.0053	0.0035	0.09267 ±0.0067	0.0083	0.01272 ±0.008	0.314
M1-R3	0.000743 ±0.00023	0.0626	0.0833 ±0.00042	0.0567	0.03935 ±0.004	0.0613
R2-M2	0.001325 ±0.00262	0.251	0.06291 ±0.0919	0.261	0.156354 ±0.014	0.613
R2-R3	0.00635 ±0.00381	0.214	0.02291 ±0.0537	0.000	0.0025062 ±0.0121	0.0213
M2-R3	0.000574 ±0.00043	0.000	0.1629 ±0.0092	0.162	0.17239 ±0.01315	0.146

CHAPTER 5

DISCUSSION AND CONCLUSION

Aim of this study to understand and observe the effect of Turkish music modes upon human galvanic skin response, skin temperature and blood volume pulse on Turkish and foreign subjects.

Music can be used therapy method on human. According to famous thinker Farabi, each music modes have different impact on people. Many researches have been done before about effect of music upon human, but there are a few studies about music modes effect on subjects. Generally studies were interested about just music type's effect (rock, classical, traditional, and jazz). There are 600 modes but todays 20 modes commonly used. According to Farabi, rehavi mode gives a person the idea of eternity, rast mode gives person happiness and comfort, uşşak mode gives a person the laughter, kuçek makam gives sadness. We used two mode types in this study; Kuçek Makam and Rast Makam. When kuçek makam gives negatively effect, rast makam gives positive effect to person.

In this thesis, skin temperature (ST), skin conductance (SC) and blood volume pulse (BVP) signals were collected from healthy 15 Turkish and 15 foreign subjects with by BIOPAC® system. A MATLAB® software algorithm was used to signal processing and SPSS® software was used to make statistical analysis. Some exclusion criteria is identified and subjects who has these criteria is eliminated. Participants were selected from doesn't use any medication and alcohol. Because, side effects of medications may affect autonomic nervous system activation.

Also, using alcohol affect brain and heart function. These factors prevent us to obtain accurate results. The signal recording start with resting state (R1), after M1 period began with by kuçek mode then resting state started (R2) and after this period, M2 period started by rast mode, finally (R3) period began and recording is finished .During the recording, participants sat up on the chair and did not move.

In Turkish group, skin temperature was slightly higher in R1 period than other periods. ST was slowly decreased after than R1 period and regressed lowest value in R3 period. Turkish participants started with high skin temperature value and they had a higher ST value than foreign group at all periods. Foreign subjects started lower ST value in first period, after that increase occurred in M1 and R2 period, and then began to decline during M2 and R3 period. Paired sample Student's t-test and independent t-test were used to determine the difference in the periods. When using paired student t-test in Turkish group, we obtained mean, standard deviation, and p value parameters in between periods. İf p value is smaller than 0.05, we can accept them significant. We observed significant p value only between R1-M1 periods in Turkish group. Other periods and foreign group periods didn't have significant difference. According various study results, music can influence blood circulation, heart rate, breathing, and sweating. Body temperature can be associated with these factors. Lively music and rock music can raise our body heat a few degrees, while soft music with a weak beat can lower it. But we didn't have significant difference between resting and music period. Consequently, we found that kuçek and rast modes did not affect skin temperature sufficiently during recording signals or participants were affected because of noise in the room, for these reasons we couldn't obtain enough result. Some research has found that music is effective on body temperature but most studies show that music is not effective on human body temperature or is slightly effective.

SC value was lowest in R1 period and reached highest value in M2 period in Turkish group. Same result is observed in foreign group. Due to resting state, expected results were decrement in R2 and R3 periods. We saw these results in both groups. Highest mean was obtained in M2 period in both groups. Reason of this result can be rast mode effect upon skin conductance. We determined evident rising on M1 period. İt can be related auditory stimulation effect. Participant listened kuçek mode in M1 period. Kuçek mode normally has distressing effect. İf participants didn't like kuçek mode, their skin may suddenly give to reaction during playing. Music stimulation came after R1 periods. Participants can be scared in this phase because of music voice level, later they may have to adapt. Just by looking at the average values and standard deviation we cannot do correct assessment. Furthermore, we can examine the p values results between different periods on the both group. Turkish group have significant difference

in R1-M1, M1-R2, R2-M2, M2-R3, R2-R3, M1-M2 periods. According to these, SC values are affected from both modes. Because we obtained significant difference in periods where there is music. Additionally we determined significant p value between R2-R3 periods. Possibly, effect of modes continued between these resting periods. In foreign group significant difference observed in R1-M1 (P=0,003), R2-M2 (P=0,049), M2-R3 (P=0,024), M1-M2 (0,0494).We can say same things for this group. According to the Robyn armon et al study, participant's galvanic skin responses were not affected by music tempo but on the contrary Georgy H. Zimny and Edward Weidenfeller found that exciting music increases the conductivity of the skin [62]. İn addition, in another study of Georgy H. Zimny and Edward Weidenfeller, GSR increased with the calming music and decreased by exciting music on children [63]. As can be seen, experiments have given different results. In our experiment result, when listening kuçek and rast mode, GSR mean increased in both group. But highest increase occurred during listening rast mode. it may show that rast mode affect skin conductivity more than kuçek mode.

Heart rate variability is time interval between heartbeats. Heart rate variability (HRV) is good evidence for cardiac autonomic regulation and mostly analyzed on ECG signal. PPG is the non-invasive technique that can work as ECG and HRV may be processed on PPG signal. Heart rate (HR) of Turkish group was higher than foreign group at all periods. HR of Turkish group decreased during M1 and R2 periods. After, it is on the rise at M2 periods and again decreased at R3 period. Heart rate of foreign group decreased in M1 and R2 periods. The same situation was observed in Turkish subjects. After R2 periods heart rate significantly increased. And then decrement is occurred in R3 period. According to these results kuçek mode caused reduction in M1 periods and rast mode caused increment in M2 period in both group. At the end of the recording, both group had lower HR from their starting HR. Turkish and foreign group showed increased parasympathetic activation due to auditory stimulation. In addition, significant difference is observed in R1-M1 period for Turkish subjects and M2-R3, M1-M2 period for foreign subjects.

Power component of HRV was calculated for both group and Turkish group values were higher than foreign group. İn R1 period, power value was almost similar to foreign group. In M1 period there was increase in Turkish group but foreign power value was decreased. Turkish group reached highest value during M1 period and in the same period foreign group was a lowest value. In R2 period power decreased, but there was opposite effect in foreign group also foreign group was highest value in R2 period. Turkish groups' power value increased in M2 period but decrease observed in same period for foreign group. In maximum amplitude (MA) component of Turkish group was also higher values at all periods than foreign group and highest value was detected in M2 period and lowest value was in R1 period for both group. Significant change was occurred between R1-M1, M1-R2, and R2-M2 periods in Turkish group. In foreign group these period were different, R1-M1, R1-M2, R2-R3 periods that significant difference was observed. R1-M1 period was common in both group. Amplitude of HRV gives information about ANS balance that higher amplitude shows higher autonomic balance. According to Rollin mc craty et al. study, İf people feel such as gratitude, appreciation, love and any positive emotions, they mostly show concinnity. In opposite situation, if people feel such as fear, anxiety, despair, depression and any negative emotions, their heart rate variability mostly show inconsistency [64]. High MA was expected in M2 period, and observed in M2.Because we used rast mode in this period. Rast mode gives happiness and comfort and amplitude of heart rate variability is affected positively. Frequency value of Turkish and foreign group reached highest number at R3 period also they had lowest value in R1 period. Frequency increased in M1 period in both groups. When listening rast mode, frequency decreased in Turkish, but opposite effect occurred in foreign. Significant difference was observed R1-M1, M1-R2 and M1-R3 periods in Turkish subjects, foreign group had a significant difference in R1-M1, R1-R2, M1-R2 and R2-R3. In conclusion, according to this study result, we found that kuçek and rast modes did not affect the skin temperature sufficiently during recording signals. While listening kuçek and rast mode, we obtained increase of GSR in both group. But highest increase occurred during listening rast mode. It may show that rast mode affect skin conductivity more than kuçek mode. Heart rate results show use kuçek mode caused reduction in M1 periods and rast mode caused increment in M2 period in both group. But we examine the p value in these parameters,

we cannot say distinct things because we didn’t get enough meaningful results in p value. Kuçek and Rast modes have been less effective than expected. Test procedure may affect these results. Probably, participants could have acted or ten minutes for procedure with eyes closed, may be long to subjects. We can shorten procedure time, or can make different time. It can be provide to obtain more accurate result. İn this study, foreign and Turkish subjects didn’t show satisfactory result. We mostly observed similar results with each other.

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APPENDICES

Appendix A

Deney Koşullarına Uygunluk

Teste gönüllü kişinin Adı ve Soyadı:	**Tarih:**
Yaş:	**Cinsiyet**

	Evet	**Hayır**
24 saat içinde alkol tüketimi	☐	☐
Düzenli kullanılan ilaç	☐	☐
Hamilelik Durumu (Sadece Bayanlar)	☐	☐

Figure A.1 Compability to the experimental conditions

Bilgilendirililmiş Onam Formu

Fatih üniversitesi'nde "Türk müziği makamlarının sağlıklı insanlar üzerinde fiziksel etkilerinin değerlendirilmesi" isimli tez çalışması kapsamında katılımcılardan bazı elektrofizyolojik sinyaller alınacaktır.

Çalışma kapsamında GSR(Galvanik Skin Response), ST(Skin tempereature) ve BVP (Blood Volume Pulse) ölçümünün yapılması planlanmaktadır. İşitsel uyaran olarak Türk müziği makamlarından ; kuçek ve rast makamları kullanılacaktır. Hiçbir girişimsel işlemde bulunulmayacak ve herhangi bir ilaç verilmeyecektir. Çalışmaya gönüllü katılımcılar alınacaktır. Ayrıca kişisel bilgi formu doldurulacaktır.

Çalışma kapsamında elde edilen tüm verilerin ve katılımcıların isimlerinin gizli tutulacağı, bilimsel bir amaçla bu verilerin toplanıldığı ve sadece bilimsel çalışma kapsamında kullanılacağı bana bildirildi. Bu çalışmaya kendi rızamile katılmayı kabul ediyorum.

Katılımcı:

Tarih :

İmza:

Figure A.2 Participant Consent Form

CURRICULUM VITAE

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