

HEART RATE VARIABILITY CHANGE DURING COGNITIVE TASKS IN DIFFERENT AGE GROUPS

Submitted in partial fulfillment of the requirements for the award of
Master of Technology degree in Medical Instrumentation

By

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**DEPARTMENT OF BIOMEDICAL ENGINEERING
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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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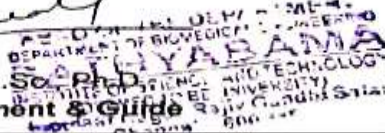
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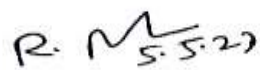
BONAFIDE CERTIFICATE

This is to certify that this project report is the bonafide work of **Vigneshwaran. S** (Reg. No. 41440013) who carried out the project entitled "**Heart rate variability change during cognitive tasks in different age groups**" under our supervision from **November 2022 to April 2023**.


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Submitted for Viva-voce Examination held on 05 - 05 - 2023


Internal Examiner


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DECLARATION

I, **Vigneshwaran. S (Reg. No. 41440013)** hereby declare that the project report entitled “**Heart rate variability change during cognitive tasks in different age groups**” done by me under the guidance of Dr. **T. SUDHAKAR**, M.Sc., Ph.D., Department of Biomedical Engineering is submitted in partial fulfillment of the requirements for the award of **Master of Technology** degree in **Medical Instrumentation**.

DATE: 05.05.2023

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

Cognitive functions are mental skills that enable accurate environmental information management and interpretation. The simplest daily duties as well as the most complicated occupations require proper cognitive functioning. The cognitive changes brought on by aging can potentially become clinically significant and severe enough to impair daily functioning. Given the sociodemographic settings of today (population aging), the challenge for modern research is to understand the causes of this pathological decline and to try to find the early signs of cognitive impairment. When there are autonomic dysfunctions, cognitive function deteriorates. Heart rate variability (HRV), which is seen as an indicator of the autonomic control of the heart, is viewed from this perspective as a possible physiological correlate of cognitive function. This research explains about the cognitive ability of test individuals with the help of determining the heart rate variability of different age groups by using a device, "BIOPAC" and data analysis software.

KEYWORDS: Daily functioning, Autonomic dysfunctions, Heart rate variability, BIOPAC.

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LIST OF ABBREVIATIONS

BP	BLOOD PRESSURE
BSL	BIOPAC STUDENT LAB
ECG	ELCTROCARDIOGRAM
HRV	HEART RATE VARIABILITY
SVB	SYMPATHETIC VAGAL BALANCE
ANS	AUTONOMIC NERVOUS SYSTEM
SNS	SYMPATHETIC NERVOUS SYSTEM
PNS	PARASYMPATHETIC NERVOUS SYSTEM
VLF HRV	VERY LOW FREQUENCY HEART RATE VARIABILITY

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CHAPTER 1

INTRODUCTION

Through the sympathetic and parasympathetic branches, which compete with one another to maintain a dynamic equilibrium of vital processes, the autonomic nervous system controls visceral functions. This non-stationary equilibrium causes the cardiovascular system's heart rate variability, or the variation between intervals of successive heartbeats called Heart rate variability (HRV).

It has been found in researches that impaired autonomic function is a reliable independent predictor of death following myocardial infarction.

A wide range of additional pathophysiological problems, such as the development of atherosclerotic plaques, congestive heart failure, diabetic neuropathy, vulnerability to sudden infant death, and mental illnesses including depression, are affected by an imbalance in autonomic activity.

The frequency of heart beats per minute is known as heart rate. The variation in the space between subsequent heartbeats is known as heart rate variability (HRV). Heart-brain interactions and dynamic, non-linear autonomic nervous system (ANS) activities produce HRV, which measures neurocardiac function. In order to help humans, adapt to environmental and psychological obstacles, interdependent regulatory systems that operate on various time scales have an emergent trait called HRV.

The regulation of autonomic balance, blood pressure (BP), gas exchange, gut, heart, and vascular tone—the width of the blood vessels that control BP—is reflected in HRV. It may also represent the control of face muscles.

1.1 RELATION BETWEEN HRV AND CNS

The sympathetic and parasympathetic branches of the autonomic nervous system (ANS) control HRV, which is well recognized as a non-invasive indicator of autonomic nervous system function. The sympathetic branch of the autonomic nervous system, often known as the fight-or-flight mechanism, prepares us to act, respond, and perform in order to fulfil the various demands that life places on us.

The rest and digest system that enables the body to shut down and heal "once the struggle is over" is referred to as the parasympathetic side. The sympathetic branch raises the heart's rate and force of contraction (cardiac output) and inhibits heart rate variability (HRV), which are both required during physical exertion and psychologically or physically stressful conditions. To restore equilibrium after the stress has passed, the parasympathetic branch, on the other hand, decreases the heart rate and enhances HRV. The two systems' organic interaction enables the heart to react fast to a variety of conditions and demands.

1.2 IMPORTANCE OF HRV

When engaging in calming activities, such as meditation or sleep, when the parasympathetic nervous system should predominate, HRV should rise in a typical, healthy scenario. Contrarily, during times of stress, when increased sympathetic activity aids the body in meeting the requirement, HRV normally declines. As a result, HRV is often higher during periods of slow heartbeat and lower during periods of rapid heartbeat, such as those associated with stress or exercise.

If a person is chronically stressed or overloaded - physically or mentally - the natural interplay between the two systems can be disrupted, and the body can get stuck in a sympathetically dominant fight state with low HRV and high stress hormone levels, even when they are resting. The HRV level changes naturally from day to day depending on the amount of activity and, for example, work-related stress.

1.3 FACTORS INFLUENCING HRV

- *Physiological factors* - Age, gender, genetic factors, and circadian rhythm can impact your heart rate and HRV.
- *Lifestyle factors* - These include diet, physical activity, stress, alcohol consumption, tobacco use, sleep, medications, etc.
- *Diseases* - Studies have shown that HRV is lower in people suffering from diseases such as:
 - a) Diabetes
 - b) Heart diseases
 - c) Lung diseases
 - d) Renal diseases (such as chronic kidney insufficiency)
 - e) Anxiety disorders, panic attacks, posttraumatic stress disorders, epilepsy, anorexia, and other psychiatric diseases
- *External factors* - Variables that can cause changes in HRV include climate, exposure to noise, and induced pain.

This research paper included a technology called BIOPAC that with the help of the ACQ knowledge software analysis tool, analyses the heart rate variability of different individuals during their cognitive ability.

This analysis results in the different cognitive ability of different individuals and the waveforms can be informed and abnormal cognition can be detected which says a lot about their social and mental well-being.

1.4 SYMPATHETIC VAGAL BALANCE

The equilibrium between the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), often referred to as autonomic balance or sympathetic vagal balance, is referred to as sympathetic vagal balance. The "fight or flight" reaction is triggered by the sympathetic nervous system, whereas the "rest and digest" response is encouraged by the parasympathetic nervous system.

For the body to continue to perform at its best physiologically, especially in terms of heart rate, blood pressure, digestion, and immune response, these two systems must remain in a balanced state. Numerous techniques, such as electroencephalogram (EEG) recordings and heart rate variability analyses, can be used to measure sympathetic vagal balance.

Conditions including hypertension, anxiety, and stress-related diseases can result from a stronger sympathetic vagal balance, which signifies a dominance of the sympathetic nervous system. On the other hand, diseases like bradycardia, digestive problems, and sleep disturbances might result from a higher parasympathetic dominance. It is possible to achieve a balanced state between these two systems by making lifestyle changes like frequent exercise, stress management techniques, and a healthy diet.

Adults' general health and well-being depend on maintaining a good sympathetic-vagal balance. The harmony between the sympathetic and parasympathetic nervous systems can be upset by ongoing stress and other circumstances, which can have detrimental effects on health.

CHAPTER 2

LITERATURE SURVEY

Jinhyun Lee et al. (2022) discussed reduced cognitive function is linked to higher mortality rates and higher healthcare expenses. Recent research has focused on the relationship between autonomic nervous system arousal and the blood perfusion of brain areas involved in cognitive performance as evaluated by an electrocardiogram (ECG). The aim of this study was to investigate the relationship between cognitive performance during the NIH Cognitive Test (Picture Sequencing, Dimensional Change Card Sort, Flanker, and List Sorting) and changes in sympathetic vagal tone as measured by the low-frequency/high-frequency ratio (LF/HF) and ECG HR variation.

Taryn Chalmers et al. (2022) discussed the PSQI, which measures subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping pills, and daytime dysfunction, was used in the current study to examine the relationships between heart rate variability parameters during resting and stressful states. Three negative sleep indices—sleep quality, daytime dysfunction, and overall sleep score—were discovered to be inversely correlated with very-low-frequency HRV during the stress task. In other words, the lower the VLF HRV during the stress task, the worse the person's sleep quality was, and the larger the impact on their daily performance. When compared to resting condition, this study similarly found a substantial increase in systolic and diastolic blood pressure during the stressful task. During the stress task, it was discovered that high-frequency HRV was negatively correlated with both sleep delay and overall sleep quality. This may indicate that people who have trouble sleeping at night have a sympathetic preponderance when they're awake. The body of research demonstrates that shorter sleep durations and irregular sleep patterns are linked to higher heart rates, blood pressure, and stress levels during the day.

Patrycja S Matusik et al. (2022) discussed about certain studies have examined the effects of various clinical situations on heart rate variability (HRV), a measurement obtained from the intervals between normal sinus heartbeats (NN intervals), in patients with cardiovascular disorders, such as individuals with AF. Although the terms "RR intervals" and "NN intervals" are sometimes used interchangeably, the majority of HRV measurements should only be computed using NN intervals, and typically, ectopic beats and noise are omitted. The widespread use of HRV is due, in part, to the fact that HRV measurements are non-invasive, inexpensive, and reflect autonomic nervous system activity.

Derek A. Hamilton et al. (2022) found that there is now widespread agreement that executive function, inhibitory control, set-shifting performance, rule shifts, and sentence completion are all positively correlated with baseline cardiac vagal tone. According to this study, there is a substantial correlation between task switching and HRV, with higher HRV individuals showing lower switch costs than lower HRV persons. According to this study on the connection between HRV and cognitive function, diminished executive function was linked to elevated sympathetic activity and lower parasympathetic activity across a range of cognitive activities. These results collectively point to a robust correlation between elevated baseline HRV and improved executive function abilities.

Camillo Imbimbo et al. (2022) discussed the findings of this study showed that in middle-aged and elderly participants with cardiovascular risk, ULF band power of HRV is linked with cognitive function. The development of cardiovascular risk and cognitive decline may be influenced by ANS dysregulation, and autonomic dysfunction may be a precursor to cognitive impairment. The chance to enhance targeted prevention or mitigation measures for cognitive decline during the middle and late stages of ageing is provided by the identification of early correlates of cognitive performances.

Yu – Chen Huang et al. (2022) discussed In this study, HRV data from people with dementia and NCDs are combined for the first time. Our findings overwhelmingly support the notion that people with dementia and NCD, particularly those who have DLB, typically have reduced parasympathetic activity than healthy people. This discovery might help in the diagnosis of dementia and DLB. HF, RMSSD, RSA, and SDNN are a few resting HRV indices that can be used to detect the difference. Additionally, the low HRV value in MCI participants suggests that HRV measurement could be useful for the early detection of different types of dementia, but more research is needed in this area.

Kathrin Hilgarter et al. (2021) In this cross-sectional investigation, performance on verbal episodic memory was significantly correlated with phasic HRV in healthy, asymptomatic participants of all ages and sexes. In general, regardless of age or sex, a higher phasic HRV (SDNN) is linked to higher cognitive function. A sensitive marker to any change in the mental state appears to be HRV indices like SDNN. This suggests that people with high and low cognitive ability may exhibit different HRV patterns at an early stage, when no disorders have yet shown. People who anticipate emotional stress more proactively, as measured by increased HRV (SDNN), do better cognitively.

The sympathetic and parasympathetic nervous system's tight contact is the basis for the cardiovascular system's adaptation to psychological stress, and HRV is a sign of physiologic adjustment to the demands of the moment. This makes it possible to map the various stress reactivity processes differently and reveals a close relationship between HRV, anticipatory ER, and cognitive function.

Giuseppe Forte et al. (2022) discussed about the association between VMHRV and cognitive performance, particularly in decision-making, was validated. Our findings draw attention to an autonomic pattern that is characterized by a vagal modulation that begins following a preliminary assessment of the task. In both the resting and task states, the vagal tone was higher in people who made wise decisions. They seemed better able to make decisions that were informed by the long-term effects of their choices, not just those that were more appealing at the time but less favorable overall. Participants with higher VMHRV appeared to be more aware of the long-term effects of their choices, whereas lower HRV was linked to a form of myopia for the future.

In comparison to those who are not worried, those with anxiety disorders have chronically low heart rate variability (HRV) while they are at rest. However, there is conflicting information about potential between-group differences in clinically anxious vs. non-anxious people when assessing HRV in response to a stressor. Therefore, the main goal of the present study was to examine high frequency heart rate variability (HF-HRV) and heart rate (HR) responding in anxious and control individuals before, during, and after this cognitive stressor using a repeated measures design with a stressful working memory (WM) task.

Judith Held et al. (2021) discussed it's vital to be aware of the current study's limitations. First, because of the technological limitations of the HRV sensors and associated loss of 36% of the data (20% in the anxious group), our control group was limited ($n = 14$). However, in cardiovascular research, HRV data loss is a typical occurrence. Importantly, when data was lost, the entire participant's data set was impacted, not just a specific slice. Second, despite power calculations showing that the sample size would be able to detect significant effects, the overall sample size was small. Larger samples would be desirable even if the current sample size is equivalent to that of earlier studies.

Bernhard Grassler et al. (2020) discussed about the Executive functions, memory and learning, language skills, visuospatial functioning, and processing speed were all examined separately. Additionally, the overall cognitive function assessed by cognitive test batteries was taken into account. Five databases were used in an electronic database search. The three search fields were adult participants, HRV, and cognitive function. Except for processing speed, each cognitive function showed significant associations, pointing to a link between resting HRV and cognitive performance.

The mechanisms explaining this link between cognitive and cardiovascular health are examined. Future diagnostics could use HRV as a marker for cognitive decline prior to the onset of dementia symptoms. Preventative measures could be started at an early stage of dementia with a prompt diagnosis

Christopher L Schaich et al. (2020) discussed that their results are in line with several earlier epidemiologic investigations of autonomic function and cognitive function. For instance, the Montreal Cognitive Assessment, a measure of general cognitive ability, revealed a cross-sectional connection between lower quintiles of SDNN and inferior performance, according to findings from the Irish Longitudinal Study on Ageing

Shawn D. X. Kong et al. (2020) discussed in older persons at risk of dementia, this is the first study to look at HRV during nighttime sleep. We showed that, compared to people with SCI, people with multi-domain MCI have decreased HF-HRV during NREM sleep, indicating altered parasympathetic activity during NREM sleep. According to a sleep stage analysis, this deficiency is only present during NREM sleep stages (N1, N2, and N3). Our research also demonstrated that the HF component of the HRV was eliminated by vagotomy or the administration of cholinergic antagonists, resulting in a decreased indication of vagal activity.

Felipe de Oliveira Matos et al. (2020) concluded that none of the regression models revealed a significant association between executive function and HRV-mediated physical fitness, which is contrary to the premise that HRV could serve as a bridge between cognition and physical performance. These findings confirm the negative findings of a prior study that looked into the possibility of HRV mediating the effect of cardiorespiratory fitness on young adults' cognition. Our data, however, supported their conclusions, indicating that the association between cognitive and physical fitness in the elderly may be caused by additional mechanisms not related to the NVI model. Neurotrophic levels, such as BDNF, and adjustments in CBF brought on by frequent physical activity are on the list of potential mediators.

Alice Riva et al. (2020) found that when individuals undertook a difficult psychosocial test, high HRV indices of vagal activity (RMSSD, pNN50) during anticipation of the task was related with a reduced stress-induced cortisol increase, suggesting a beneficial vagal regulatory effect on the hypothalamus-pituitary-adrenal (HPA) axis. This autonomic pattern in reaction to anticipation could be an adaptive response allowing people to activate emotional/biological changes to successfully deal with the stressor. As a result, it would demonstrate the capacity to control an excessive and/or chronic cortisol response to stress that could have a negative impact on mental health. There are certain restrictions with this research. Although the majority of studies concentrated on vagally mediated HRV, they used various indexes and varied transformation/calculation techniques; future studies might benefit from higher consistency of the HRV indexes as it would result in more trustworthy and comparable results. Future research should examine a broader range of HRV indexes, including non-linear measures, as potential markers of resilience. Non-linear HRV indices may offer further information beyond time-/frequency domain measurements since dynamic non-linear ANS processes affect the HRV and non-linear systems' variability allows them to adapt quickly to changing environments.

Giuseppe Forte et al. (2019) discussed the PRISMA-Statement was followed during the review procedure. Restrictions were put in place, choosing papers that were written in English, appeared in peer-reviewed publications, presented the measurement of HRV, and included at least one cognitive test. Studies with participants who had severe brain injuries, strokes, dementia, or other medical issues were not included. 19,431 people participated in a total of 20 investigations, which were chosen. Global cognitive functioning, attention, processing speed, executive functions, memory, language, and visuospatial skills were the cognitive domains into which the results were split.

In the absence of dementia, serious cardiovascular diseases, other medical conditions, or psychiatric disorders, both elevated sympathetic activity and decreased parasympathetic activity appear to be linked to worse performance in the cognitive areas under consideration

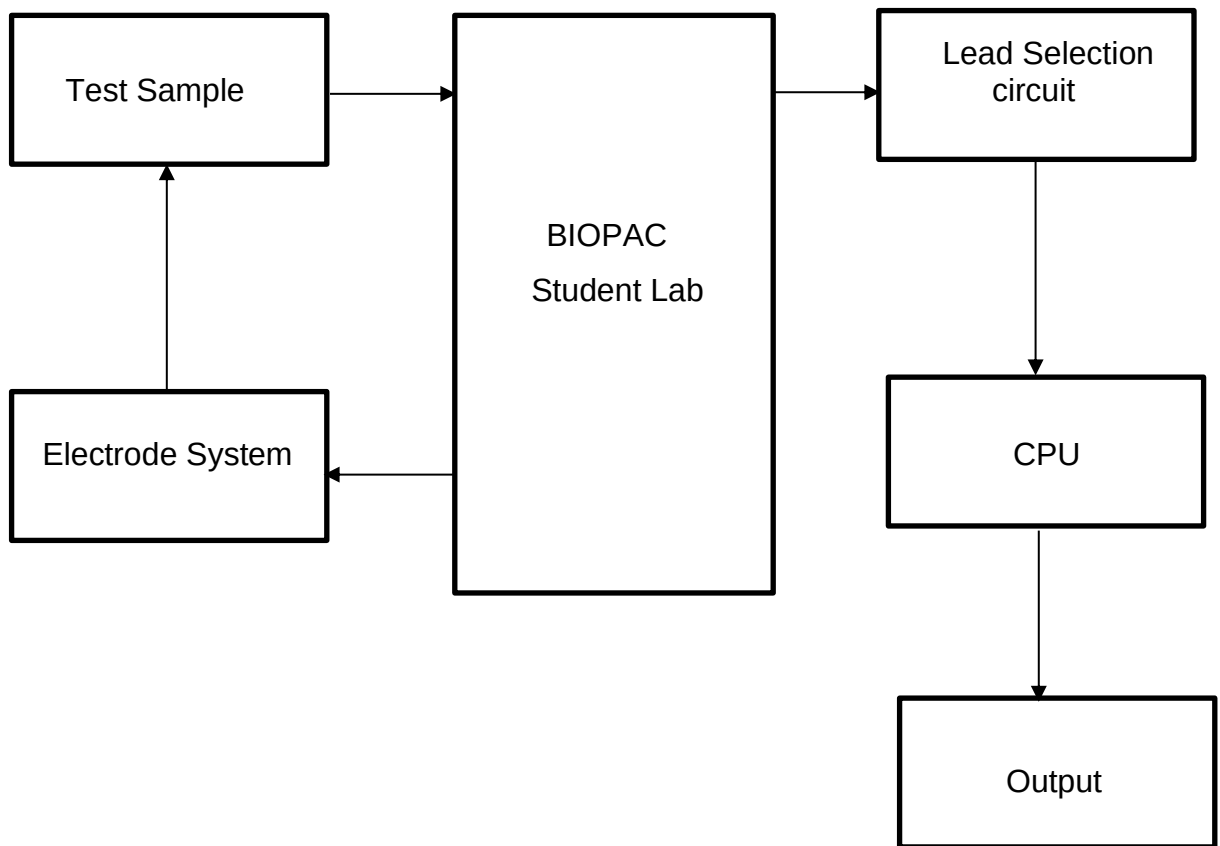
Jose C. Perales et al. (2016) found that first, HRV changed in response to task demands (with the lowest values in the working memory task). Second, and most importantly, we discovered comparable HRV levels between each of the jobs and its bizarre control equivalent, as well as a significant decline in HRV over time. The NASA-TLX results also revealed task-dependent score changes and a higher cognitive effort in the execution condition compared to the bizarre control condition. Overall, our findings imply that HRV is extremely responsive to persistent attention demands, independent of other cognitive processes as shown by another research. Our research also reveals a potential separation between objective and subjective measurements of mental workload, which has significant practical consequences.

CHAPTER 3

AIM AND SCOPE

The aim of the present work is to find the heart rate variability of the different age groups and to determine their sympathetic vagal balance. This is done with the help of the BIOPAC device and the BSL software. The sympathetic vagal balance gives us an insight about the test samples cognitive ability. And the cognitive ability for these different age groups is determined.

3.1 BLOCK DIAGRAM



The BIOPAC is the main key device which helps in the data acquisition of the HRV of all the samples. The test samples are connected with the electrode system and the input data are acquired. The lead selection circuit has the crab electrodes which is then connected to the surface gel electrode and placed on the test sample's surface. The circuit is connected with the CPU. The BIOPAC student lab software the processes acquired signal waveforms. The sympathetic vagal balance is then acquired as the output.

3.2 EXISTING SYSTEM

Through the thorough research, the existing system includes noxious electrical stimulus, a challenging mathematical backward counting task, big hardware components with many lead selection circuits. All these procedures are said to be complex and it involves disrupting the patient's mental wellbeing. These methodologies end up in certain disadvantages in the data acquisition.

3.3 PROPOSED SYSTEM

The proposed system involves the acquisition of sympathetic vagal balance of the individuals only by means of cognitive task. This task involves samples answering certain questions that trigger their cognitive ability and also their heart rate variability. The BIOPAC module helps in assessing the cognitive ability by means of recording the sympathetic vagal balance values.

This system neglects all the other hard methods of forcing the samples in acquiring the data. BIOPAC makes this method simpler in assessing the HRV values and doesn't make the patient feel uncomfortable.

CHAPTER 4

MATERIALS AND METHODS

4.1 INTRODUCTION

The electrodes and the lead selection circuits are connected to the BIOPAC. The leads are placed in the proper position as mentioned in the BIOPAC module. The white crab electrode which is said to negative is placed on the test sample's right wrist. The red crab electrode is positive and is placed on the left ankle area of the sample. The black crab electrode is the ground and is placed on the right ankle part of the sample. All these crab electrodes are mounted on the sample's body with the help of surface gel electrodes.

4.2 BIOPAC Device

A flexible system created for data collecting and analysis in research and teaching is the BIOPAC MP45 Data collecting System. A variety of physiological signals, including ECG, EMG, and EEG, among others, can be measured using the MP45. The MP45 also has HRV analysis capabilities, which are advantageous for a range of research applications.

Heart rate variability, or HRV, is the term used to describe the variance in the intervals between subsequent heartbeats. The autonomic nerve system, which regulates many of the body's automatic activities, including heart rate, can be understood better through HRV study. In particular, HRV analysis can shed light on sympathetic and parasympathetic activity, two components of the autonomic nervous system that influence heart rate in opposite ways.

The sympathetic nervous system, which stimulates the "fight or flight" reaction, and the parasympathetic nervous system, which activates the "rest and digest" response, are the two branches of the autonomic nervous system.

Numerous types of research, such as those on stress, emotion, cardiovascular disease, and other topics, have made use of HRV analysis. It is also employed in clinical settings as a predictor of cardiovascular risk and a tool for evaluating autonomic nervous system performance.

Overall, HRV is a useful marker of autonomic nervous system activity and can offer crucial insights into how the body's automatic systems function. A range of instruments and methods, including software solutions provided by businesses like BIOPAC and specialized gear for analyzing ECG signals, can be used to undertake HRV analysis.

A research-grade data acquisition device for recording and analyzing physiological data is called the BIOPAC MP45. It is a multi-channel system that has the capacity to simultaneously capture physiological data from up to 16 channels, making it an effective tool for numerous research applications. The MP45 data collection unit, a compact, transportable device that can be linked to a computer through USB, is a component of the BIOPAC MP45 system. The AcqKnowledge software, which is used to record, analyze, and analyze data, is also part of the system. A robust set of tools for data analysis, including time-domain, frequency-domain, and non-linear analytic approaches, is offered by the AcqKnowledge software. For quick and effective data processing, the software also offers automated analysis choices and editable analysis templates.



Fig 4.1 BIOPAC MP45

4.3 BSL BIOPAC STUDENT LAB SOFTWARE

A software called BSL (BIOPAC Student Lab) was created by BIOPAC with the purpose of being used in educational settings to teach physiological concepts and carry out laboratory investigations. Because of the software's user-friendly and intuitive design, even students with little to no physiology or data gathering experience can use it.

The BSL software also contains a variety of tools for data analysis and visualization, including time-domain analysis, frequency-domain analysis, and trend analysis, in addition to the pre-designed lab assignments. The software additionally enables modification of the channel, sample rate, and filter parameters used in data acquisition. The BSL software is a flexible and adaptable tool for physiology instruction since it works with a variety of BIOPAC data gathering systems and sensors. It is a useful tool for both students and teachers and is utilized in educational institutions all over the world, from high schools to colleges.

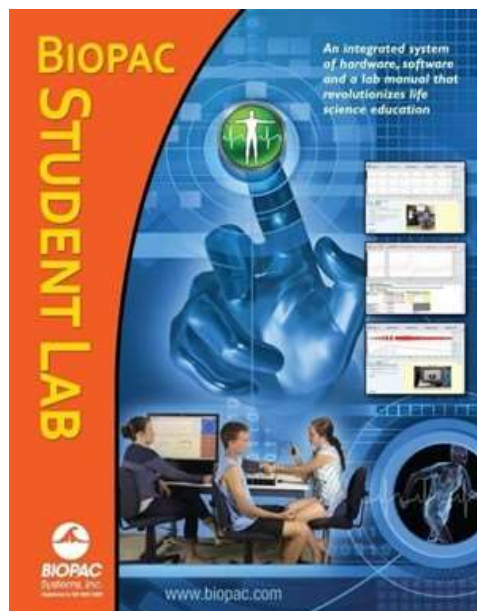


Fig 4.2 BIOPAC Student lab software

4.4 SURFACE GEL ELECTRODES

Heart rate variability (HRV) signals, which are used to evaluate the autonomic nervous system and cardiovascular health, can also be recorded using surface gel electrodes. Surface gel electrodes are adhered to the skin with conductive gel or glue in order to record HRV signals. After the electrodes are connected, a BIOPAC data acquisition device records the ECG signals and uses specialized software to analyze the HRV.

Time-domain and frequency-domain analysis are frequently used in HRV study, and both techniques can reveal information regarding the activity of the parasympathetic and sympathetic branches of the autonomic nervous system. This data can be used to evaluate stress levels, cardiovascular health, and general wellbeing. Overall, BIOPAC surface gel electrodes provide a practical and dependable solution for physiological data collection and analysis. These electrodes can be utilized for a wide range of physiological signals, including HRV. Surface gel electrodes are non-invasive, simple to use, and commonly used for HRV monitoring. It has been applied in a variety of clinical and scientific settings, including the evaluation of autonomic function in patients with illnesses like cardiovascular disease, diabetes, and psychiatric disorders. To reduce the danger of infection and harm, it is crucial to adhere to adequate hygiene and safety precautions when using any medical device.



Fig 4.3 Surface gel electrodes

4.5 LEAD SELECTION CIRCUIT

With BIOPAC MP45 data collecting devices, a certain kind of shielded lead is referred to as a "SS2LB." The BIOPAC MP45 system's essential component, SS2LB shielded lead, enables the precise and dependable recording of physiological data in a range of research applications.

It is a fully insulated cable assembly that enables high resolution biopotential recording utilizing disposable electrodes in series. Standard pinch connections are used to connect the 2-meter adaptor to surface electrodes. The BIOPAC Student Lab data acquisition (MP45) research unit and the SS2LB are interfaced.

The subject is covered by the leads, which have an end that resembles a crab pin, on the top surface of the surface electrodes that are adhered to the subject.



Fig 4.4 SS2LB – Lead selection circuit

CHAPTER 5

RESULT AND DISCUSSION

5.1. INTRODUCTION

The components are connected as shown in the block diagram and the data acquisition is done. The BIOPAC then generates the corresponding waveform for the test sample. Then this waveform is processed using the BSL software and the sympathetic vagal balance for the individual is acquired with its help. Now this value gives us an insight about the test sample's cognitive ability. The values are then classified according to the test sample's ages.

5.2 TESTING PROCEDURE

All the required components are tested and calibrated. The subject is explained about the process clearly. The test sample is made to be at ease while the recording takes place. They are also informed to remove any sort of jewelry, watches and bracelets. The basic personal details of the subject are recorded.

The subject is said to be still in order to avoid any kind of artifacts that may occur during the recording procedure. The subject is also said to be calm and composed for convenient detection of the heart rate variability. The subject is given few questionnaires and is asked to answer the questions accordingly.



Fig 5.1 BIOPAC Module setup

5.3 SVB VALUE ANALYSIS

The appropriate steps are conducted in order to compute the individual's sympathetic vagal balance value. The sympathetic vagal balance values of roughly 30 participants have been taken into account in this study. The 30 subjects come from a range of age ranges and come from different walks of life. For the assessment of sympathetic vagal balance, nearly five series of measurements were taken. The readings were initially taken in a normal setting and are designated as the sympathetic-vagal balance reference value one. Under specific requirements, the subjects must complete a limited number of cognitive tasks during the allotted time period in order to obtain the remaining four readings of the sympathetic vagal balance values.

There were several questions that the participant had to respond to as part of the cognitive tasks. The questionnaires had questions that tested respondents' memory retrieval abilities, spatial perception, and general knowledge. Then follows the Heart Rate Variability. The BSL Software is then used to analyze the Heart Rate Variability. After that, sympathetic vagal balance is detected and categorized.



Fig 5.2 SVB Analysis procedure

5.4 RESULT

Sample	Age	SVB REF	SVB 1	SVB 2	SVB 3	SVB 4
1	45	0.203875	0.30932	0.998806	0.10018	1.29343
2	47	0.620485	0.199915	0.624911	0.68846	1.6154
3	48	0.28816	0.557395	0.393274	0.397142	2.14196
4	25	0.469813	0.604794	0.813193	0.377153	0.936593
5	25	0.52469	0.312313	0.995041	1.04728	1.67722
6	25	0.326212	0.347836	0.349937	0.356309	1.53452
7	24	0.216191	0.397114	0.411722	0.457621	1.52214

Table 5.1 SVB tabulation for age group 45 – 24

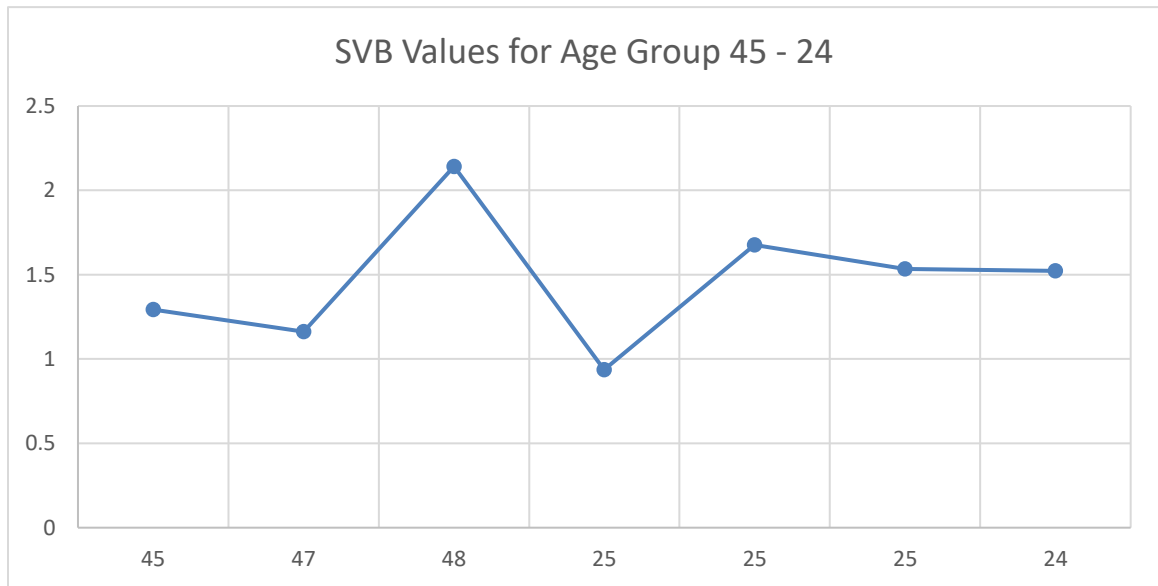


Fig 5.3 Graphical representation of SVB values for age group 45 - 24

Sample	Age	SVB REF	SVB 1	SVB 2	SVB 3	SVB 4
8	23	0.232339	0.337553	0.312331	1.32755	1.42932
9	23	0.256983	0.385717	0.385945	0.471224	0.844791
10	23	0.325481	0.319749	0.435745	0.409539	0.615083
11	23	0.202171	0.293026	0.303946	0.401163	0.671743
12	22	0.264538	0.279702	0.321763	0.509187	0.559374
13	22	0.106074	0.27877	0.542823	2.02998	6.54236
14	22	0.220097	0.424581	0.705596	0.974631	1.13196
15	22	0.186831	0.195071	0.271662	0.311922	0.452324
16	22	0.459906	0.496837	0.682415	0.924885	0.959446
17	21	0.332613	0.452756	0.758911	0.76819	1.9499
18	21	0.23145	0.2722	0.30848	0.36617	0.69335
19	21	0.21446	0.38404	0.46861	0.55458	0.58342

Table 5.2 SVB tabulation for age group 23 – 21

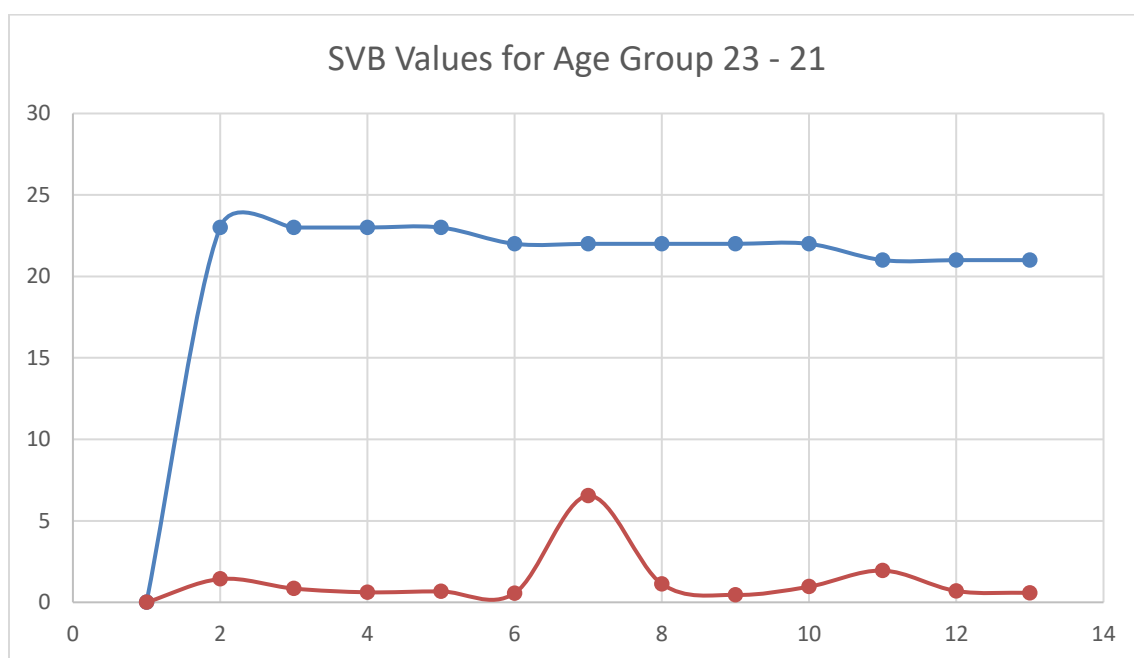


Fig 5.4 Graphical representation of SVB values for age group 23 - 21

Sample	Age	SVB REF	SVB 1	SVB 2	SVB 3	SVB 4
20	19	0.23453	0.3421	0.36481	0.55952	0.82543
21	19	0.16345	0.21335	0.23678	0.91643	4.6801
22	19	0.12549	0.23971	0.34682	1.71886	2.88629
23	18	0.28763	0.25479	0.23719	0.92843	1.34385
24	18	0.13421	0.12965	0.22345	0.23822	0.44619
25	18	0.19835	0.2101	0.23013	0.33959	0.63858
26	18	0.23985	0.26918	0.27698	0.36003	0.63812
27	18	0.26187	0.3971	0.53219	0.75737	0.89685
28	18	0.24693	0.3259	0.39129	0.80815	1.33093
29	17	0.29863	0.31265	0.35988	0.35156	0.52432
30	17	0.2017	0.20348	0.32643	1.91003	3.72358

Table 5.3 SVB tabulation for age group 19 – 17

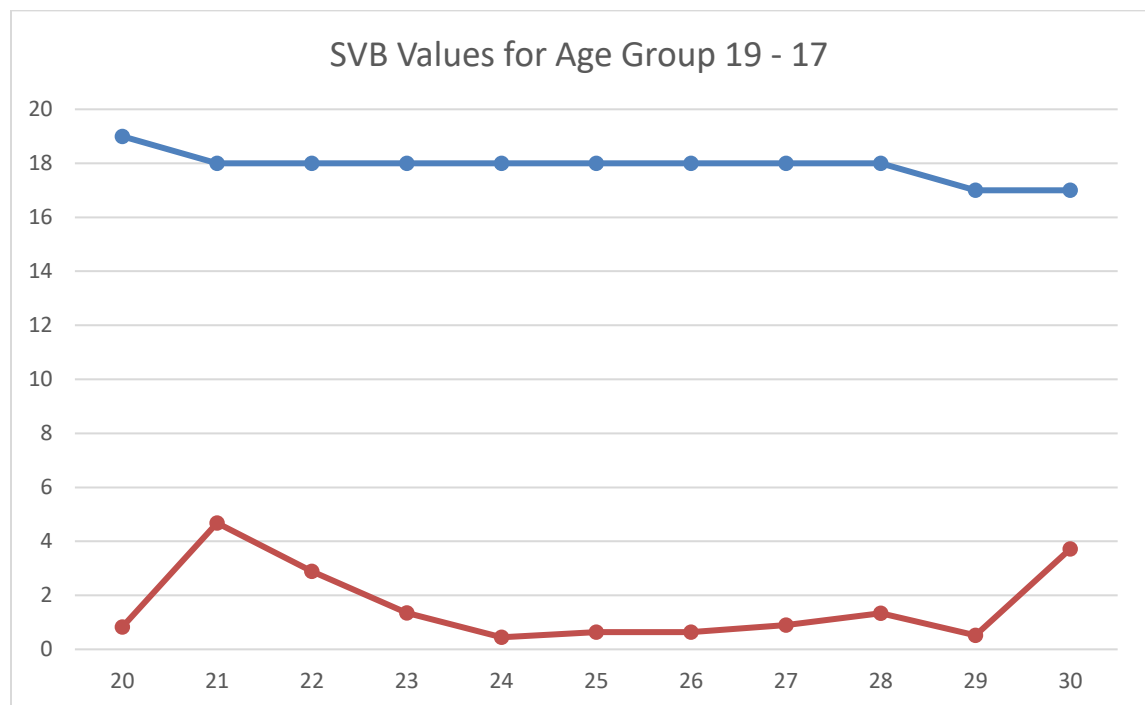


Fig 5.5 Graphical representation of SVB values for age group 19 - 17

The figure 5.3 denotes the graphical representation of sympathetic vagal balance values for the age group 45 – 24 years. The X-axis in that graph denotes the age and the Y-axis denotes the SVB value. This age category individuals showed less cognition and it took them a while to respond to the questions. They had higher sympathetic vagal balance values and lower cognition, as evidenced by this. In that figure sample aged 48 had the end sympathetic value above 2 and it denoted the abnormal condition. The table 5.1 displays all the values acquired during the process.

For the age range of 23 to 21 years, the sympathetic vagal balance values are represented graphically in figure 5.4. The sympathetic vagal balance values are represented by the X-axis in the graph, while the age of the subjects is represented by the Y-axis. People in this age group had controlled sympathetic vagal balance levels and moderate cognitive impairment. One specific person, sample 13, showed aberrant SVB levels, and when they were questioned, they revealed that their behavior had caused the issue beforehand. The sympathetic vagal balance values for each individual were categorized in table 5.2.

The sympathetic vagal balance is graphically represented for the age range of 19 to 17 years in figure 5.5. The age of the participants is shown on the X-axis, and the sympathetic vagal balance values are shown on the Y-axis. Compared to the other two age groups, this one displayed a lower sympathetic vagal balance and better cognition. The tabulation in section 5.3 makes this clear. The young adults are better able to complete their cognitive tasks quickly and effectively. Without any issues, they completed their cognitive questionnaires as well.

CHAPTER 6

CONCLUSION AND FUTURE WORK

This research project effort provides information on the cognitive abilities of various people. The most important variable in determining a person's heart rate variability is the sympathetic vagal balance. The cognitive exercises required a lot of thought from the participants, which led to aberrant alterations in the sympathetic vagal balance values. The release of catecholamines in the human body causes the heart rate to increase, which is why the sample's heart rate variability has increased. The final results show that older samples have worse cognitive abilities. And it was claimed that younger people had better cognitive abilities than older people. But only a few samples had some unusual circumstances.

Future applications for this BIOPAC gadget include a variety of hospitals, healthcare settings, educational institutions, and many other locations that demand accurate physiological tests. It is clear from this research that as we become older, our cognitive ability declines. Few perfect examples with aberrant sympathetic-vagal balance values are visible. This is possible given the level of stress and pressure the person experiences on a daily basis. It is also said that their heredity is a contributing factor in this aberration. By identifying further causes for these odd sympathetic vagal balance values, this research can be developed further.

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