USING EYE TRACKING TO TEST THE EFFECT OF FIBOD SMART BALANCE WITH TABLE SOCCER GAME ON ATTENTION AND MEMORY

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UNIVERSITI SAINS MALAYSIA

2021

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by

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Research project report submitted in fulfilment of the requirements for the degree of Master of Cognitive Neurosciences

DECEMBER 2021

ACKNOWLEDGEMENT

First and foremost, I would like to thank Allah s.w.t. for helping me in getting through this journey of this research. Without His guidance and blessings, I would not be able to be motivated to finish this journey.

Next, I would like to express my deepest gratitude to my main supervisor, which is Professor Dato Dr Jafri Malin Abdullah and my co-supervisor which is Dr. Mohamed Faiz Mohamed Mustafar who had always helped me throughout my research since the beginning, during the study and until the end of thesis submission. And a special thanks to my examiner, Associate Professor Dr Sarimah Abdullah. They always guided and suggested me with the possible solutions for all the problem that I have encountered.

Not to forget, to all staff in Department of Neurosciences, HUSM who were lending their hands to help me in completing my research on time, especially Puan Athirah Raihanah and Puan Nurul Aini. Thank you for all the kindness that I have received during my data collection phase.

Last but not least, I would like to thank my family members especially my parents; Mak and Apak, who keeps on supporting their youngest daughter's dream, and can't forget my friends for always being there, by my side and listening to my rants.

---Thank you again to every single soul that were involved in my research journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS AND SYMBOLS

USM	Universiti Sains Malaysia
HUSM	Hospital Universiti Sains Malaysia
PPSP	School of Medical Sciences
PPSK	School of Health Sciences
PPSG	School of Dental Sciences
JEPEM	Human Research Ethics Committee of USM
VST	Visual Search Task
FMT	Figure Memory Task
AOI	Area of Interest
SATO	Speed Accuracy Trade Off
RT	Reaction Time
SPSS	Statistical Package for Social Sciences
WHO	World Health Organization
EEG	Electroencephalogram
%	Percentage
M	Mean
SD	Standard Deviation

LIST OF APPENDICES

ABSTRAK

Kajian ini dilakukan bertujuan untuk mengenal pasti hubungan antara penggunaan Fibod *Smart Balance* dari aspek perhatian dan ingatan semasa memakai alat penjejak mata. Pemboleh ubah yang dikaji pada peserta adalah masa reaksi dan ketepatan. 30 peserta dari USM Kubang Kerian dipilih. Untuk mengukur ingatan dan perhatian mereka, mereka perlu menjawab *Visual Search Task* dan *Figure Memory Task* sebelum dan selepas tempoh intervensi sambil memakai alat penjejak mata. Semasa tempoh intervensi, 15 peserta dalam kumpulan kawalan diminta menjalani kehidupan normal. Manakala 15 peserta dalam kumpulan eksperimen perlu menjalani 12 sesi latihan selama satu bulan. Latihan selama 15 minit untuk setiap sesi selama satu bulan. Mereka harus bermain exergame yang dipanggil *Table Soccer* di mana mereka perlu mengawal keseimbangan di atas alat keseimbangan Fibod *Smart Balance* semasa bermain permainan video tersebut. Keputusan menunjukkan tiada perbezaan antara kumpulan eksperimen dan kumpulan kawalan dengan perhatian dan ingatan. Walau bagaimanapun, kajian menunjukkan terdapat perbezaan antara kumpulan eksperimen dan kumpulan kawalan dalam reaksi masa pergerakan mata ($p<.001$). Hal ini menunjukkan bahawa Fibod Smart Balance tidak memberi kesan terhadap perhatian dan ingatan selepas 4 minggu intervensi, tetapi memberi perbezaan pada reaksi masa pergerakan mata para peserta.

THE EFFECTS OF FIBOD SMART BALANCE WITH TABLE SOCCER GAME ON ATTENTION AND MEMORY USING EYE TRACKING

ABSTRACT

The objective of this study is to identify the relationship between the use of Fibod Smart Balance and cognitive functions, mainly attention and memory while wearing eye tracking device. The variables studied were focused on the participants' reaction time and accuracy. 30 participants from USM Kubang Kerian were chosen at random. To measure their memory and attention, they had to take Visual Search Task and Figure Memory Task before and after intervention while wearing the eye tracking device. During the intervention phase, 15 participants in the control group were requested to lead their normal life, whilst the other 15 participants in the intervention group had to undergo a series of practice for one month, which a total of 12 sessions consisting of 15 minutes per session. They had to play exergames called Table Soccer game in which they needed to practice their balance using a balance device called Fibod Smart Balance while playing the casual video games. Findings showed that there is no significant differences between intervention group and control group in terms of attention and memory. However, there is a significant difference between participants' reaction time of the eye movement during the attention task ($p<.001$). Therefore, it can be concluded that there is no significant effect between 4 weeks of intervention of Fibod Smart Balance and Table Soccer game with attention and memory, but a significant improvement showed in the reaction time of participants' eye movement during attention task.

CHAPTER 1

INTRODUCTION

1.1 Introduction

As humans grow older, our balance and cognitive functions deteriorate and decline over time. In today's world, healthcare providers worldwide are finding ways to improve our quality of life. This is to strengthen the world's health system even better. In order to improve physical balance and cognitive functions, researchers and healthcare providers encourage us to do physical activities since physical activities do help to improve cognitive functions (Rogge et al., 2017). This is due to the fact that physical activities and cognition are interrelated in healthy people. Even though there is yet any evidence on which type of exercise or physical activities that can affect our cognition, there are several researches who have proven that a balance training program improves memory and spatial cognition (Bherer, Erickson & Liu-Ambrose, 2013; Fisher, Chacon & Chaffee, 2019).

Physical activity or exercise is an act of body movement that requires energy. It can be done anywhere such as walking, cycling, or sports and at any level of skills and as for enjoyment to all (World Health Organization, 2020). Not only can it reduce the risk of injury but also reduce boredom. There are many advantages of physical activities on humans of all ages. Children who go through physical activity training have resulted in better performance for strength, flexibility, speed and object control (Drenowatz *et al.*, 2021). Older adults with cancer who went through a series of physical activity training before-, during-, and after-chemotherapy found that the

training may have hazards of recurrence and mortality reduced (Cannioto *et al.*, 2021). In addition, it shows that regular physical activity can help to lower the risk of getting diseases such as diabetes, stroke, and even cancers. It is also proven to lower the risk of cognitive impairment (Talhaoui *et al.*, 2021). This means that physical activity can actually improve our cognitive functions.

Among the developing countries including Southeast Asian countries, the prevalence of obesity has reached an alarming level (Mohd Sidik, Lekhraj & Foo, 2021). (Khoo *et al.*, 2020) reported that from the whole Malaysian adult population, only three quarters are physically active. Being one of the countries in the world to record the highest obesity rate among adults shows that Malaysians are lacking the effort to engage themselves in physical activities. Physical activities consist of two intensities which are moderate intensity and vigorous intensity. Some examples of moderate intensity are walking briskly, hiking, golfing, gardening, washing a car manually, doing yoga and carrying out moderate house chores. Meanwhile, examples of vigorous intensity are jogging, skipping rope, moving around furniture, and playing football. Here is how to differentiate these two intensities, if during a physical activity, one can still have a conversation, that shows it is a moderate intensity. However, if one needs to gasp for air to breathe while doing a physical activity, then that is a vigorous intensity activity (National Institute on Aging, 2021). In other words, moderate intensity is an activity where one is still able to carry a conversation while sweating a little with slight increase in the heart rate.

A balance exercise falls into the moderate intensity of physical activity. Balance is defined as a biological system that enables us to know where our bodies are in a specific environment and to maintain a desired position. A normal balance depends on information from the inner ear, also other senses, and our muscle

movements (Stoppler, 2021). There are many examples of balance exercises. Among them are standing with our weight on one leg. Other balancing sports are tai chi or yoga and using equipment or tools to challenge our balance (Watson, 2020). Bosu ball, fit ball or big gym ball, wobble disc and even skate balance boards are some of the traditional and famous balance board tools. In today's life, many innovations have been carried out on balance board tools to make them more challenging and fun to use and practice with family members and friends. Hence, to assess for a positive balance outcome, the researcher decided to use a balance board as an intervention tool in the study.

In this current study, researcher used a Fibod Smart Balance as an intervention tool. It is a sensor-based portable smart balance board for users to train and assess their balance skill with biofeedback and objective assessment programs. It is also an interesting tool since participants can actually play balancing virtual games while using the balance board. Virtual video games are known as interactive softwares for entertainment as well as stimulation. These softwares are known for their vibrant colours and complex graphics that are usually played using devices like computers, mobile devices or gaming consoles like PlayStation or Nintendo. There are various genres of video games, such as action games, adventure games, role playing games, simulation games, strategy games, sports games, and puzzle games (Vince, 2018). The most famous type of game is the action game that includes shooting or fighting games such as Call of Duty or Mortal Kombat. Video games are created for almost everyone, young and old, in their leisure time. However, children still need some kind of supervision from parents on the type of video games they should play and how much time they can spend playing video games. This is because some studies found that children with uncontrolled amounts of time playing violent video games portray

aggressive cognitions and behaviours in real life (Zhang, Cao & Tian, 2021). However, the virtual video game that was used in the current study while using the Fibod Smart Balance is called the Table soccer game. It is a strategy game in which players are required to develope strategy and tactics to overcome challenges to win the game.

In the current 21st century, people with innovative ideas are creating new models and tools. One of the current and promising tools that were created is called exergaming. It is a word combination from the words 'exercise' and 'game'. It requires bodily movements while playing video game.. Playing exergames actually stimulates an active gaming experience making it equivalent to physical activity (Benzing & Schmidt, 2018). It also comes as a fitness routine tool in the form of rolling, playing, or even dancing. Game developers have gone further to invent tools with some sort of physical activities in virtual video games. Based on several researches in the past, there are several kinds of innovation on exergaming tools that support exergaming such as Nintendo Wii Fit, and Microsoft X-Box 360 (Fakhro, Hadchiti & Awad, 2019). Whilst, the games that can be played with the exergaming tools are Just Dance 2019 and Zumba Fitness. These games need to be played while holding a hand-held device controller that can detect one's behaviours and movements by the game modem. With the rapid evolution in technology heading towards the 4th Industrial Revolution, experts have built advanced technology tools for use in everyday life. Technology has been a major key in its application to contribute to any profession and field, especially in the discipline of psychology and neurosciences.

Hence, Fibod Smart Balance has become one of the new innovation tools in the exergaming world. This tool is one of the many evidence of how technology has changed in the era of 4th Industrial Revolution to identify and contribute accurately in

areas of health and also learning. Fibod Smart Balance comes with an android modem box and also a balance board. Players are required to stand on a balance board that looks similar to the traditional wobble disc. They need to balance their weight while standing on the board and playing interactive virtual video games at the same time. Any movement on the balance board will surely affect their movement in the virtual game. For example, if the player tries to balance their body on the board and move to the right, the character that they are playing in the game will also move to the right and vice versa.

Fibod Smart Balance Balance has yet to be used as an intervention tool for cognitive functions. Cognitive function is defined as multiple mental abilities (de Bruin *et al.*, 2016). Intervention tools can be used as devices to manipulate and trigger our cognitive functions. This includes the process of learning, thinking, memorising, focus and attention, problem solving and decision making. The examples of the assessments that are famously being used are Stroop Task, Stop-Signal task, No Go Task, Cost and Benefit Analysis and n-Back Test. For the purpose of this study, the researcher will focus on attention and memory. This is due to the fact that the task do have the ability to represent, analyse and mentally manipulate objects (de Bruin *et al.*, 2016). The psychological assessments that were used in this study, in order to assess cognitive functions, are Visual Search Task and Figure Memory Task. This would be explained more under 4.0 Methodology.

The combination of cognitive functions and neuroimaging tools studies are needed to explore more on cognitive neuroscience fields. Some examples of neuroimaging tools are functional magnetic resonance imaging (fMRI), electroencephalogram (EEG), functional near-infrared spectroscopy (fNIRS) and eye tracking device. This current study focuses on eye tracking devices since eye tracking

device is usually used when assessing cognitive functions. This device has been used to measure cognitive functions on various types of populations and in other assessments. Eye tracking has been used in studies among adults with autism spectrum disorder and children born preterm (Dean *et al.*, 2021; Greene *et al.*, 2021). This device also has been used with assessments such as Winconsin Card Sorting Test, Stroop Task, and Hanoi Tower (Leitner, 2021; Micai, Vulchanova & Saldaña, 2021; Zhu *et al.*, 2021). Hence, all this has proven the credibility of this device to be used for research purposes. Moreover, eye tracking devices have many parameters. Some of the examples are pupil size, heatmap, ratio, saccades, micro-saccades, and fixations (Ghose *et al.*, 2020). This study focuses on reaction time and dwell time for the cognitive functions tasks.

Previous researchers had conducted studies on stability, exergaming and cognitive functions for the elderly and patients with cognitive impairment or post-stroke as their participants (Khor *et al.*, 2018; Beato *et al.*, 2020). Researchers have found very little evidence on balance and exergames affecting healthy university students' cognitive functions (Douris *et al.*, 2018). According to World Health Organization (WHO), 'healthy', here, is defined as a complete physical, mental and social well-being with no diseases (World Health Organization., 2020). Healthy university students are assumed to be healthy and balanced in terms of physical and cognitive functions. With that in mind, this study would only focus on healthy university students.

There have been studies on healthy young adults and cognitive functions (Majer *et al.*, 2010; Al-Thaqib *et al.*, 2018). These studies show the existence of improvements in cognitive domains, especially attention and motor functions. However, it would be interesting to see new findings on healthy young adults

population's condition. According to Erik Erikson's theory, psychosocial stage 6 comprises of young adults, ages between 18-40 years old (Cherry & Gans, 2020). In this current study, the participants are young adults who are also university students from Universiti Sains Malaysia (USM) to undergo balance exergame training to see effects on their cognitive functions. Universiti Sains Malaysian (USM) has three major campuses: Main Campus and Engineering Campus located in Pulau Pinang and Health Campus located in Kelantan. Since the venue of this study was located in Kelantan, the participants taken were among USM students from the Health Campus. Health campus is chosen as a venue to see the importance of attention and memory for students in medical sciences since it is equipped with the necessary tools needed to carry out the experiment. The Health Campus or also known as Hospital Universiti Sains Malaysia (HUSM) is made up of three different academic schools which are School of Medical Sciences (PPSP), School of Health Sciences (PPSK) and School of Dental Sciences (PPSG). The Health Campus students are mostly from medical sciences background (Kamari, 2009).

1.2 Rationale

This research, hopefully, would help to confirm whether Fibod Smart Balance is beneficial at improving attention and memory in healthy adults, specifically young adults (as in this study, university students). Most research involving intervention tools is about stability and the elderly were the subjects of studies (Khor *et al.*, 2018; Garciá-Bravo *et al.*, 2020). This is because the elderly have a higher risk of falling and being in a state of instability. There are also studies about stability among clinical

populations, especially those with stroke and cognitive impairment (Volkers & Scherder, 2014; Xiang *et al.*, 2017; Beato *et al.*, 2020). Most of these studies cited positive improvement after a few interventions and training. Hence, the researcher would like to investigate whether stability and balance using exergaming does affect one's cognitive functions in young and healthy adults.

This study had, also, wanted to see the efficiency and feasibility of Fibod Smart Balance tools. There are several intervention tools besides physical exercises that had been used in previous researches that included exergames such as Nintendo Wii Fit, Microsoft Xbox 360, interactive Physical and Cognitive Exercise System (i-PACES) and other multicomponent exercises (Ordnung *et al.*, 2017; Anderson-Hanley *et al.*, 2018; Kim *et al.*, 2020). On the contrary, none of these researches had included Fibod Smart Balance as their intervention tools in order to seek proof of any form of impact or improvement on cognitive functions among students as the result of using the tools. Only a handful studies had used Fibod Smart Balance as an intervention tool (Xiang *et al.*, 2017; Khor *et al.*, 2018). As a result, the researcher would like to investigate the practicality of using these equipments as intervention tools to investigate, not only, on attention but also memory.

1.3 Research Questions

1. Is there any significant difference in attention and memory between the Intervention Group and the Control Group?
2. Is there any significant difference in attention and memory in the Intervention Group and the Control Group?
3. Is there any significant difference in reaction time and dwell time spent in the Intervention Group and the Control Group?

1.4 Research Objectives

General objective: To investigate the relationship between the use of Fibod Smart Balance and cognitive functions: attention and memory

1. To compare the differences in attention and memory between the Intervention Group and the Control Group
2. To compare the differences in reaction time and accuracy during attention task
3. To compare the differences in reaction time and accuracy during memory task
4. To compare the differences in reaction time and dwell time between the Intervention Group and the Control Group

1.5 Research Hypothesis

The use of Fibod Smart Balance does help improve attention and memory

1a There are differences between Intervention Group and Control Group in attention

1b There are differences between Intervention Group and Control Group in memory

2a There are differences in reaction time between pre- and post- attention

2b There are differences in accuracy between pre- and post- attention

3a There are differences in reaction time between subjects' pre- and post-memory

3b There are differences in accuracy between subjects' pre- and post- memory

4a There is differences in reaction time varies between subjects' pre- and post- assessments

4b There is differences in dwell time spent varies between subjects' pre- and post- assessments

1.6 Term Definition

There are several important concepts in this study that need to be defined. Among them are as follows:

1.6.1 Attention

Attention is the focus of mental activity. According to Stone, attention is an act that can be made a necessity to form memory. Moreover, attention is a stage of active processing of limited information and is derived from the senses, memory and cognitive processes.

Operationally, in this context, attention is tested via a Visual Search Task that is administered to the participants of both groups. The analysis that is carried out takes into consideration the time period between stimulus and response. Hence, participants have to make a choice within seconds in order to provide the reaction time, and the accuracy of the responses.

1.6.2 Memory

Memory is the ability to retain information based on the mental processes of learning across some interval of time (APA, 2022). It is a process involving the storage and retrieval of information that come in different forms such as auditory or visual. It is also defined as recalling and retrieving a specific information.

Hence, in this context, memory is measured using a Figure Memory Task that is administered to the participants in both groups. The task consists of two phases. First, the Learning phase. Here, nine images are displayed and participants need to observe and memorize the details in each image. Each picture appears within three seconds for identification to be made. The next phase is the Recognition phase whereby images will appear one by one and participants need to decide if they have seen the images during the Learning phase or it is just a false image. Their reaction time and correct answers are recorded for analysis.

1.6.3 Accuracy

Accuracy is closely related to precision. It is a measure of performance during tasks. It can also be defined as the proportion of correct responses by participants during psychological assessments (APA, 2022). In this context, correct responses are recorded and assessed during both attention and memory tasks.

1.6.4 Reaction time

Reaction time is defined as time between the presentation of a stimulus and the event of a specific response to the stimulus. In this study, the reaction time is measured during psychological assessments: tasks for attention and memory. Hence, when the

stimulus is shown on the screen, the timing begins and ends when participants give feedback on the stimulus.

As for the eye tracking session, reaction time is defined as the duration between the onset of the stimulus and the correct feedback and response from the participants. Reaction time is measured from the beginning of a stimulus event to a response event (Lange, 2018). It is measured and recorded to ascertain efficiency and effectiveness whilst performing the task (Bruce, 2004).

In this context, once the participants find the stimulus, which is the letter T, in the attention task, they need to respond to the stimulus immediately. On the other hand, during the memory task, participants will have to retrieve the image from the recognition phase for them to give feedback. Thus, the time taken from the time the stimulus is displayed until they respond is recorded and assessed.

1.6.5 Dwell time

Dwell time, also known as time spent, is defined as the amount of time participants spend looking at a stimulus (Farnsworth, 2020). In this context, the duration of observation is recorded to see how long the participants need to retrieve information before giving feedback during the memory task .

1.7 Conclusion

This chapter describes the introduction, research questions, and research objectives. In addition, the chapter also includes, in more detail, the rationale and research hypothesis. In the following chapter, the researcher shared previous studies related to the current study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter contains discussions and reviews on some previous research papers that are related to the focus of this current study. Among the aspects discussed in this chapter are physical activity, physical balance, cognitive functions, video games, exergames, eye tracking, theoretical framework and, last but not least, conceptual framework.

2.2 Physical activities affect cognitive functions

There are several studies that investigate the differences between physical activity and cognitive functions. In neuroscience fields, a study using Magnetic Resonance Imaging (MRI) shows that physical activity has no contribution to white matter. However, our corpus callosum and the right superior corona radiata link the relationship between physical activity with working memory (Ruotsalainen *et al.*, 2020).

Interestingly, regular moderate to vigorous intensity of physical activity do have benefits to cognitive and mental health measures compared to just walking among young adults (Nakagawa *et al.*, 2020). Besides, Aslankhani, Ghasemian &

Dulabi, (2020) stated that physical exercises have shown improvements in executive functions and it also benefits in, both, speed and accuracy on cognitive tasks involving n-back test and Stroop test carried out among students. Students aged 11-15 years old carried out 4 weeks of physical activity training and the results showed that physical exercises during the morning break improve cognitive functions and may motivate the participants to do it regularly (Tilp *et al.*, 2020). However, cognitive functions and academic performance or academic achievement are not the same. Cadenas-Sanchez *et al.*, (2020) reported that physical activity showed no impact whatsoever on children's academic achievements. This is also supported by the research by de Bruijn *et al.*, (2020) of which the findings showed that academic achievements do not have significant differences in physical activity.

According to a study by Iuliano *et al.*, (2015), a number of 80 elderlies participants underwent four different types of physical activities, and the results showed that different types of physical activity have resulted in different effects on cognition. For example, cardiovascular training was proven to affect our attention whilst resistance training has effects on praxis which are planning and sequencing. Yongtawee *et al.*, (2021) also agreed that different types of physical activities affect different domains of cognitive functions. In their study involving athletes in interceptive sports and strategic sports who went through physical activities training, the findings displayed that they were advanced in visuospatial functioning and cognitive flexibility respectively.

Relating to the clinical population, Verret *et al.*, (2012), reported that among ADHD children who underwent 10 weeks of physical training activity, the results

showed improvement in cognitive functions, motor skills, muscular capacity and level of information processing. However, in another study involving Dementia patients who had 24 weeks of low and high intensity physical training activity, they showed no significant difference on any form of cognitive measures (Sanders *et al.*, 2020).

2.3 Balance affect cognitive functions

Balance is often associated with physical activities such as yoga, Tai Chi, Pilates and any movement that use a balance tool. In most of the previous researchers, elderly and clinical populations such as Parkinson and stroke patients were taken as subjects as, in this case, they are always related to gait and balancing problems (Schättin *et al.*, 2016; Moon, Jung & Cho, 2020). Nonetheless, the researcher was still able to find a handful of other studies that involved adults as participants.

Clinical Pilates training that focuses on walking and balance can improve postural stability, core stability and cognitive function, This can be seen in a study involving 21 patients with Multiple Sclerosis (Abasıyanık *et al.*, 2020). Kaya and Alpozgen, (2021) conducted a study involving two types of physical exercises, namely aerobic and Pilates. The results found that both types of exercises had provided some improvements among participants in selective attention, verbal fluency and executive functions. As to comparing the Pilates and the yoga groups, it was recorded that the Pilates group improved in balance, whilst the yoga group improved in cognition (Thakkar *et al.*, 2021).

Physical exercise can help in cognitive-motor. It helps in reducing cognitive-motor interference. According to Subramaniam & Bhatt, (2017), a group of participants who went through yoga training had shown that it can reduce cognitive-motor interference by increasing attentional resources for balance and executive cognitive functions. This conclusion is also agreed by Nagendra, Kumar & Mukherjee, (2015). In their research, involving 30 participants, who were students, showed improvement in the participants' cognitive functions mainly attention, neural activity and executive functions after trying yoga balance training.

In another research carried out among a group of clinical population, Abasıyanık *et al.*, (2021) reported that both yoga and Pilates activities had no effect on cognition but, nevertheless, the Pilates group did improve at walking speed, quality of life and balance as compared to the yoga group. In addition, Chandler *et al.*, (2021) conducted a study on patients with Mild Cognitive Impairment (MCI) and the results found that yoga balance practices had improved the physical performance but had no impact on general physical decline in patients with MCI.

According to Xu, Baker and Ren, (2021), Tai Chi practice is a beneficial exercise in order to maintain an active lifestyle during this pandemic. Also, from the neuroscience aspect, Tai Chi practitioners have higher global cognition because the functional connectivity is higher between prefrontal cortex, motor cortex and coordination of left and right brain (Shi *et al.*, 2021). Apart from that, Tai Chi has helped them to improve their balance, sleep quality, and cognitive performance. This is the results of a study using Fall Efficacy Scale, Pittsburgh Sleep Quality Index and Trail Making Test respectively on the elderly in Vietnam according to Nguyen &

Kruse, (2012). In another study involving 12 weeks of Tai Chi intervention among middle and older age showed improvement through MoCA scores (Tao Xiao *et al.*, 2020).

Not only Tai Chi has contributed in supporting frail and independent older people with physical and cognitive limitation (Saravanakumar *et al.*, 2014), but also in patients with Multiple Sclerosis of which it helps improve their balance, coordination and depression after 6 months of training intervention (Burschka *et al.*, 2014). Tai Chi-based stroke rehab programs, also, can improve the symptoms in physical and cognitive functions among stroke survivors (Song *et al.*, 2021).

Besides these physical balance activities, balance assessments can also help with cognitive functions when used as a tool. The findings of a study that had used 'The Balance Error Scoring Systems (BESS)' and a modified 'Star Excursion Balance Test (mSEBT)' to measure both static and dynamic balances respectively on ballroom dancers (Mackin ,2019) showed that the subject's balance had indeed improved even though she had had a balance deficit history. In another study by Shim *et al.*, (2020) in which they had used 'Bertec Computerized Posturography Plate' to improve stability among preschool children using pedal-less bicycles. The results did show some improvement in stability within 4 weeks of training. Hence, it was concluded that the Smart balance intervention tools do improve in balance and attention with the help of some amount of training.

2.4 Exergames and video games affect cognitive functions

To promote good health in adults, smart balance intervention tools can be combined with exergames and integrated into physical therapy practices (Agmon *et al.*, 2011; Mirelman, Maidan & Deutsch, 2013). A home-based balance programme called Wii Fit where it uses a balance board can help improve static and dynamic balance, mobility and functions. Previous researchers have testified that the use of Wii Fit had not only resulted in positive balance outcomes, but also in functionality, power, and performance after using intervention tools such as Nintendo Wii Fit balance games (Campelo, Hashim & Katz, 2019; Fakhro, Hadchiti & Awad, 2019; Mohammadi, Hadian & Olyaei, 2020). This suggests that Wii Fit is one of the products that can be used as exergames, hence as an intervention tool for this research as well.

Exergames are defined as games that involve exercising since the games require lots of body movements. Exergames and smart balance are popular recent intervention tools and their usage is increasing rapidly in neurological rehabilitation (Campelo, Hashim & Katz, 2019). One of the the benefits of Exergames is that they are proven to have helped and assisted in balance rehabilitation programs (Kefalis, Kontostavlou & Drigas, 2020).

Ping Pong exergames is another activity that is beneficial. Participants involved in a study perform better in attention and memory after playing Ping Pong exergames with a good usability score (Zhang *et al.*, 2021). Besides ping pong, Xbox 360 Kinetic are famously used as exergames tools. According to M. Monteblanco Cavalcante *et al.*, (2021), in a 6-week study of training using Xbox 360 Kinetic exergames, the results showed improvement in language domain, abstraction domain,

and memory delayed/recall domain. Sápi *et al.*, (2021) also agreed when they did their study using the same intervention tool on adults over 60 years old and the results showed that it helped improve stability and reduced fall risk and it is a safe tool to use.

Other than Nintendo and Microsoft, Swinnen *et al.*, (2021) used VITAAL Stepping exergames in their research. The findings indicated that it is usable for older adults with major neurocognitive disorder (MNCD). Meanwhile, Schättin *et al.*, (2016) used pressure-sensitive plate Dividat Senso exergames for patients with Multiple Sclerosis and it seems to be usable and feasible for them.

Findings in a most recent study by Corregidor-Sánchez *et al.*, (2021) during the current pandemic situation have implicated that video games containing exergames can help in rehabilitation treatment and impairment of elderly who are affected by the pandemic. Exergaming is different from a combined exercise. Exergaming alone has resulted in a better global cognition improvement as compared to a combined exercise (Ying-Yi Liao *et al.*, 2021).

In general, research has also shown that not only exergames are helpful in medical therapies, but even video games can help in improving executive functions (Dye, Green & Bavelier, 2009; Petilli *et al.*, 2020). It is quite surprising to find that expert video games players often outperform non-players on measures of basic attention and memory performance. This can be seen in a study by Dye, Green & Bavelier, (2009) that suggested a way to improve attentional resources is by playing action video games. It allows gamers to better allocate their attention, both, in space and time. There are a few researches claiming that by playing video games, gamers can improve, not only at attentional skills, but also at visuospatial skills (Green &

Bavelier, 2006; Spence & Feng, 2010). Besides action games, playing casual video games can also improve cognition training (Dye, Green & Bavelier, 2009). The results from their study suggested that casual video games can improve working memory and attention.

Besides video games, esport games can also benefit its users. Sousa *et al.*, (2020) believe that esport games have various executive functions and psychological variables involved; mainly in the attention and memory during pre and post. Meanwhile, in a research by Ozdogar *et al.*, (2020) involving patients with Multiple Sclerosis as participants had shown positive effects by playing exergames. They seemed to have improved in cognitive function with exceptions in processing speed, balance related measure, fatigue and quality of life.

2.5 Eye tracking

A wide use of eye tracking can be found in the related field of neurosciences and psychology. Eye tracking devices have been a useful tool in today's studies. The positive finding is seen in a research by Lee and his colleagues (2021). From the findings, they believe that eye tracking training can improve one's inhibitory control.

Activities involving Visual Search Task have effects on reaction time. According to a study by Palanica & It ier, (2011) who used visual search tasks in their research, reaction time had improved on the direct gaze. Yang and colleagues (2013) reported that when participants were searching for familiar things, the reaction time was faster and less saccade. This is supported by several studies. Participants from the traditional sports group and the esport group might have improved in reaction time

in similar length as compared to the controlled group who did not do any sport (Bickmann *et al.*, 2021). In a study by Chiu, Chen & Liu, (2021), when participants were searching for stimulus in Visual Search Task, the reaction time and number of fixation showed significant differences. Studies who used clinical populations as participants recorded slower and longer reaction time to respond during the tasks (A. Röslera *et al.*, 2005; Rose *et al.*, 2019).y76][=u78

Naderer *et al.*, (2020) claimed that their study on children's cue reactivity towards healthy and unhealthy food images found that their memory seemed to be less dependent on visual attention because the unhealthy food images did not require too much attention to be memorised. This finding suggests that familiar and desired images, or words, eye movement will result in shorter reaction time.

Visual memory is benefitting in the process of dwell time (Laeng *et al.*, 2014). From the findings of their study, Elias and colleagues claimed that participants with social anxiety spent extra time on dwell time due to the feeling of uneasiness (Elias, Massad & Lazarov, 2021). This claim is supported by Drew and colleagues. They added that if there are a lot of distractors and memory set sizes, participants' dwell time spent would increase (Drew, Boettcher & Wolfe, 2017). The findings showed that Dwell time improved when participants were relaxed and familiar with the goal of the task. This is also favoured by Parks & Hopfinger, (2008) where they claimed that the dwell time increases when participants see target stimulus for the first time. In addition, the increase in Dwell time also portrayed conditions of uncertainty and hesitance (Hedge & Leonards, 2013; Andrychowicz-Trojanowska, 2018).

2.6 Theoretical Framework

The ideas of attention and memory are very interrelated. In order to memorise information, one needs to give attention and focus. However, there are factors that may influence our attention. The famous Kahneman Capacity Model explains that in order to complete a task related to attention or memory, one needs some form of mental effort. It suggests that there is a limit to human capacity to perform mental tasks. Other factors may disrupt the available capacity. Some activities require different amounts of attention. Hence, some tasks require extra mental effort and fill the capacity. When there is only a little space of availability, the level of performance will decline and deteriorate.

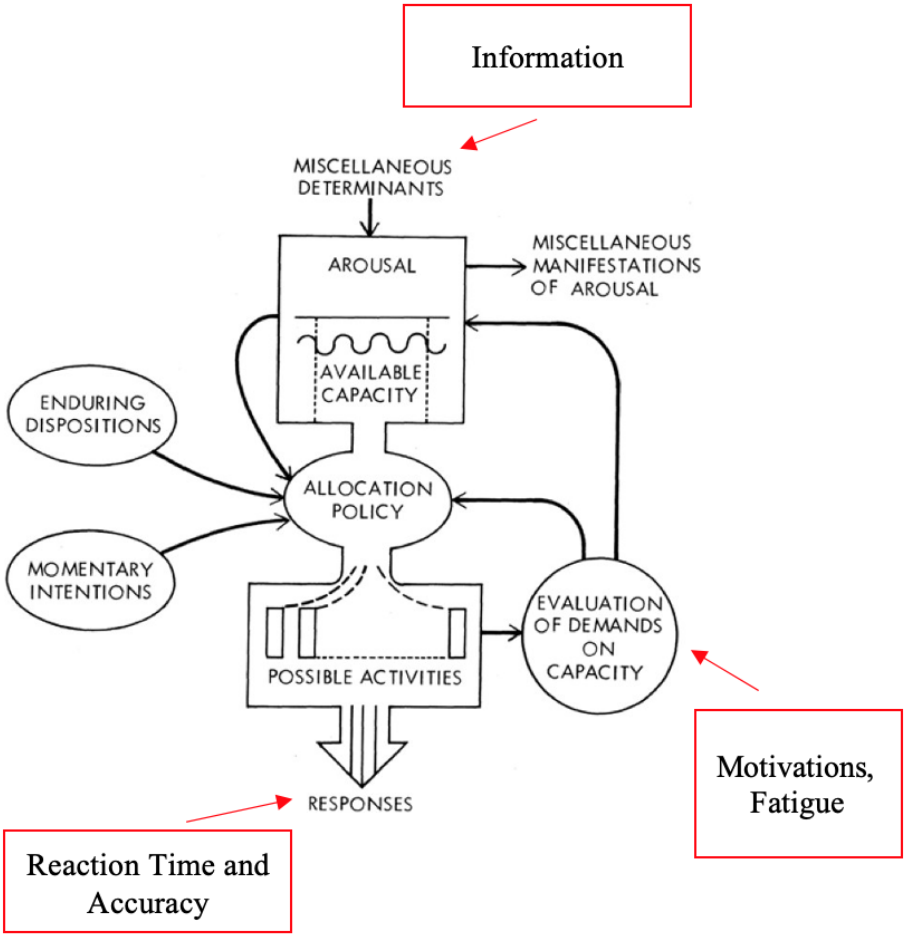

Figure 2.1 Adapted Kahneman Capacity Model (Pichora-Fuller et al., 2016)

Figure 2.1, adopted from Pichora-Fuller et al., (2016), displays the Kahneman Capacity Model. Capacity, here, refers to how much information can be stored. To simplify the figure - when information comes into the human capacity, the external factors which is the evaluation of demands on capacity can influence the information processing before giving any responses.