國立體育大學
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探討單組太極拳練習與其他運動模式對於高齡者持續性注意力之影響

The Effect of An Acute Bout of Tai Chi Chuan and Different Modes of Exercise on Sustained Attention in The Older Adults

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中 華 民 國 108 年 9 月

國立體育大學
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This thesis is dedicated to my two grandmas

Johannette Berghäuser

and

Habibeh Pakzad

both of whom did not have the access to knowledge and education that I have

本論文：**The effect of an acute bout of Tai Chi Chuan and different modes of exercise on sustained attention in the older adults**
（探討單組太極拳練習與其他運動模式對於高齡者持續性注意力之影響）

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摘要

本研究目的是比較 3 種不同運動模式對於高齡者持續性注意力的立即影響。研究方法：本實驗招募了 12 位具有太極拳經驗的實驗參與者分成 3 組，分別進行 30 分鐘的太極拳運動，協調性運動以及腳踏車測功儀的有氧運動介入。在不同的運動模式介入前與介入後，實驗參與者皆需要完成持續性注意力測試 (Continues Performance Test)。結果發現：在太極拳運動後實驗參與者的注意力辨識度顯著提升 (p=0.01)，錯誤率 (p=0.06) 與反應時間 (p=0.09) 顯著降低；在協調性運動後反應時間 (p=0.026) 與反應時間標準差 (p=0.002) 皆顯著下降；在腳踏車測功儀的有氧運動介入後只有錯誤率 (p=0.031) 顯著減少。本研究發現不同的運動模式對於注意力有不同的立即性影響：複雜協調性運動有利提升注意力，太極拳運動可增加注意力的辨識度與抑制性，有氧運動有益增加抑制功能。

關鍵字：協調、冥想練習、腳踏車、高齡者、持續性注意力測試

The Effect of An Acute Bout of Tai Chi Chuan and Different Modes of Exercise on Sustained Attention in The Older Adults

Abstract

There have been international efforts to promote an active and healthy lifestyle for the older population in order to keep medical costs low as well as maintain quality of life in the elderly. Physical as well as cognitive factors are important in this light. Attention is one of the key-functions in cognition. In recent years Tai Chi Chuan (TCC) has become popular among older adults, since it is a low cost, slow kind of exercise for body and mind. We assumed that in a sport scientific point of view TCC consists of three major parts: coordinative, cardiovascular and meditative. Therefore the purpose of this study is to evaluate the effects of an acute bout of TCC, bicycle ergometer, coordination session and meditation practice on attention in older TCC practitioners. 12 older male adults (M=69.4 ±3.8 years), five with two years of TCC experience and seven with more than five years of experience participated in the study. All participants had to undergo four exercise sessions [TCC (T), Coordination (C), Bicycle (B) and Meditation practice (M)]. The exercise sessions were counterbalanced and lasted for 30 minutes each. Before and after exercise sessions participants had to do a 14-minute long CPT test. Results show that attention improved after TCC in the commission mistakes value and Hit RT and missed significance level marginally with p=0.06 and p= 0.09 respectively. Detectability value, a measure for attentiveness, improved significantly with p=0.01. Hit RT value and Hit RT SD improved significantly after coordination with p=0.026 and p=0.002 respectively. The commission mistakes improved significantly after bicycle ergometer with p=0.031. However, a tendency for worse response time consistency (Variability value) with p=0.069 was found. Meditative practice did not show any improvement. Additionally, more experienced TCC practitioners showed a tendency for better vigilance. The four exercise programs did only differ significantly in the Hit RT value. Coordination significantly differed from mediation practice and Bicycle ergometer session, whereas TCC significantly differed from meditative practice and showed a tendency to differ from bicycle ergometer session. TCC and coordination session did not differ from each other. It seems that acute bouts of different exercises enhance different areas of attention; therefore it seems important to study different kinds of exercise and their effect on attention.

Key words: Coordination, Meditation Practice, Bicycle, Elderly, CPT

Acknowledgments

Over the past six years I have received support and encouragement from a great number of individuals. Dr. Chan and Dr. Jang have been mentors, colleagues, and friends. Their guidance has made this a thoughtful and rewarding journey. I would like to thank my colleagues from the SPDI Miss Dr. Wang and Miss Dr. Chen for their great support and friendship. In addition, I want to thank Dr. Lu from the Taiwan National University of Physical Education and Sport in Taichung for using his facility. I also want to thank Dr. Fang and Dr. Chen for their support and suggestions. I would also like to thank the Tai Chi Chuan practitioners who took part in this study as well as Ida for generously sharing their time.

I also want to thank my husband Dr. Peter Mayer for supervising the ECG during fitness test, securing subjects well-being as well as his support over the past years.

Finally, thanks to my mom, Dr. Ursula Pakzad and my dad, Dr. Firoz Pakzad for always believing in me and support me without questioning or doubt.

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1 Introduction

With demographic changes in our societies the need to maintain health in older adults has become an important issue over the last years (Taylor et al., 2009). There have been international efforts to promote an active and healthy lifestyle for the older population in order to keep medical costs low as well as maintain quality of life in the elderly. Physical, psychological as well as social factors are important in this light. The recommendation from the American College of Sports Medicine and the American Heart Association of 2007 (Haskell et al.) as well as the guidelines of 2010 (Thompson et al.) evaluate many studies concerning health and physical exercise and they come to the conclusion that the right amount of physical activity is a key point to an active lifestyle. But an active healthy lifestyle does not only depend on one's physical fitness but it also depends on mental fitness. Aging is usually accompanied by physical and mental decline. Especially in the older population (over 65) age-related cognitive impairment is a serious problem.

This cognitive decline can be found in different areas including information processing speed, reasoning and memory (Salthouse, 2003). Cognition describes the process of knowing and by definition refers to higher-level functions of the brain. It includes aspects of mental processing and is very important in our daily lives. Attention is also included in cognition and is one of the key-functions to higher cognitive processes, as Zimmerman and Leclercq (2002 : 76) pointed out "…attentional processes are fundamental to all cognitive skills." Thus, attention is crucial to every area of our life. Its function is to interact during information perception and processing with all other cognitive functions such as memory, planning, reception and orientation (Zimmermann and Leclercq, 2002). The cognitive decline also includes aspects of attention and some even hold age-related decline in fields of attention, such as inhibition, responsible for cognitive cutbacks (Linden and Collette, 2002).

It is generally believed and scientifically researched by the American College of Sports Medicine (Thompson, 2010) that physical activity can reduce age related declines; and cognitive declines (Hillmann, Erickson and Kramer, 2008). Hence, in recent years adequate physical activities for the older population were promoted and Tai Chi Chuan (TCC) with its slow and thoughtful movements can be considered a very suitable kind of exercise. Health attributed benefits for TCC are improved balance (Tsang and Hui-Chan, 2003 and Gatts and Woollacott, 2007), cardiovascular fitness (Lan et al., 1999) and psychological fitness (Liu et al., 2005 or Kuramato, 2006).

TCC is a safe and low cost sport, which is very suitable for older people because of its slow and thoughtful movements. Giving the fact that physical and mental decline already starts after reaching the 3rd decade and that the age-related decline rate accelerates after the 6th decade (Salthouse, 2009), it is important for healthcare to engage the older population in physical exercise that can stop or reduce these health related declines. Only then can older people live a more active and healthy life without fear of losing their independency. Attention is especially important in that light. For the elderly, independence includes being able to do your own groceries or doctor visits, which includes walking or driving a car in the usual road traffic. For their safety on the road, attention is a crucial part to avoid accidents.

This research should help to understand the effect of TCC practice on attention aspects, which are a key point for higher cognitive processes. Since TCC is a complex form of martial art, we split it up in its components relevant for exercise.

We assumed that in a sport scientific point of view it consists of three major parts: coordinative, cardiovascular and meditative. Therefore, we chose four different kinds of exercise that we wanted to evaluate: TCC, Coordinative exercise, Bicycle and Meditative practice in order to understand which part in TCC might be responsible for any kind improvement.

This leads to the following research questions:

1. Can an acute bout of TCC influence attention in older adults?
2. Is there a difference between experienced TCC master's and beginner's cognitive abilities (attention) after an acute bout of TCC?
3. Does an acute coordination training session influence attention?
4. Does an acute cardiovascular training session on a bicycle ergometer influence attention?
5. Does an acute meditative practice influence attention?

Therefore in this paper following hypotheses will be tested:

1. An acute bout of TCC exercise facilitates cognitive abilities (attention) in older adults.
2. Experienced TCC master have better cognitive abilities (attention) after an acute bout of TCC exercise than beginners.
3. An acute bout of bicycle ergometer training improves attention differently from TCC.
4. An acute coordination session improves attention differently from TCC.
5. An acute meditative practice improves attention differently from TCC.

2 Literature Discussion

2.1 Attention

This chapter gives an outline about different attention theories.

Eysenck and Keane (2000) refer to attention commonly as the selectivity of processing which is not a function that is controlled uniquely but rather describes a complex system including different aspects of attention. Niemann and Gauggel (2006: 111) describe attention as “the ability to be alert and sustain this alertness in order to detect process relevant information and the ability to select information to consciously process, plan and execute deeds” (own translation). Eysenck and Keane (2000) first distinguish between *active* and *passive* attention. *Active* attention is controlled by the individual’s goal and is a top-down process. Whereas the *passive* attention is a bottom-up process, which means that the attention is controlled by external stimuli. Secondly, they distinguish between *focused attention* and *divided attention*. *Focused attention* is referred to processing only one input despite of being presented with two or more stimuli, whereas *divided attention* processes all inputs (see Fig 2.1).

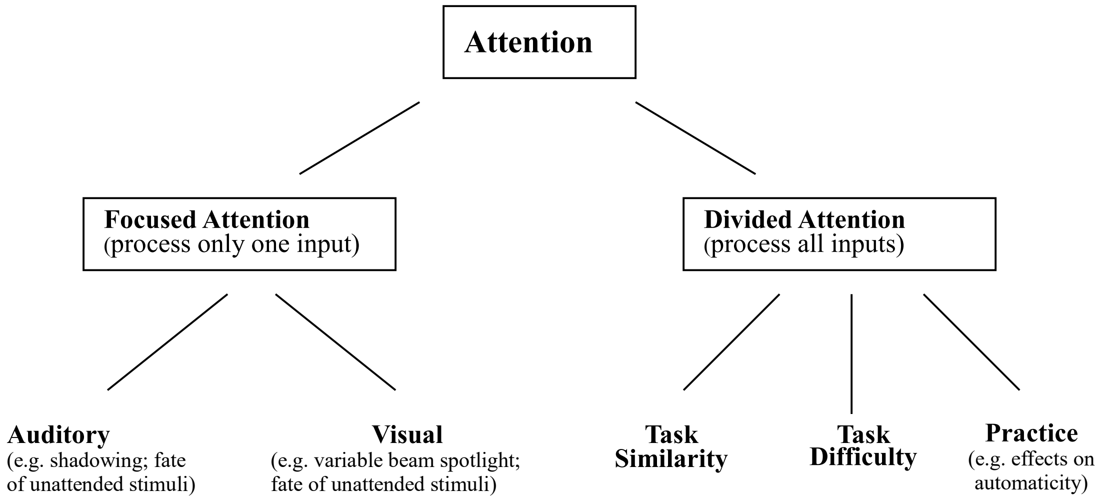


Fig 2.1: The ways in which different topics in attention are related to each other (Eysenck and Keane, 2000 : 120)

2.1.1 Psychological Attention Theories

In this chapter only a short outline of the psychological attention theories are presented.

1) Broadbent's theory of information processing: Broadbent argued that after inputs are registered only one passes through a selective filter according to physical characteristics and importance of the input. Broadbent argues that the filter is necessary to avoid overloading of information. (Eysenck and Keane, 2000).

2) Treisman's attenuation theory: Treisman's attenuation theory is an extension of Broadbent's theory in so far as she argues that inputs are systematical and hierarchical processed. Due to limited capacity, only important inputs are processed to the top of the hierarchy while the others remain in the buffer for later processing.

3) Deutsch & Deutsch's theory: Deutsch & Deutsch claim that all stimuli are fully analyzed, but only the most relevant stimulus causes the response (Eysenck and Keane, 2000).

In summary these theories differ from each other in the aspect of input selection. In Broadbent's theory the aspect of selection occurs very early in information processing by the selective filter, whereas in Treisman's theory the input selection is later and in Deutsch & Deutsch's theory it is at the bottom (see Figure 2.1.1).

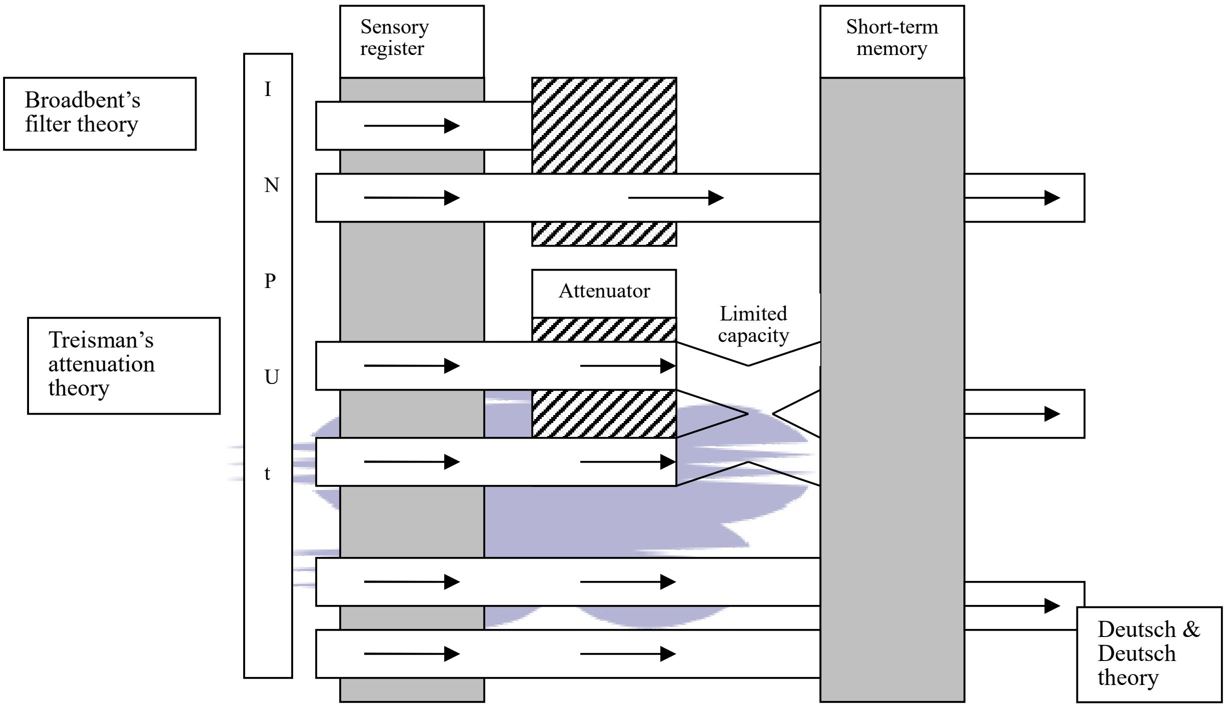


Fig 2.1.1: A comparison of Broadbent's (top), Treisman's (middle) and Deutsch & Deutsch's theory (bottom) modulated from Eysenck and Keane, 2000)

2.1.2 Attention Network Theory

Posner and colleagues tried to integrate the functions of attention in a neural network model, which first differentiates between the anterior attention, posterior attention and vigilance network (Webster and Ungerleider, 2000). This network splits up in the three major areas: The anterior and posterior attention network and the vigilance network. They can also be defined in terms of Neuroanatomy (Fig.

2.1.2). The posterior network is associated with orientation bringing attention to a location; it is the orienting to sensory stimuli (Posner and Peterson, 1990). It includes visual orienting, selectivity and selective attention (Schäfer, Beauducel, and Brocke, 2000). The anterior network on the other hand is responsible for target detection and includes ideas stored in memory (Posner, 1994). The vigilance network's purpose is to maintain the alert state and can therefore influence both the anterior and posterior attention network. The noradrenergic pathway and the right hemisphere play an important role in the vigilance network (Posner, 1994).

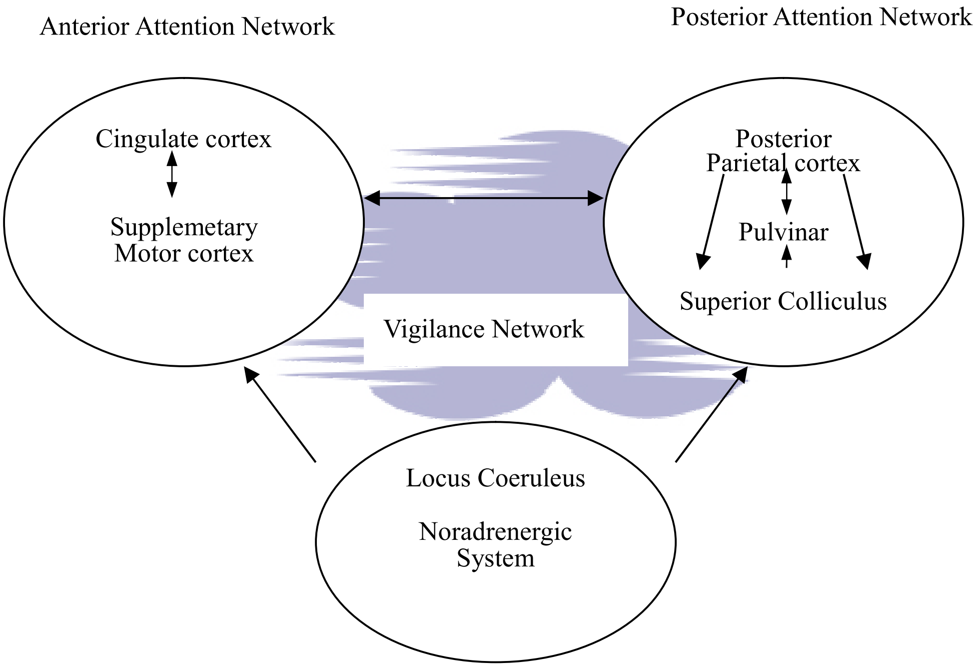


Fig 2.1.2: A diagrammatic representation of the neural network model of attention described by Posner and colleagues (Webster and Ungerleider, 2000:29)

This Figure shows that the term attention cannot be seen as one central system but rather a variety of modules with certain functions that are interconnected with each other to tackle cognitive challenges.

Bunce (2001) argues that especially for older people, who are retired and spend more time watching TV or reading, sustained attention is an important issue. Sustained attention is also required and very important in terms of safety in our daily life driving a vehicle. Therefore the focus in this research was on sustained attention.

2.1.3 Functions of attention

As was pointed out in the earlier chapters, attention describes a complex network of different attention areas. In the field of neuroscience and neuropsychology different kinds of tests were developed in order to detect attention deficiencies, which helped to identify the different areas of attention. Here six major aspects of attention are taken into account: Alertness, sustained attention and vigilance, selective and focused attention, divided attention, executive attention and speed of information processing.

1) Alertness: The ability to be alert for a short time because of an outside stimulus or a general state of alertness. Here Posner et al. (1987) differentiate between tonic and phaseal alertness. The former refers to the general responsiveness, which varies during the day. The later refers to a short increase of alertness due to alarm signals. Here the focus is on speed of the response.

2) Sustained attention and vigilance: Describe the ability to sustain attention over a period of time. Sustained attention and vigilance differ in the frequency of the stimuli (the representation of the target). Vigilance refers to the ability to keep attention during low frequency of stimuli and therefore in monotonous situations. Sustained attention on the other hand is a more general term for all situations where

attention is kept during a longer period of time with higher frequency of stimuli (Sturm and Willmes, 2000). During testing the focus is on the number of Hits, misses and false alarms.

3) Selective attention: The ability to focus on task oriented stimuli.

4) Divided attention: The ability to process more than two inputs

5) Executive attention: consciously directing attention and not reacting to distracting inputs

6) Information processing: Speed of information processing.

These are all aspects of attention, which can be tested in order to diagnose deficits of performance.

2.1.4 Neuroscience and Attention

Due to new technology in neuroscience like the Magnetoencephalography (MEG), magnetic resonance tomography (MRT), X-ray computed tomography (CT) or Positron emission tomography (PET), the understanding of the brain and its structure has been improved. With these methods certain areas of the brain and their activation can be measured. The former described aspects of attention can be located in different areas in the brain.

Neuroanatomy of vigilance:

The noradrenergic part of the formatio reticularis, intralaminare nuclei of the thalamus, cholinergic part of the basal frontal lobe and the right prefrontal cortex are involved in the neuroanatomy of vigilance (Niemann and Gauggel, 2006). The formatio reticularis is an area in the central nervous system consisting of islands of gray matter and fine nerve fibers. It regulates the state of alertness and sleep with its projection to the thalamus (Trepel, 2004). It functions as a filter, a gate which decides which signals are of importance to us and therefore will come to our conscious attention. This process is also a function of the Reticular Activating System (RAS) which is illustrated in Fig. 2.1.4.1. It regulates the autonomic nerve system as well as arousal, attention, consciousness and motivation.

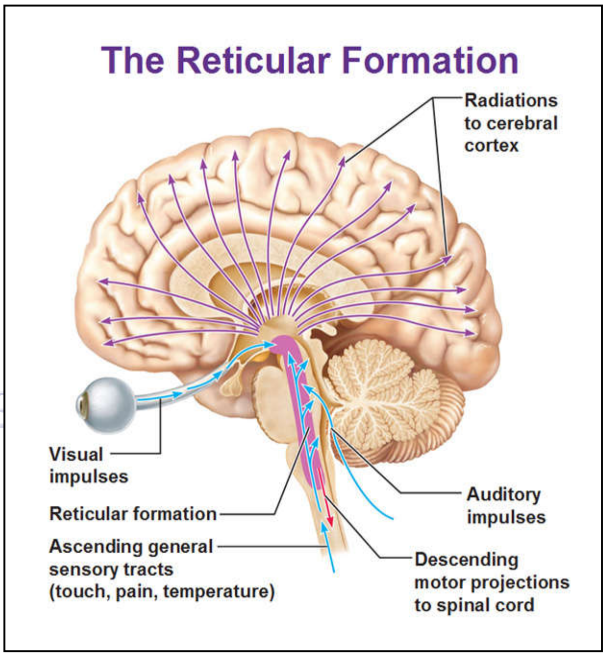


Fig 2.1.4.1 : The Reticular Formation and the Reticula Activating System (RAS)

http://lilachrysikou.wordpress.com/

Neuroanatomy of Alertness:

The right prefrontal cortex (like Brodmann- area 6), parietal lobe and the locus coeruleus are responsible for alertness. The locus coeruleus located in the pons, controls with its noradrenergic system the input from the sensory system. Together with the formation reticularis (Fig 2.1.4.1) it is responsible for states of alertness and sleepiness (Trepel, 2004).

Neuroanatomy of selective attention:

The parietal lobe, temporal-parietal transition zone, the superior colliculi, which plays an important role in directing eye movement/shifting attention, and the frontal eye field are involved in selective attention. The right parietal lobe and frontal lobe are important for attention into contralateral space. An injury on the right hemisphere, can cause a dysfunction in spatial orientation to the point of neglect of the contralateral side of vision or sometimes even the own body (Trepel, 2004).

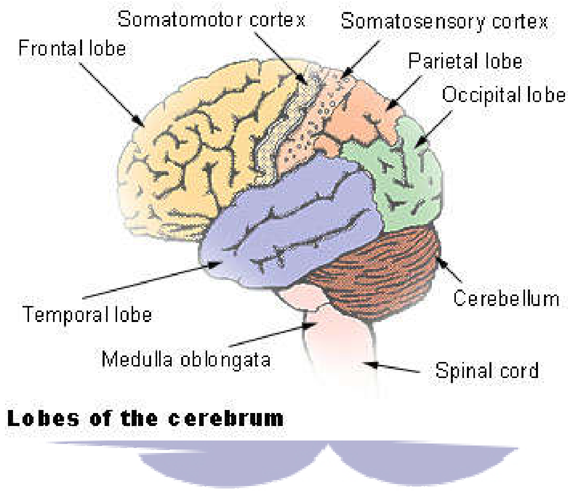


Fig 2.1.4.2: Lobes of the brain

http://en.wikipedia.org/wiki/File:Illu_cerebrum_lobes.jpg

Neuroanatomy of divided attention:

Most likely frontal brain structures are responsible for divided attention (Trepel, 2004).

Neuroanatomy of executive attention:

The neuronal network involved in executive attention consists of medial parts of the frontal cortex including the anterior cinguli gyrus and the supplementary motor area (SMA) as well as the nuclei basales (Trepel, 2004).

2.2 Exercise and Cognition

This chapter gives an overview of the influence exercise has on cognition

2.2.1 Energetic approach

Physical activity as a kind of stressor leads to several reactions of the body like increase in heart rate (HR), energy rate, and release of catecholamine just to name some of them, which help the body to regulate and cope with the increased demand of energy. These stimuli will cause the body to adapt for a short period of time or a long period of time depending on the quantity and quality of the stimuli. Some research has been done to examine how acute exercise can influence cognition. From an energetic perspective, studies conducted on animals and humans, found a release of brain catecholamine and indolamines (serotonin and 5-hydroxytryotamine). Catecholamine can help to preserve alertness and so filter inputs (noradrenergic system which is located in the locus coeruleus) as well as modulate neural activity (dopaminergic system located in the substania nigra pars compacta) to energize outputs while the serotoninergic system (located in raphe nucleus) deactivates and inhibits the former systems (Audiffren, 2009).

The noradrenergic and dopaminergic pathways in the brain on the other hand are important in the activation of cognitive and emotional regions. However, the intensity and dose of exercise play an important role in activating or damping cognitive centers of the brain. “It would appear that when exercise is at an intensity at which brain catecholamine and cortisol concentrations show moderate increases from baseline, cognitive performance can be optimal.” (Mc Morris, 2009 : 68). The hormone cortisol plays an important role during exercise. It facilitates fat metabolism, muscle function, and glucose production from proteins.

Dishman et al. (2006) pointed out that exercise increases levels of mitochondrial uncoupling protein 2, which seems to modulate BDNF production. BDNF is short for Brain Derived Neurotrophic Factor, which is responsible for synaptic plasticity and mediates learning capacity. (see also 2.2.2).

2.2.2 Cerebral blood flow

Another important factor, which might explain the influence of exercise on cognitive functioning is cerebral blood flow. As early as 1987, Herholz et al. found a significant increase of blood flow in almost all brain areas at very low intensity (25 Watt) and an increase in all brain areas at a moderate intensity of 100 Watts. The increase of blood flow can be beneficial for cognitive functions as it increases the supply for glucose and oxygen as well as growth factor IGF-1 (Hollmann, Strüder and Tagarakis, 2005). The Brain Derived Neurotrophic Factor (BDNF) for example increases significantly after only a few days of exercise. The BDNF maintains and preserves existing neurons and is responsible for growth and differentiation of new neurons (Hollmann, Strüder and Tagarakis, 2005). Therefore they concluded that an aerobic, dynamic training can enhance brain plasticity and directly influence quality as well as quantity of neurons and synapses. These factors then can positively influence cognitive functioning of the brain. The research done by Zoladz et al. (2000), although conducted earlier, showed supporting facts in the same direction. After five weeks of endurance training, subjects' general BDNF level in resting position as well as BDNF level right after an acute bout of maximal incremental cycling exercise test increased.

To sum up, exercise seems to have an influence on cognitive regions in the brain from an energetic and neuroendocrinological as well as a neurogenetic view point.

However, since cognition can be separated in many cognitive functions, the question remains in how far exercise does influence these functions separately. Psychological tests have been conducted together with exercise to survey this question (see 2.2.4).

2.2.3 Acute and chronic exercise for cognition

There are two research approaches: investigation of chronic exercise or acute exercise on cognition. There are long terms effects of exercise training, which can only be measured after a certain period of time e.g. muscle growths, capillarisation or even anatomical changes in brain structures. On the other hand there are immediate effects of one bout of exercise, which in its accumulation will lead to the long term effects, like the release of brain catecholamine or the modulation of the activity of neural network (McMorris, Tomporowski and Audiffren, 2009). Mitchell et al. (1990) for example found an increase in norepinephrine during exercise. So depending on the focus of research both approaches have their eligibility. In cognition research both approaches are used (for reviews see: Lambourne and Tomporowski, 2010, Uffelen et al., 2008).

However, the research done on acute bouts of exercise are less than on chronic exercise. Studies of acute bouts of exercise are important to understand the mechanisms that might lead to an improvement in long-term exercise. When a short bout of exercise can enhance attention, it might as well be practiced and used in everyday life.

2.2.4 Cognitive tests and exercise

Until now, only a few studies examined the effect of an acute bout of exercise on older people. Barella, Etnier and Chang (2010) investigated the immediate and delayed effect of an acute bout of exercise on cognition in healthy older adults. Using the Stroop test, their results showed an improvement only in the Stroop color test. Therefore, they come to the conclusion that a 20 minutes moderate exercise session might be beneficial for speed of processing but not for other types of cognitive function. That might due to the sample, which consisted of older healthy adults and the fact that for healthy adults a 20 minutes moderate training might not be enough to enhance cognitive function. In his review on acute exercise and cognition Tomporowski (2003:315) ascertains that "…submaximal aerobic exercise performed for durations between 20 to 60 min facilitates multiple cognitive functions". Therefore, in this study the exercise duration was defined to be 30 minutes.

In a meta-regression analysis Lambourne and Tomporowski (2010) found a small improvement in cognitive function after acute bouts of exercise (Effect Size (ES) 0,20). The ES, however, seemed to depend on exercise mode. All of the studies included in the analysis used either bicycle ergometer exercise or treadmill for evaluation. The bicycle ergometer training intervention had a better effect on cognition than the treadmill interventions. Energy expenditure, which is less in cycling exercise due to the reduced vertical excursion of the body's center of mass in a seated position, might explain this phenomenon (Lambourne and Tomporowski, 2010). Hence, after running the sensory afferent is still active and therefore influences the integration of cortical activation which leads to a lower signal-to noise ratio and therefore to less efficient information processing (Lambourne and Tomporowski, 2010). Considering these results and the fact that other research, so far, has largely focused on cardiovascular training and has neglected to investigate other modes of exercise and their effects on cognition, it is important to analyze in how far other modes e.g. TCC, which is especially interesting for the older population, effects cognition. Like Chang et al. (2010) point out in their review that there are other mechanisms than cardiovascular that account for a better cognitive performance.

2.3 Tai Chi Chuan

This chapter outlines the characteristics of Tai Chi Chuan.

Tai Chi Chuan (TCC) was originally developed as a form of martial arts but is now also used as a practice for health. There are many different styles of TCC, nevertheless, five major styles can be differentiated: the Chen, Yang, Wu, Hao and Sun style. Yang style is the most popular of the TCC styles in the West and East, whereas the Chen style is the oldest of them and goes back to the Chen village in Henan province (Kennedy and Guo, 2005).

Considerable attention has been given to the Yang style and its beneficial effects for older people. In Asia it has been used for centuries as an exercise for health. Its slow and thoughtful movements made it especially attractive to elder people. Basically TCC consists of several individual movements, which are combined together in a smooth and continuous way, so that one movement smoothly leads to the next. Weight shifting, coordination of arms/hands and legs, breathing and concentration are important features of it. The harmony between body and mind is achieved by breathing and concentration. Due to these features, people have suggested that TCC can have a positive influence on balance and several researches have been done to study its effects. These researches showed that TCC has the ability to promote strength (especially in leg muscles), balance, better quality of life and aerobic fitness (see Wu and Ren, 2009, Xu et al., 2005, Hui, Woo and Kwok, 2009, Taylor-Piliae, 2008 and Kuramato, 2006).

Only a few studies have examined the cognitive benefits of TCC. Margaret Matthews and Harriet Williams (2008) had quite promising results in their 10 weeks TCC intervention study. Twenty 65 years and older healthy adults participated in a 10 weeks including 30 sessions of Sun Style for Arthritis Tai Chi program. Each session was 50 minutes long including 10 minutes of warm up and cool down and 30 minutes of TCC practice. Executive function tests as the Trail Making parts A and B, Digit Symbol Substitution and the Clock Drawing Task were tested before and after the 10 weeks intervention. The Trail Making Test is a neuropsychological test of visual attention and task switching. In part A, a series of numbers has to be connected as fast as possible. In part B the subject has to alternate between numbers and letters (1-A-2-B…), which makes part B more difficult. Therefore, part B is associated with higher-level cognitive processes as distinguishing, organizing and planning (Kay, 1984). The clock drawing Task includes ”… goal selection, planning, motor sequencing, selective attention, and the self monitoring of a subject’s current action plan” (Royal, Cordes and Polk, 1998 : 588). After 10 weeks intervention the subjects improved significantly in the Trail Making Test part B and the Clock Drawing Task. However, no benefits were observed for the Digit-Symbol Substitution Task, which is a test for speed processing and memory. Giving these results Chang et al. (2010) concluded that TCC might have a positive effect for executive functions but not necessary for information processing.

Liu et al. (2005) also examined the psychological and physiological effect of the 24-Yang-Style TCC form. In their study they used electroencephalography (EEG) and the Profile of Mood State (POMS) to measure the effects of one session of TCC and one bicycle ergometer training session. EEG was recorded before and three minutes after exercise as well as three minutes after the heart rate (HR) returned to rest HR value. The results show that θ-waves, which display sleep or drowsiness, were reduced and α-waves, which are characteristic for a relaxed but alert state, were increased after HR returned to rest level. The authors interpreted that TCC might shift the α-waves from the ordinary occipital to the central or frontal regions of the brain indicating that TCC is useful to improve concentration capacity and hence attention. Their results could also show that TCC had a stronger relaxing effect on the cerebral cortex activity than bicycle ergometer training.

However, Kuramato (2006) argued that it is unclear which of the components in TCC accounted for health benefits. She stated that the effects of TCC especially in the elder might solely due to the relaxing and meditative aspects. Recent research in the field of short-term meditation and cognition also provided evidence that brief mindful meditation can enhance sustained attention and higher order attention-related neuronal activations (Zeidan et al., 2010).

In accordance with these studies this research wanted to look at three aspects of TCC: the coordinative, meditative and cardiovascular aspects. The aim was to examine which component of TCC might account for beneficial cognitive effects or if the combination of the three, which makes TCC a special kind of exercise, leads to higher cognitive enhancement rather than the three on their own. A study by Fabre et al. (2002) could also show that the combination of physical exercise and mental exercise had the best results in cognitive functions.

2.4 Test methods of vigilance

This chapter explains why the CPT was chosen as a test measurement for this study.

Since attention is the basic for many other cognitive tasks, one has to make sure that measurement of attention can rule out other cognitive abilities like memory or planning. Thus the task demands "…need to involve limited cognitive processing and thus be relatively simple" (Riccio, Reynolds, Lowe, 2001 : 17). Additionally, measurements of vigilance or sustained attention need to focus on their key points: repetition and duration. In 1956 Rosvold, Mirsky, Sarason, Bransome and Beck were the first to develop a Continuous Performance Test (CPT) to measure vigilance. In their CPT the letter X was the target stimulus and a lever had to be pressed when the target between other non-target letters appeared. Letters were presented at a fixed rate. Since then many different versions of the CPT have evolved differing in the choice of target or non-target (numbers, pictures, words and so on). Due to its simple task the CPT is the most frequently used measure of vigilance, which gives quantitative information about the ability to sustain attention over time. Major CPTs in clinical use are the Conners' Continuous Performance Test (Conners' CPT), the Gordon Diagnostic System (GDS), the Integrated (or Intermediate) Visual and Auditory Continuous Performance Test (IVA) and the Test of Variables of Attention (TOVA) (Riccio, 2001).

The Conners' CPT developed by Conners in 1992 is a 14-minute long test where the space bar has to be pressed when a letter is presented except for the letter

X. When the letter X appears the subject has to refrain from hitting the space bar. The standard test consists of six blocks, which are divided into three sub-blocks. 20 trials of target and non-target stimuli are presented in each sub-block. The time between letter appearances randomly changes from 1000 to 2000 or 4000 milliseconds. The test is very simple without any distractor conditions. Although the Conners' software offers the option to develop own customized CPT tests by changing the number of blocks or targets, these collective data do not have normative and can therefore not be used for clinical decision making (Riccio, 2001).

The Gordon Diagnostic System was developed by Gordon in 1983 and consists of three basic paradigms including one vigilance task. In contrast to the original CPT the GDS uses numbers as stimuli. A version for children aged 6 to 16 years is available which lasts for nine minutes. Children have to press the button whenever the target, a combination of two numbers (1/9), is presented. There are two other versions of the GDS, a pre-school version and an adult version both lasting for six minutes. All versions consist of two to three blocks in order to monitor subject's vigilance decrement over time (Riccio, 2001).

The IVA uses auditory and visual modalities in a 13-minute CPT. Here subjects have to press the mouse button when presented with the target stimulus e.g. the number 1 in visual or auditory format. Unlike the Conners' CPT and GDS there is only a single non-target stimulus (e.g. the number 2). IVA also provides a distractor condition with differing target frequency. A counterbalance design for target-to-non-target ratios and visual and auditory stimuli are used to control learning effects and motivational aspects (Riccio, 2001).

The TOVA has a visual and an auditory version. A microswitch has to be pressed every time the target stimulus is presented. The target stimulus is a colored square containing a smaller square at the top edge of the larger square. For the non-targets the smaller square is located at the bottom of the bigger square. The TOVA test is non-language based and is therefore better test to conduct the measures of inattentiveness and executive control. The test takes 11 minutes for four- to five-year old children and 22 minutes for all others. It is separated in four intervals with the first two (target stimulus shown 22,5 %) to measure attention and the second half (target stimulus shown 77,5%) to measure impulsivity (Riccio, 2001).

In this research the Connors' CPT was chosen because of several reasons. For the measurement of vigilance it was important to keep measurements simple and since the purpose of this study is to evaluate vigilance only, the Conners' CPT provides the wanted features. Financially, the Conners' CPT and the TOVA were the better alternatives with one third of the IVA and GDS purchase costs. Economically, the Conners' CPT needs only 14 minutes to be conducted whereas the TOVA is 22 minutes long. Since in this research subjects had to do the test procedures eight times in total (before and after on four separate exercise trials; *also see Chapter 3*), time and motivation played an important role.

3 Methods and Materials

3.1 Study design

We assumed that an acute bout of TCC has positive effects on cognition, in specific sustained attention. Since TCC is a complex form of martial art, we split it up in its components relevant for exercise. We assumed that in a sport scientific point of view it consists of three major parts: coordinative, cardiovascular and meditative (independent variables). That is why we did not not only evaluate the acute effects of a session of TCC but also the effects of a cardiovascular training session (at the 2 mmol lactate threshold), a coordinative training session and a meditative practice. This can help to understand which of the three components found in TCC exercise is beneficial for cognition or if the combination, the specialty of the TCC practice itself is more beneficial than its components on its own. Qualitative experimental study design was used to analyze the effects. In order to limit bias when analyzing independent variables, the same subjects had to undergo all the tests. The CPT-attention test was the dependent variable, which was evaluated before and after the acute bouts of exercise. Heart rate and blood pressure (only for fitness test) was measured during testing period and exercise period.

The tests in Taipei were conducted at the Taiwan National Sports University (Bicycle ergometer fitness test and 30 minutes bicycle session) and at the community center in Tusheng. In Taichung the tests were conducted at the National Taiwan University of Physical Education and Sport (Bicycle ergometer fitness test and 30 minutes bicycle session) and at the China Medical University.

The following figure shows the test procedure.

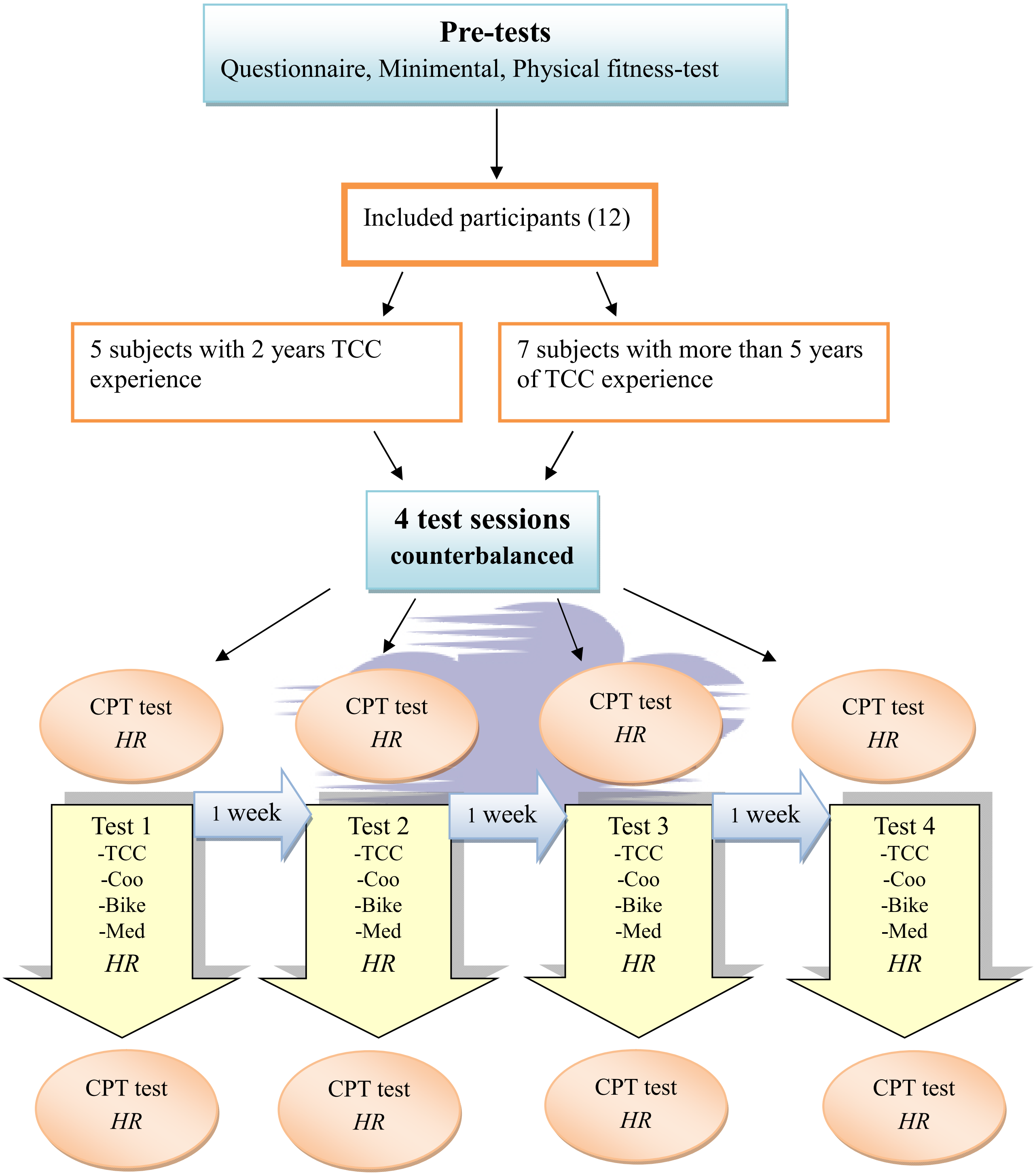


Fig 3.1: Test procedure (Coo for Coordination)

3.2 Subjects

Older people from different TCC clubs (age over 65 years) in Taipei (11) and Taichung (1) were recruited to participate in the study. To qualify for the study, subjects first had to fill out a health history questionnaire, cognitive impairment questionnaire (Mini Mental Sate Examination -MMSE), and give information about training dose and years of experience. Participants had to give written consent. Subjects were then separated in two groups according to their years of experience (A= between 1 to 2 years and B= 5 years and more). 12 Participants who fulfilled the inclusion criteria had to undergo a physical fitness test to evaluate fitness level in order to estimate the 2mmol lactate threshold.

3.3 Material

3.3.1 Physical fitness test

For the physical fitness assessment a Lode Excalibur Ergometer (Medgraphics) was used in Taipei and a Bosch ERG 550 was used in Taichung at the National Taiwan University of Physical Education and Sport.

Fig. 3.3.1.1: Bicycle Ergometer Lode Excalibur from Medgraphics (left) and Bosch ERG 550 (right) www.medgraph.com/datasheet_excalibur.html http://mtc-hamburg.com

The participants were first informed about the WHO testing procedure. Participants started with 25 Watt for two minutes. The workload was increased by 25 Watt after two minutes of cycling as suggested by Rost (2005). At each step participants had to evaluate their fatigue level using the Borg Scale. Additionally blood lactate, HR, and blood pressure were measured. Indications for terminating exercise testing were as followed:

- Subject's desire to stop (fatigue)
- Moderately severe angina
- Increasing nervous system symptoms (e.g. attaxie, dizziness, or near syncope)
- Signs of poor perfusion
- Technical difficulties in measuring blood pressure or ECG
- Malign Arrhythmias
- ECG changes (e.g. St elevation (+1.0 mm) in leads without diagnostic Q-waves)
- Shortness of breath
- Drop of systolic blood pressure of > 10 mmHg from baseline; for safety reasons systolic blood pressure should not exceed 250 mmHg and diastolic 115 mmHg.

(ACSM, 2010 and Rost, 2005)

ECG (Fukuda M-E, Bio-scope M100) transmitted data, which were monitored by a medical doctor to secure subjects safety during bicycle ergometer test (Fig. 3.3.1.2).

Fig. 3.3.1.2: ECG Fukuda M-E, Bio-scope M100

3.3.2 HR, blood pressure and blood lactate

HR was measured using a polar S725x.

Fig 3.3.2.1: Polar S725x
www.polar-deutschland.de/de/support/produkt_support?product=285

www.polar-deutschland.de/de/produkte/accessoires .jpg

Blood pressure was measured by TMD-36AB Tatung portable wrist type measurement device.

Fig 3.3.2.2: Portable blood pressure measurement device

www.amazon.com/Tatung-Wrist-Blood-Pressure-Monitor/dp/B000VRV7OU

A 10μL blood sample was taken from the ear lobe to measure lactate with a Biosen C-line measurement from EKF Diagnostic.

Fig 3.3.2.3: Biosen C-line

3.3.3 Minimental State Examination (MMSE)

The MMSE is a screening test for cognitive impairment. It consists of 30 questions and is a quick way screening method (see attachment). On the first day, participants had to fill out the MMSE.

3.3.4 Conners' Continuous Performance Test (CPT II)

The CPT measures a person's sustained and selective attention and impulsivity (Conners et al., 2009). The ability to maintain a consistent focus on some continuos activity or stimuli is called sustained attention; it is also associated with impulsivity. Selective attention on the other hand is the ability to focus on relevant stimuli and ignore competing stimuli (associated with distractibility). Subject sat in a quiet room with the investigator. On a 14 inch computer the subjects were asked to focus on the letter which would be displayed on the screen in different inter-stimulus intervals (ISI: 1, 2 and 4 seconds) and click the spacebar whenever a letter appeared. The subject, however, had to refrain from clicking it when the letter X was presented (Conners et al., 2009). Reaction time, omissions, and commissions were recorded.

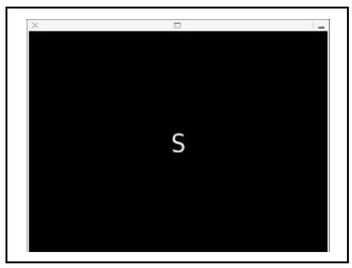


Fig 3.3.4: Computer and non-target on screen

The CPT protocol also showed if attention could be maintained during the whole 14 minutes of testing. Subjects were tested at the same time of the day during all testing protocols. The table below gives an overview of CPT's measures.

Tab. 3.3.4: CPT's measures

Variables	Unit	Details
Hit Reaction time (RT)	Nearest millisecond	Measure of impulsivity Atypical fast RT Measure of inattentiveness Very slow RT
Hit Reaction Time Standard Rrror	SD variable reactions	Mesure of inattentiveness Consistency of response time
Omission	Non response to a target	Mesure of inattention
Commission	Respond to a non-target	Measure of inattention/impulsivity
Attentiveness d'	Discrimination between target and non-targets	Mesure of inattention/impulsivity
Hit RT Block Change	Change of RT over 5 time blocks	Measure of vigilance Positive slope: slowing RT Negative slope: quicker RT
Hit Standard Error Block Change	Slope of change in reaction time standard errors over six time blocks	Measure of vigilance Positive slope: RT bacame less consistent as the test progressed Negative slope: RT became more consistent as the test progressed
Variability of Standart Error		Response speed consistency
Perseverations	Respond that occurs less than 100ms after stimulus	Mesure of impulsivity Anticipatory responding
Response Style Indicator (Beta)	Individual's responds tendency	Higher values than average: cautios response style, try to avoid commision errors Lower values than average: more free response style, trying to response to most or all targets
Reaction Time by	Change in average RT	Positive slope: slowing of

Inter-Stimulus Interval (ISI)	over the different ISI (1, 2 or 4 seconds)	RT as the time between target increases Negative slope: faster RT as the time between target increases
Standard Error by ISI	Change in standard error of RT over the different ISI	Positive slope : more erratic as the time between target increases Negative slope: increased consistency as the time between target increasd

High commission mistakes and fast Hit RT are markers for impulsivity, whereas slow Hit RT and many omission or commission mistakes show inattention. The Hit RT Block Change measures the change in RT over the six time blocks and is therefore a marker of vigilance. A high score resembles a slower RT and therefore a loss of vigilance.

3.4 The four exercise sessions

3.4.1 Tai Chi Chuan exercise program

Yang style is the most popular TCC style in the East and West. However, there are different Yang style TCC forms. The form created by Zhen Man Ching with 37 movements, is especially popular in Taiwan and America. The TCC short form consist of only 24 movements and was created to make TCC easier to learn for everybody and therefore more popular. The 88- and the 108-form are the so-called "long forms" because of their 88 and 108 movements. More recently, a medium long competition form has been developed, which consists of 66 movements. To guarantee motivation, participants could choose which Yang TCC form they wanted to perform. 11 of the 12 subject choose the competition form, because, if performed slowly it takes about 25 minutes. All participants performed for 30 min including 5 minutes of warm-up. A notice was given 30 seconds prior to 30 minutes of exercise, so subjects could slowly come to an end.

3.4.2 Coordination exercise program

Together with the instructor participants did a coordination program containing the most important coordination abilities also found in TCC. The program focused on balance, rhythm, eye-hand coordination, arm-leg coordination and ability to differentiate. The program was created so that the movements would cover the coordinative abilities, but not resemble the TCC movements. The arm-leg coordination movements consist of forward and backward as well as left and right movements, cross steps and arm movements. Speed was controlled using a metronome AM-703 at 75 beats/min (Fig.3.4.2.1). Static balance was practiced standing on one leg for as long as possible (longest 30 sec.) with eyes open and then closed. Dynamic balance was practiced on one straight line with eyes open and closed. For rhythmical abilities, subject had to walk over five (1m) mats. The mats were put in a straight line with a distance of 1 m in-between. They had to walk using a different amount of steps starting with one-one (one step on the mat and one between), the one-two, two-two, two-three, three-three similar to an agility training. After some time arm movements were added to the routine to increase the degree of difficulty.

Fig. 3.4.2.1: Metronome AM-703

http://www.musik-aktiv.de/Metronome-Stimmgeraete/Metronome/Aroma-AM-703-Metronom.html

For the hand-eye coordination the subjects had to throw a ball into two different sized buckets, which varied in distance.

Fig. 3.4.2.2: Different sized buckets and soft sand bag used in the coordination session

The first bucket was 2 m away the second 4 m and the third 6 m. The subjects could try to throw the ball into each bucket for two minutes. After this series, smaller buckets were used as targets to increase the level of difficulty. A full description of the used exercises is available in the appendix.

3.4.3 Physical exercise program

Participants performed a 30 minutes aerobic bicycle ergometer training at the 2 mmol lactate threshold (Mader et al., 1976). The workload was estimated by using the data from the initial fitness test on the bicycle ergometer. Two bicycle ergometers were used since participants were recruited from Taipei and Taichung. In Taipei the bicycle ergometer Lode Excalibur from Medgraphics was used. In Taichung a Bosch ERG 550 was used for the exercise testing as well as for the physical exercise program.

3.4.4 Meditative practice

Participants were seated in an air-conditioned, shaded room. They were asked to sit comfortably on a chair. Participants were instructed to sit quietly for 30 minutes focusing on their full breath starting on the tip of their nose and proceeding to the abdomen and back in accordance with Zeidan et al. (2010) or alternatively focus on a bottle of water standing on a table in front of them. A person of the test team stayed in the room to make sure that participants were not falling asleep or interrupting their session.

3.5 Statistics

One-way ANOVA (repeated measures) was used to assess attention in the different exercise programs. SPSS 12.0 was used for assessment of group differences with $p<0.05$ and mean (±) SD, for the dependent t-test (before and after exercise programs) and independent t-test for group comparison (experienced Tai Chi practitioners versus not so experienced Tai Chi practitioners).

4 Results

In this chapter the t-test results for all variables of the CPT are shown and the one way ANOVA.

4.1 Participants

Twelve men (age m=69.4±3.8 years) participated in this study. Seven participants had five years or more of TCC experience while the other five had not more than two years of TCC experience. All of the participants completed the MMSE test without any noticeable impairment. All used to practice TCC more than 3 times a week except of one who practiced 2-3 times a week. The training session lasted 30 to 60 minutes for eight participants and 60 to 90 minutes for four participants. Most of the participants (n=8) had the habit of sleeping 6 to 8 hours, four people slept less than 6 hours per night. Additionally, eight participants reported having a good sleep while four people reported not having a good night's sleep; three of the four reported sleeping less than 6 hours. Only three men had meditation practice before and six had practiced Qi Gong before. Two of the participants were not reading any kind of newspaper while the others were reading 3 times a week or every day.

Tab. 4.1.1: Anthropometrical Data

no	Age (yr)	Experience in Tai Chi (yr)	Training per week (hr)	Minutes each session
1	77	5	> 3	30-60
2	72	6	> 3	30-60
3	67	2	> 3	30-60
4	76	2	> 3	30-60
5	67	2	> 3	60-90
6	69	15	> 3	30-60
7	69	7	> 3	60-90
8	69	8	> 3	30-60
9	68	2	> 3	60-90
10	65	15	> 3	30-60
11	68	2	2-3	60-90
12	66	10	> 3	30-60
Mean	69.4	6.3	> 3	30-60
SD	3.8	4.9	-	-

One subject could not participate in the bicycle ergometer exercise program because of restricted range of motion in his left knee due to a former knee operation. Therefore, all data from the bicycle intervention include only 11 participants.

<u>Physical fitness test</u>

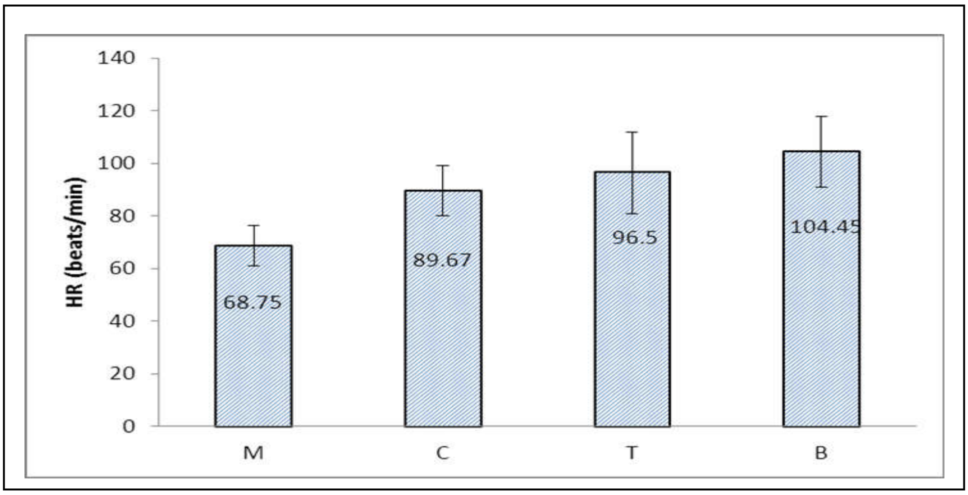
According to the WHO (see chapter 3.3.1) the fitness test started at 25 Watt and was increased by 25 Watt after two minutes of cycling. After each step HR was recorded and a blood sample from the ear lobe was taken to measure lactate. In the following table these data as well as HR around the 2 mmol and 4 mmol lactate threshold are presented. Only two participants showed an accumulation of 4 mmol lactate or more (number 7 and 12).

Tab. 4.1.2: Fitness test

NO	Watt	R	25	50	75	100	125	150	**2mmol**	**4mmol**
1	**La**	1.17	1.03	1.37	1.94	3.02				
	HR		84	92	111	130			**112**	
2	**La**	1.35	1.56	1.6	1.77	2.61	3.53			
	HR		77	85	104	118	142		**109**	
3	**La**	1.25	1.17	1.36	1.73	2.44				
	HR		77	93	105	116			**110**	
4	**La**	1.84	1.86	2.01	2.46	3.39				
	HR		67	74	81	90			**74**	
5	**La**	1.13	1.39	1.57	1.85	2.71	3.6			
	HR		85	93	100	105	120		**101**	
6	**La**	1.39	1	1.03	1.14	1.57	2.4	3.9		
	HR		76	87	95	106	114	130	**111**	
7	**La**	1.27	1.19	1.28	1.68	2.69	4.34			
	HR		92	106	117	133	151		**123**	**148**
8	**La**	1.50	1.18	1.21	1.35	1.72	2.31	3.17		
	HR		75	83	86	98	110	128	**104**	
9	**La**	1.11	1.04	1.22	1.67	2.71				
	HR		64	82	90	108			**95**	
10	**La**	1.32	1.28	1.33	1.46	1.97	2.19	3.32		
	HR		77	91	101	115	130	144	**117**	
12	**La**	1.00	1.92	2.21	2.63	3.99	5.83			
	HR		85	92	105	118	133		**86**	**118**
Mean	**La**	1.3	1.33	1.47	1.79	2.62	3.46	3.46		
SD	**La**	0.23	0.32	0.36	0.44	0.71	1.32	0.39		
Mean	**HR**		72	85	92	107	129	134	**104**	**133**
SD	**HR**		8.14	8.2	10.76	12.81	14.92	8.72		

Heart Rate

The following table shows the mean HR during the four different exercise programs. These exercise modes were designed as aerobic exercises, around the 2 mmol lactate threshold, which can be referred from the graph and table (4.1.3).



Graph 4.1.3: Mean HR during different exercise programs

The right hand column shows the HR at the 2 mmol lactate threshold.

Tab. 4.1.3: Individual's mean HR during different exercise programs

	Meditative practice (Mean bpm)	**TCC (Mean bpm)**	**Coordination (Mean bpm)**	**Bicycle (Mean bpm)**	**2 mmol HR Threshold**
1	78	107	77	109	112
2	60	89	93	115	109
3	71	82	96	106	110
4	57	75	81	82	74
5	66	98	99	101	101
6	68	98	88	111	111
7	79	128	103	129	123
8	73	115	87	113	104
9	78	82	72	93	95
10	62	100	89	103	117
11	73	102	100		
12	60	82	91	87	86
Mean	68.75	96.5	89.67	104.45	103,8
SD	7.76	15.49	9.45	13.44	14.20

4.2 Measures of inattention and impulsivity

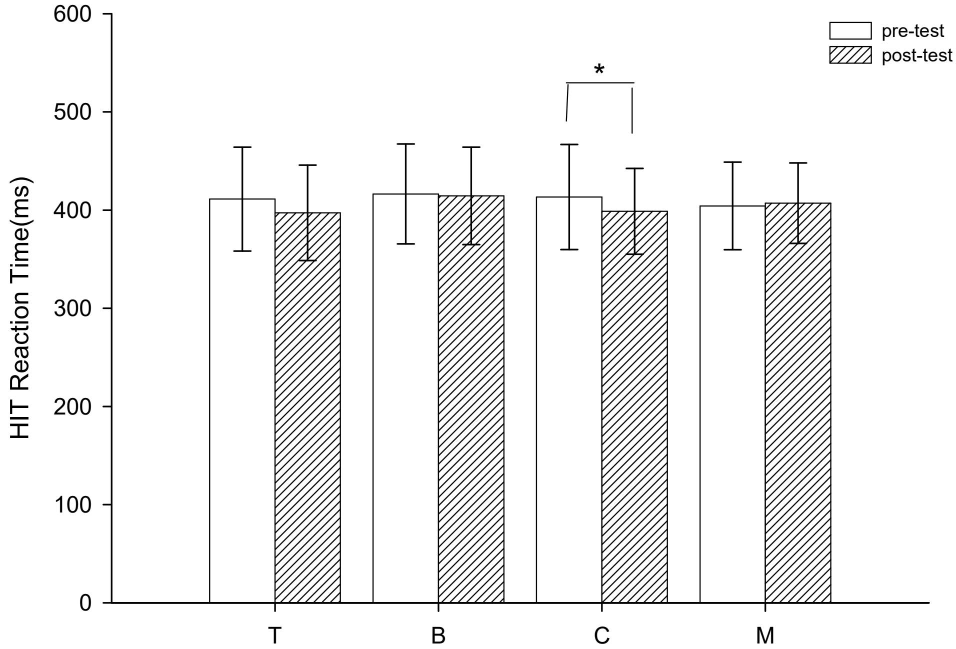
Comparison before (R) and after intervention (E)

4.2.1 Hit Reaction Time

Hit Reaction time before and after the four interventions are shown in table 4.2.1. The t-test did not show any significant differences between pre-test (R) and post-test (E) for the bicycle (B) (p=0.592) and meditative practice (M) (p=0.565) intervention. The coordination (C) intervention with p=0.026 showed a significant faster reaction after the coordination session. The TCC (T) intervention missed significance level with p=0.093 but showed a tendency for better reaction time performance after intervention. The graph 4.2.1 and the table 4.2.1 show these changes.

Tab. 4.2.1: Hit Reaction Time before (R) and after (E) intervention

Hit RT		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
	T	408	51.9	397	46.4	0.093
	B	416	50.9	414	49.7	0.592
	C	405	62.9	390	52.2	0.026*
	M	393	44.6	396	41	0.565



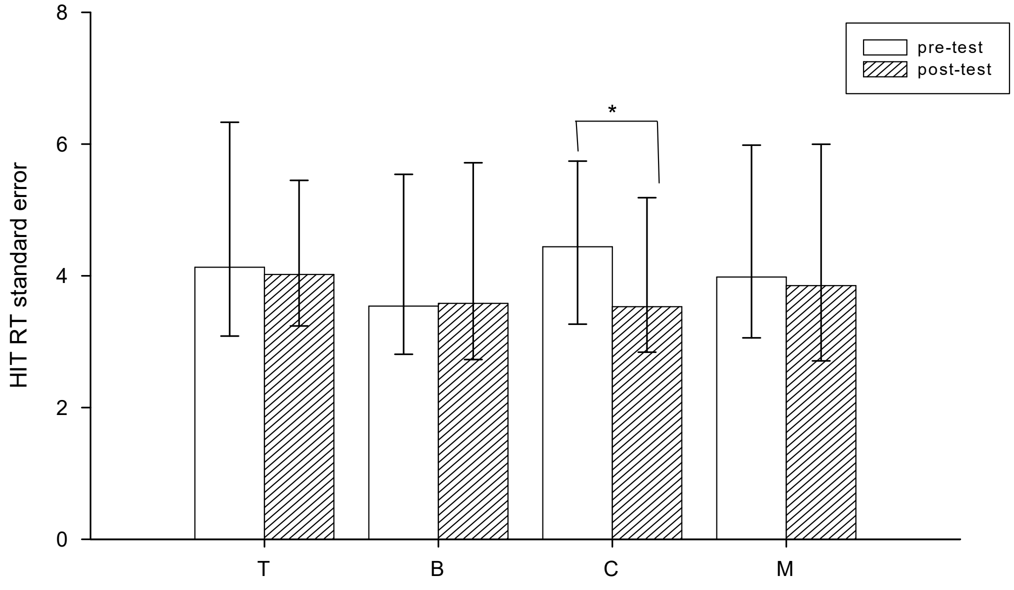
Graph 4.2.1: Hit RT before and after intervention (p<0.05)

4.2.2 Hit Reaction Time Standard Error

The graph 4.2.2 shows the standard error of the Hit reaction time. The p value for coordination (p=0.002) was significant. The other interventions TCC (p=0.123), bicycle (p=0.797), meditative practice (p=0.440) showed no significant changes.

Tab. 4.2.2: Hit RT standard error before (R) and after (E) intervention

Hit RT SE		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
	T	5	1.6	4	1.1	0.123
	B	4	1.4	4	1.5	0.797
	C	5	1.3	4	1.1	0.002*
	M	4	1.5	4	1.6	0.440



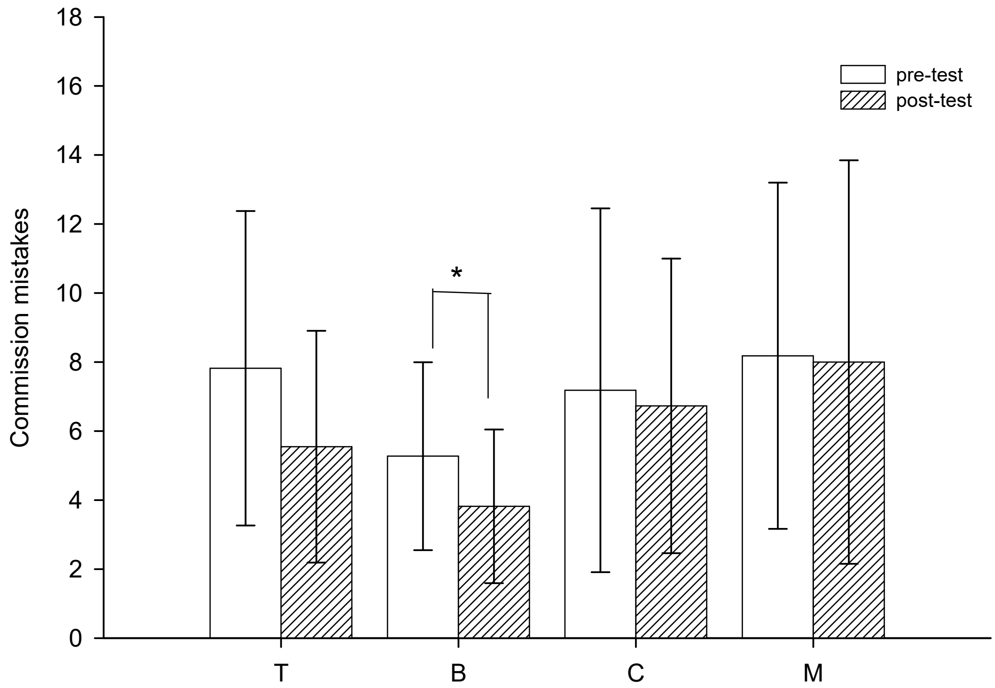
Graph 4.2.2: Hit RT standard error before and after intervention (p<0.05)

4.2.3 Commission Mistakes

The commission values were all normally distributed except for the bicycle values. For this value a Wilcoxen test was administered. The results are shown in the table 4.2.3. Here again TCC (p=0.060) showed a tendency towards improving commission mistakes, however, significance level was not reached. Bicycle on the other hand showed a significant improvement of commission mistakes with p=0.031. Meditative practice (p=0.619) and coordination (p=0.242) did not improve commission mistakes significantly.

Tab. 4.2.3: Commission mistakes before (R) and after (E) intervention (p<0.5)

Commission Mistake		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
	T	8	4.4	6	3.6	0.060
	B	5	2.7	4	2.2	0.031*
	C	10	8.8	9	6.9	0.242
	M	10	5	10	5.8	0.619



Graph 4.2.3: Commission mistakes before and after intervention ($p < 0.05$)

4.2.4 Omission Mistakes

No significant improvement was administered for the omission mistakes (see table 4.2.4 below) neither in TCC (*p*=0,119), bicycle (*p*=0,914), coordination (*p*=0,203) nor meditative practice (*p*=0,279). One subject showed an abnormal high mistake value in T1 and was therefore not taken into account (N=11).

Tab. 4.2.4: Omission mistakes before (R) and after (E) intervention

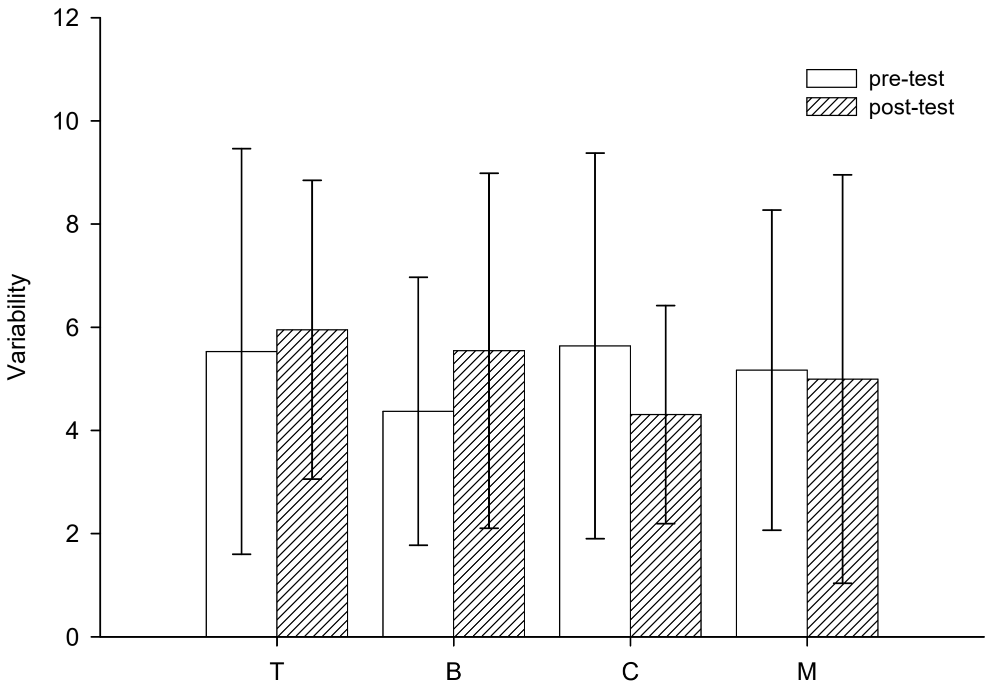
Omission Mistakes		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
N=11	**T**	1.73	2.28	0.55	0.52	0.119
N=10	**B**	1.3	2.79	2.1	5.26	0.914
N=11	**C**	2.36	4.11	1.18	1.99	0.203
N=11	**M**	2.27	3.77	3.09	4.85	0.279

4.2.5 Variability

No significant changes were administered in the variability value for TCC (p=0.618), coordination (p=0.137) or meditative practice (p=0.793). Bicycle showed a tendency with p=0.069 towards an increase of variability after intervention, but missed significance level. The graph 4.2.5 shows the result.

Tab. 4.2.5: Variability before (R) and after (E) intervention

Variability		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
	T	6	3.9	6	2.9	0.618
	B	4	2.6	6	3.4	0.069
	C	6	3.7	4	2.1	0.137
	M	5	3.2	5	4.1	0.793



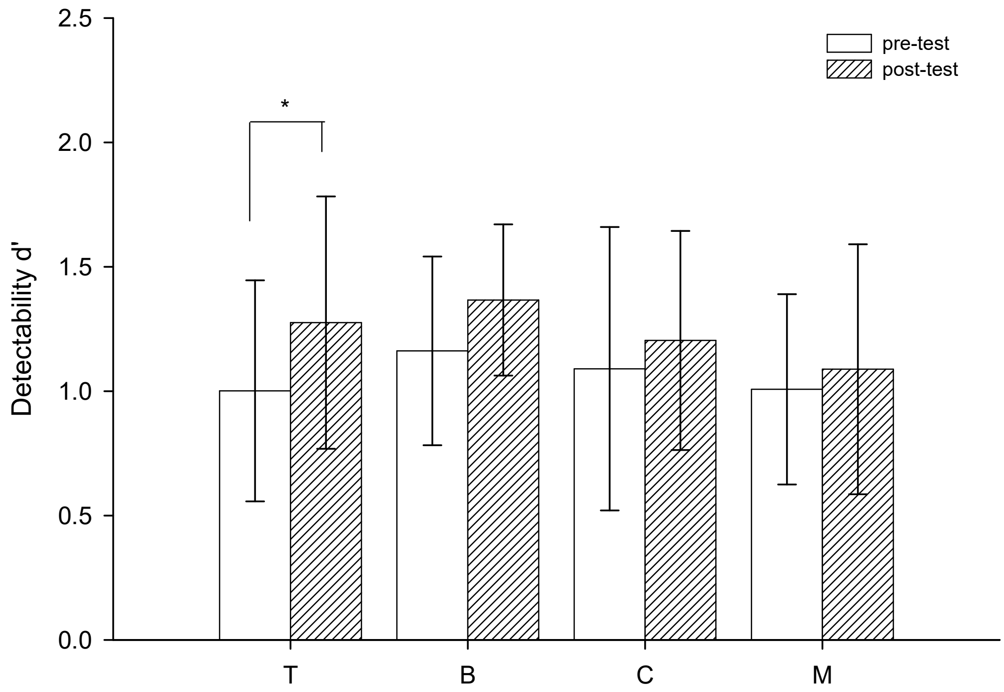
Graph 4.2.5: Variability before and after intervention

4.2.6 Detectability

The changes in attentiveness (Detectability or d') are shown in the table 4.2.6. Participants showed a significant improvement in this value after TCC intervention *p*=0.01, while there was no change after the other interventions (bicycle: *p*=0.13, coordination: *p*=0.11, meditative practice: *p*=0.57).

Tab. 4.2.6: Detectability before (R) and after (E) intervention

Detectability		**R (mean)**	**R (SD)**	**E (mean)**	**E (SD)**	***p*-value**
	T	0.97	0.4	1.23	0.5	0.01*
	B	1.16	0.4	1.37	0.3	0.13
	C	0.92	0.6	1.07	0.5	0.11
	M	0.92	0.4	0.98	0.5	0.57



Graph 4.2.6: Detectability before and after intervention (p< 0.05)

4.3. Measures of Vigilance

4.3.1 Hit Reaction Time Block Change

The changes in Hit block change are represented in the table 4.3.1. No significant differences were administered.

Tab. 4.3.1: Hit block change before (R) and after (E) intervention

Hit block change		R (mean)	R (SD)	E (mean)	E (SD)	*p*-value
	T	0.0142	0	0.0092	0	0.235
	B	0.0009	0	0.01	0	0.167
	C	0.0076	0	0.0049	0	0.53
	M	0.0008	0	0.0042	0	0.569

4.3.2 Hit Standard Error Block Change

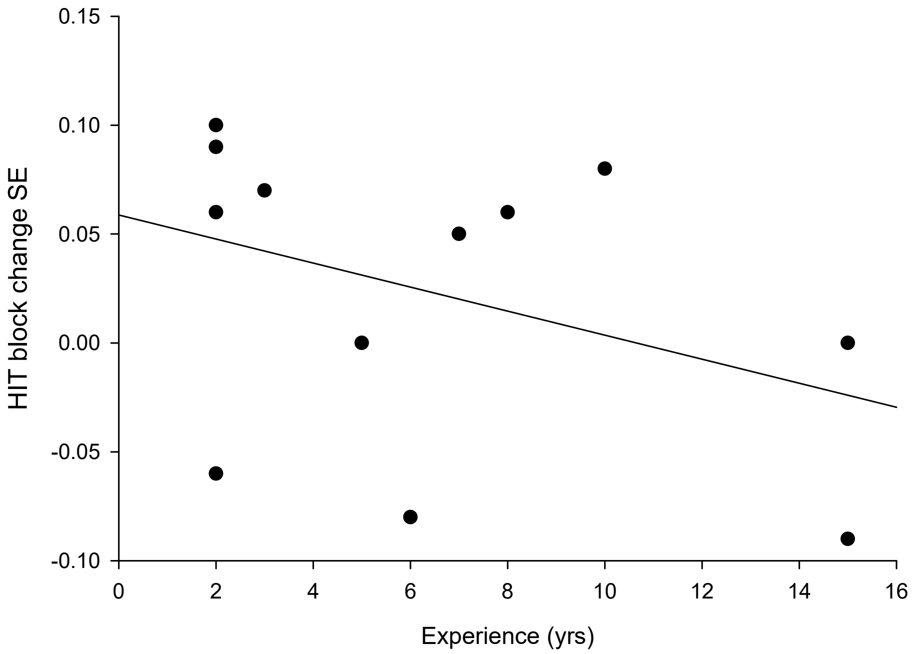
Hit standard error (SE) block changes are represented in the table below. No significant differences were administered. Bicycle performance showed a tendency with p=0.057, but missed significant level.

Tab.: 4.3.2: Hit block change SE before (R) and after (E) intervention

Hit block change SE		R (mean)	R (SD)	E (mean)	E (SD)	*p*-value
	T	-0.0008	0	0.0225	0	0.220
	B	0.0027	0	0.0455	0.1	0.057
	C	-0.0075	0	0.006	0	0.502
	M	0.0242	0.1	0.0308	0	0.683

4.4 Influence of experience on Tai Chi performance

After the differences of post-test to pre-test in the eight attention values were evaluated, an independent t-test was administered comparing two groups: experienced TCC practitioners (more than five years of experience) and less experienced TCC practitioners (two years or less of experience). The analysis showed no influence for most data (Omission p=0.138, Commission p=0.62, Hit Reaction Time p=0.116, Hit Reaction Time SE p=0.523, Hit block change p=0.857, Detectability p=0.892, Variability p=0.161). However, experience had a significant influence during TCC practice for the Hit block change value SE with p=0.005. The direction of the influence is shown in graph 4.4. More experienced Tai Chi practitioners showed a tendency towards a decrease of Hit block change SE value and therefore a better consistency as the test progressed.



Graph 4.4: Hit block change SE

4.5 Differences between the four exercise programs

In order to evaluate the differences between the four exercise programs with ANOVA, a within-subject factor was first calculated with SPSS. If the within subject factor was not significant, further differentiation between the exercise groups were not necessary.

The table 4.5.1 shows the within-subject factor of the different CPT values.

Tab. 4.5.1: Tests of within subject factor (*p<0.05)

Value	Within subj. factor sig
Omission	0.155
Commission	0.303
Hit RT	0.027*
Hit RT SE	0.274
Variability	0.301
Hit block change	0.281
Hit block change SE	0.209

Only the Hit RT value showed a significant within subject factor and was therefore further evaluated. The one way ANOVA statistical analysis revealed that the Hit RT value in TCC and coordination intervention were significantly different from meditative practice (p=0.027 and p=0.039, respectively). Coordination intervention also differed significantly from bike intervention (p=0.047). No difference was found between TCC and coordination intervention (Table 4.5.2).

Tab. 4.5.2: ANOVA paired t-test for Hit Reaction Time value

Diff. exercise programs HitRT		Mean Differences (I-J)	Std. Error Difference	Sig.[a]	95% Confidence interval of the Difference	
					Lower	Upper
1	2	.499	7.978	.951	-17.278	18.276
	3	-12.159	6.490	.090	-26.620	2.302
	4	-16.928*	6.525	.027	-31.467	-2.389
2	1	-.499	7.978	.951	-18.276	17.278
	3	-12.658*	5.591	.047	-25.117	-.200
	4	-17.427*	7.360	.039	-33.827	-1.028
3	1	12.159	6.490	.090	-2.302	26.620
	2	12.658*	5.591	.047	.200	25.117
	4	-4.769	5.363	.395	-16.718	7.180
4	1	16.928*	6.525	.027	2.389	31.467
	2	17.427*	7.360	.039	1.028	33.827
	3	4.769	5.363	.395	-7.180	16.718

1:Tai Chi, 2: Coordination, 3: Bike, 4: Meditative practice

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .05 level.

5 Discussion

This chapter follows the hypothesis described earlier. Chapter 5.1 is about TCC exercise and its influence on cognition. Chapter 5.2 discusses whether TCC experience influences the outcome on attention. Chapters 5.3 to 5.5 discuss the different modes of exercises and their influence on attention.

5.1 Hypothesis 1: An acute bout of TCC exercise facilitates cognitive abilities (attention) in older adults

This research focused on attention and TCC in comparison to other exercise modes. In the past, a positive relationship between cognitive functions and TCC was found (e.g. Taylor-Piliae et al., 2010). This study was a randomized clinical trial with two training groups (Tai Chi and Western exercise program), which lasted 12 months and one control group, which consisted of a six months health class. Taylor-Piliae et al. (2010) could show that TCC participants significantly improved in the Backward Digit Span test. They interpreted their finding as an improvement of attention, concentration, and mental tracking, whereas the other training group did not show any significant changes in cognitive functions. They concluded that because TCC is a special form of body and mind training and concentration, it has a significant effect on cognitive functions. We assumed in accordance with Taylor-Piliae et al. (2010) that an acute practice of TCC would have an effect on attention as well. Our results show an improvement of detectability, which is a measurement for attentiveness, after all exercise programs, but only the increase after TCC practice was significant (p=0.01). This shows that participant could better discriminate between target and non-target, also shown in the decrease of commission and omission mistakes. Therefore, practitioners were more attentive after an acute bout of TCC.

Additionally, commission mistakes, which are a marker for inhibition, showed a tendency (p = 0.06) for improvement after TCC practice, it missed significance level marginally. Hillman, Snook and Jerome (2003) as well as Hillman et al. (2009) found an improvement of inhibition after an acute bout of treadmill walking. In both tests the Eriksen Flanker task was used to assess inhibition in young adults (Hillman, Snook and Jerome, 2003) and in children (Hillman et al., 2009). These findings were corroborated by an increase in P3 amplitude after exercise. This is a marker for enhanced attentional allocation (Hillman, Snook and Jerome, 2003) and describes the "…attentional resources devoted to a given task" (Kamijo et al., 2007 : 119). In Hillman, Snook and Jerome's (2003) study no significant change in reaction time was measured after exercise. The authors concluded that acute exercise enhanced accuracy or controlling inhibition more than reaction time. In accordance reaction time did not improve significantly after TCC practice in our study with p = 0.09. However, there is a tendency for improvement. There is a probability that TCC practice enhances similar brain regions as treadmill walking in Hillman et al. (2003 and 2009) by an increase in P3 amplitude and therefore shows a tendency for improved control of inhibition. The focus of the burden is in both, the treadmill walking and TCC, on the lower extremities and therefore might enhance similar brain regions. Since no EEG was administered, this assumption cannot be verified. However, Kamijo et al. (2004) also suggested that P3 amplitude is influenced after an acute bout of exercise. In their study, Kamijo et al. (2004) examined the P3 amplitude after different exercise modes. The amplitude did not change after a bout of low intensity exercise (HR_{mean}=84 bpm and lactate = 1.8 mmol/l), but increased significantly after medium-intensity exercise (HR_{mean}=118 bpm and lactate = 3.77

mmol/l) and decreased again after high-intensity exercise (HR_{mean} = 190 bpm and lactate = 12.10 mmol/l). In our study the mean HR during TCC performance was only 96 bpm but since our subjects were much older (M=69.4) (versus 22 to 33 years old adults), this HR represents a moderate intensity around 2mmol lactate. That might explain why the measurement for accuracy as well as reaction time showed a tendency for improvement but were not significant. It might be that the intensity was too low to show significant improvement. The average HR for the bicycle exercise session was slightly higher HR_{mean} = 104 bpm and the commission mistakes showed a significant improvement after exercise $p = 0.031$.

Since there was a tendency towards better RT it might be the small sample size of TCC practitioners why significance level was missed. Kwok, Hui-Chan and Tsang (2010) for example could show that older TCC practitioners had a faster reaction time than the control group. The explanation, why an acute bout of TCC in our study just showed a tendency but missed significant level, might be that TCC practitioners already start off with a better reaction time ability baseline. So it might be that this effect is not so vivid after an acute session of TCC, but can be measured in a TCC intervention study.

5.2 Hypothesis 2: Experienced TCC master have better cognitive abilities (attention) after an acute bout of TCC exercise than beginners

The Hit Block Change SE showed a significant (p=0.005) group effect between short-term practitioners (two years of experience) and long-term practitioners (more than five years). It showed that the participant did not lose vigilance as the test progressed. All of the other attention measurements showed no group effect. This might due to the fact that the chosen subjects practiced TCC for at least two years and were familiar with the movements. It might be that the facilitating effect of TCC in the other measurements takes place in an earlier phase of movement acquisition. It might be that just the first months of learning new or unknown movements facilitate attentiveness. Budde et al. (2008) for example showed that an acute bout of coordinative exercise could enhance attention and concentration, measured with the d2-test (Test of attention from Brickenkamp and Zillmer, 1998), more than a non-specific physical education lesson. In the coordination session different bilateral coordinative abilities with different difficulties were stressed. They "hypothesized that coordinative exercise would lead to a general pre-activation of cognitive-related neuronal networks…" (Budde et al. 2008 : 220). Since TCC also includes bilateral coordination abilities, which need most attention during motor skill learning, but become automatic movements after practicing for a long time, it is possible that TCC when practiced as a novice would have similar effects on attention and concentration as a coordinative demanding exercise session. Since our beginner practitioners practiced TCC for at least two years there was no difference found between the two different groups in the other measurements.

Additionally, aerobic chronic exercise leads to an up regulating of growth factors like for example the brain-derived neurotrophic factors BDNF, which is important for the survival of dendrites and for the synaptic plasticity in the brain (Ploughman, 2008). BDNF is also a mediator for neurogenesis after exercise (Churchill et al., 2002). All of these exercise-induced changes in the brain are long term changes and do not refer to an acute bout of exercise. However, since our participants all were engaged in TCC practice twice to three times a week for 60 to 90 minutes for two years or more, positive long term changes in the brain are possible; considering the fact that TCC practice is a moderate to low- intensity, bilateral demanding exercise. Therefore, our participants' cognitive functions might already be elevated in comparison to sedentary elderly, so that the effect of an acute bout of TCC is not so immanent.

5.3 Hypothesis 3: An acute bout of bicycle ergometer training improves attention differently from TCC

After a 30 min bicycle exercise, the commission mistakes decreased significantly (p=0.031) in our subjects. Commission mistakes are a marker for inhibition and together with Hit reaction time, a marker for attentiveness. In accordance with our results Hillman, Snook and Jerome (2003) as well as Hillman et al. (2009) found an improvement of inhibition after an acute bout of treadmill walking (see 5.1). One explanation for this improvement could be the sympathoadrenal system, which is activated during exercise. This activation results in an increase of Dopamine, which can also enhance cognition (McMorris et al., 2008). Reaction time did not improve significantly after the acute bout of ergometer exercise (p=0.59), although former research showed that an acute bout of moderate intensity exercise can improve reaction time in older adults (Pesce et al., 2011). However, it seems that reaction time improvement is dependent on exercise intensity (at least moderate intensity) (Pesce et al., 2011, Kashihara et al., 2009 and Cordova et al., 2009). In Cordova et al. (2009) the subjects significantly improved simple response time after a moderate exercise program at the anaerobic threshold.

In this research subjects were assigned to three different exercise groups (60%, 90% and 110% of individual's anaerobic threshold). The most significant improvements in response time and executive function were administered for the group training at 90% of their anaerobic threshold.

In our research, however, participants only exercised around the aerobic threshold (2mmol lactate), so less than 90% of their anaerobic threshold. In Cordova et al. (2009), a bicycle ergometer training at only 60% of individual's anaerobic threshold resulted in no cognitive improvements. Therefore, one might argue that the low intensity around (2mmol lactate threshold) in this study might be the reason, why no improvement of reaction time was measured. However, no other values improved either. Quite on the contrary, bicycle training reduced one of the vigilance measurements, Hit block change SE (p=0.057), missing significant level only marginally. The data changed into a positive slope, which indicates "…that reaction time becomes less consistent as the test progressed…" (Conners et al., 2009:31). Additionally, variability showed a tendency towards an increasing variability after intervention (p=0.069).

5.4 Hypothesis 4: An acute coordination session improves attention differently from TCC

Although, all the exercise programs were performed within the 2mmol lactate and 4mmol lactate threshold, except for the meditative practice session being below 2mmol lactate threshold, there were no significant improvements in Hit reaction time after all exercise programs but the coordination session.

Our findings are in accordance with Pesce et al. (2011) and Budde et al. (2008), who pointed out that not only exercise intensity, but also how cognitively demanding the exercise is, have an influence on cognitive function. In contrast to other exercise programs, which might focus on automatic motor movement, coordinative exercise programs have a higher motor demand and thus a higher prefrontal cortex motor activity (Serrien, Ivry and Swinnen, 2006). Voelcker-Rehagen, Godde and Staudinger (2010) also emphasized the importance of motor skills in terms of perceptual speed, executive control and working memory. Our coordination exercise consisted of balance, rhythm, eye-hand coordination, arm-leg coordination and ability to differentiate (see chapter 3.4.2). Difficulty level was progressively increased for each part of the coordination program. Since most of the movements were new to the participants, this exercise was the cognitively most challenging one. So most likely prefrontal motor cortex was more active during coordination exercise than during bicycle ergometer exercise, which is an automatic motor movement and therefore as suggested by Serrien, Ivry and Swinnen (2006) controlled by the basal ganglia. This might explain why an acute bout of coordination exercise enhanced Hit reaction time while bicycle ergometer did not, although intensity in bicycle ergometer exercise was higher (M= 104.45 bpm) than coordination exercise (M= 89.67 bpm).

Additionally to Hit reaction time, Hit SD significantly decreased after the coordination exercise program. Both measurements are a measure of inattentiveness. In other words, an acute coordinative demanding /new 30 min exercise program seemed to facilitate attentiveness. Therefore, our findings in accordance with Budde et al. (2008) would suggest that not only the exercise intensity determines the effects on cognitive functions, but also the exercise program itself. It seems that there are more complex structures involved in facilitating cognitive functioning.

The assumption arises if the coordinative demanding aspect in TCC facilitates cognitive functioning, which would be even more vivid when working with novice. This could be an interesting thought for further studies. Coordination exercise and TCC exercise for example did not significantly differ in the Hit reaction time value in the one way ANOVA analysis, whereas, the bicycle ergometer exercise as well as the meditation practice did significantly differ from the coordination exercise program.

Another aspect, which should be taken into consideration, is the fact, that the coordination session was accompanied with an instructor doing the movements together with the subjects. There might be an additional motivational aspect to mimic instructor's actions. This could have an effect on mood and motivation.

5.5 Hypothesis 5: An acute meditative practice session improves attention differently from TCC

Kuramato (2006) pointed out that "the positive effects of Tai Chi may be due solely to its relaxing, meditative aspects" (p.45). Although we cannot refute her assumption, this research showed that an acute bout of meditative practice had no effects on attention. The one way ANOVA analysis also showed that the meditative practice differed significantly from coordination and TCC exercise in the Hit reaction time value. There was a significantly better reaction time after the coordination session but not after the meditative practice. Which does not mean, that meditation, when practiced for a period of time, does not have effects on brain areas and attention, which many researches in this field show (Lou, Nowak and Kjaer, 2005, Zeidan et al., 2010, Moore, A. and Malinowski, 2009, Bushell, 2009, Raffone and Srinivasan, 2010).

Most of our practitioners (9) did not have meditative practice before and for beginners it is hard to focus for 30 minutes in a quiet sitting position. Therefore, a limitation to the study on hand was that the meditative practice used in this study was a concentrative meditational technique (Cahn and Polish, 2006), e.g. practitioners were asked to focus on their breathing or an object in front of them (bottle of water) only. Raffone and Srinivasan (2010) pointed out that during meditation brain areas are activated which are also engaged in attention (dorsolateral prefrontal cortex, visual cortex, superior frontal and intraparietal sulci) and that the strength of this activation showed an inverted u-shaped curve according to the length of mediation practice. This could be discussed in two ways: Either practitioners were not experienced enough with this form of meditative practice that areas engaged in attention were not stimulated sufficiently or that trying to keep the focus, concentrating for 30 minutes was too tiring to show immediate effects on attention. The later assumption could be explained by another study by Brefczynski-Lewis et al. (2007), where the authors find a higher activation of brain regions referred to attention for the novice meditation practitioners than for the long term Buddhist practitioners. Therefore, they might be tired after this kind of practice. They also state that meditation training (the long time practitioners) can decrease the attentional resources needed for a task, hence being more efficient. This is in accordance with a study from Slagter et al. 2007. It might be the nature of the concentrative technique that made participants be less attentive after this practice. Instead of using this mediation technique we could have asked subjects to do a mental training. Mental training is a training of the mind, visualizing movements, instead of practicing them physically. For the TCC practitioners this would have meant, visualizing the TCC routine, while sitting on a chair. This kind of meditative practice would have been closer to the purpose, representing the meditative or mindful state practitioners experience during their TCC practice, than the concentrative meditational technique. Another limitation is, that no measurements (eg. EEG) were used to control the subject's meditative practice. The decreasing heart rates are the only prove for practitioner's relaxed state. Additionally, whether the relaxing state of the mind enhances attention, might only be vivid after practicing for a certain time. In Zeidan et al. (2010) for example, meditators meditated 4 days for 20 minutes and showed positive effects on attention and mood.

6 Conclusion

In conclusion our research showed that an acute bout of TCC had a positive influence on inhibition (commission mistakes) and inattention values (detectability and Hit RT). Although significant level was only reached for the detectability value, the other values showed a tendency, which might due to the small sample size. Additionally, vigilance values were better the longer practitioners practiced TCC. The meditative practice on the other hand showed no effects, the other exercise programs different effects. An acute coordination program for example could improve reaction time (Hit RT and Hit RT SD) significantly. The bicycle program on the other hand could improve inhibition (commission mistakes) but not inattention (Variability) values, which became worse. It seems that an acute bout of TCC as a special form of mindful exercise can enhance attention in different ways than other exercise programs. Although there were some similarities between the bicycle program –in both commission mistakes improved- and coordination program –Hit RT improved-, TCC showed a tendency for improvement in both factors and significantly improved attentiveness (detectability), which together with the commission mistakes is a marker for inhibition. To sum up, it seems that TCC is a special kind of exercise, which positively influences attention. From our study these positive effects did not solemnly rely on cardiovascular, meditative or coordinative factors.

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Appendix

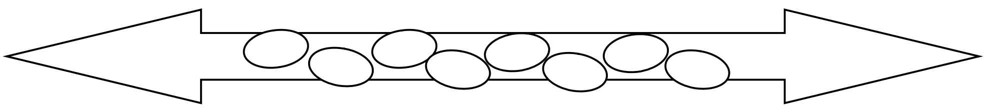
Coordination program

Static balance: Yoga stance

http://jessicalynnclark.blogspot.com/2010/03/yoga-poses.html

Dynamic balance

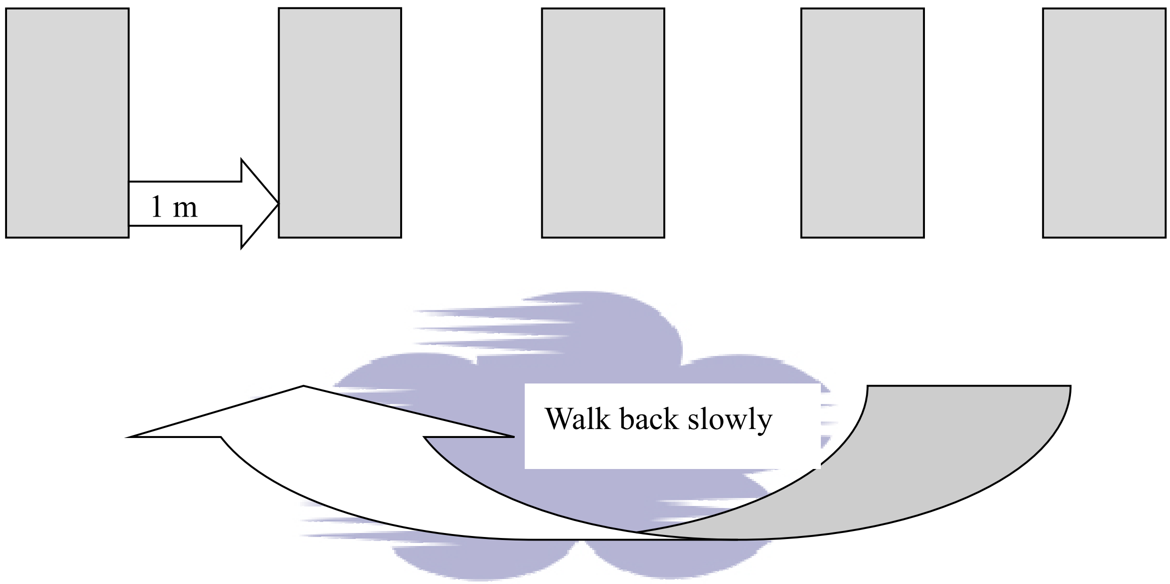
Go 10 steps forwards and backwards on a line



Rhythmical movements

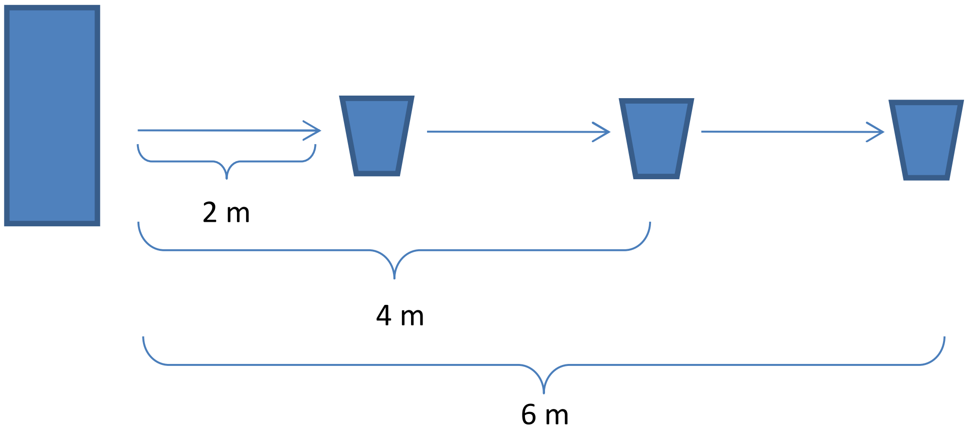
Subjects have to walk over the mat at a speed of 75 beats/min

1. One step on the mat one between
2. Two steps on the mat, one between
3. Two, two
4. Three, two
5. Three, three
6. Hands up on the mat only (do like in 5,4,3,2,1)

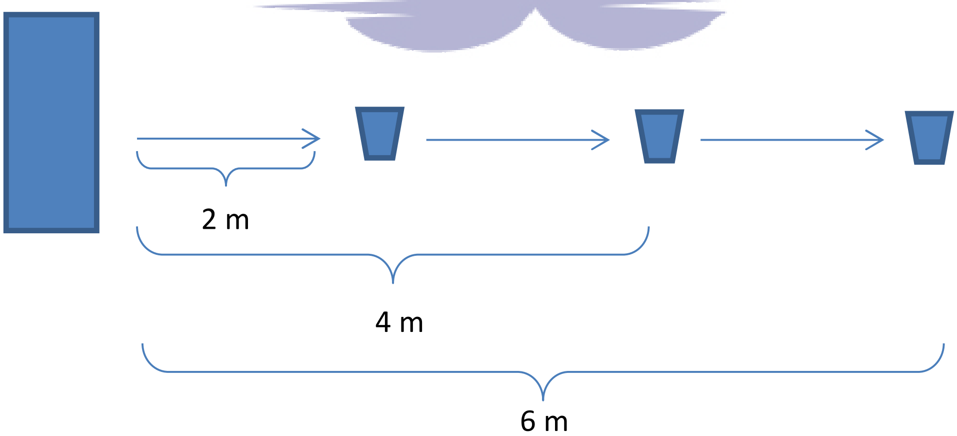


Hand-eye coordination program

Task1: Try to throw the sand bag in the first bucket (2 min) in the second (2 min) in the third (2min)



Task 2: Try to throw the sand bag in the smaller buckets



Arm-leg coordination program

1. Step to the side-right foot

2. Cross step back

3. Open

4. Feet together/clap hands

5. Open left foot

6. Cross back

7. Feet together/clap hands

8.+9. symmetric: left arm-left knee, right arm-right knee

10.+11. Asymmetric movement: right arm-left knee and vice versa

12. Walk eight steps

13. Step back-right

14. Step back-left

15. Step to the side

16. Step to the side

17. Walk 7 steps

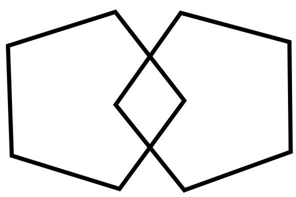
18. Jump and clap hands for the 8ths step

附件一

簡易智能狀態測驗
Mini-Mental Status Examination (MMSE)

Name: ____________ Study ID: _______________ Date: 西元______年__月__日
Chart No.: ___________ Handness: _______________ Examination: ____________

錯誤	正確	不明		
0	1	9	1)	今年是那一年？
0	1	9	2)	現在是什麼季節？
0	1	9	3)	今天是幾號？
0	1	9	4)	今天是禮拜幾？
0	1	9	5)	現在是那一個月份？
0	1	9	6)	我們現在是在那一個縣、市？
0	1	9	7)	這棟樓房/建築是做什麼用的？用途是什麼？
0	1	9	8)	這間醫院（診所）的名稱？
0	1	9	9)	現在我們是在幾樓？
0	1	9	10)	這裡是哪一科？
0	1	9	11)	樹木『牡丹』　請重複這三個名稱，按第一次複述結果計分，
0	1	9		剪刀『汽車』　最多只能重複練習三次；練習次數：________
0	1	9		火車『石頭』
	☐		12)	請從 100 開始連續減 7，一直減 7 直到我說停為止。 93______; 86_____; 79_____; 72_____; 65_____;
0	1	9	13)	樹木（三分鐘以後）
0	1	9	14)	剪刀
0	1	9	15)	火車
0	1	9	16)	（拿出手錶）這是什麼？______
0	1	9	17)	（拿出鉛筆）這是什麼？______
0	1	9	18)	“知足天地寬『心安菜根香』”
0	1	9	19)	“請閉上眼睛”
0	1	9	20)	請用左/右手（非利手）拿這張紙
0	1	9		把它折成對半
0	1	9		然後置於大腿上面
0	1	9	21)	請在紙上寫一句語意完整的句子。（含主詞動詞且語意完整的句子）
0	1	9	22)	這裡有一個圖形，請在旁邊畫出一個相同的圖形。



總分 ☐☐

（圈選 9 的部分不予計入，並說明無法施測之原因）

附件二

巴氏量表---日常生活功能量表(ADL)

項　目	分 數	內　　容
一、進食	10	☐ 自己再合理時間內(約十秒鐘吃一口)可用筷子取眼前食物。若需使用進食器具時，應會自行穿脫。
	5	☐ 需別人穿脫輔具或只會用湯匙進食。
	0	☐ 無法自行取食或耗費時間過長。
二、輪椅與床位間的移位	15	☐ 可獨力完成，包括輪椅的煞車及移開踏板。
	10	☐ 需要稍微的協助(例如：予以輕扶以保持平衡)或需要口頭指導。
	5	☐ 可自行從床坐起來，但移位時仍需別人幫忙。
	0	☐ 需別人幫忙方可坐起來或需由兩人幫忙方可移位。
三、個人衛生	5	☐ 可獨力完成洗臉、洗手、刷牙及梳頭。
	0	☐ 需要別人幫忙。
四、上廁所	10	☐ 可自行進出廁所，不會弄髒衣物，並能穿好衣服。使用便盆者，可自行清理便盆。
	5	☐ 需幫忙保持姿勢的平衡，整理衣物或使用衛生紙。使用便盆者，可自行取便盆但需仰賴他人清理。
	0	☐ 需要別人幫忙。
五、洗澡	5	☐ 可獨力完成(不論是盆浴或沐浴)。
	0	☐ 需要別人幫忙。
六、行走於平地	15	☐ 使用或不使用輔具皆可獨立行走50公尺以上。
	10	☐ 需要稍微扶持或口頭指導方向可行50公尺以上。
	5	☐ 雖然無法行走，但可獨立操縱輪椅(包括轉彎、進門及接近桌子、床沿)並可推行輪椅50公尺以上。
	0	☐ 需要別人幫忙。
七、上下樓梯	10	☐ 可自行上下樓梯(允許抓扶手、用枴杖)。
	5	☐ 需稍微幫忙或口頭指導。
	0	☐ 需要別人幫忙。
八、穿脫衣服	10	☐ 可自行穿脫衣服、鞋子及輔具。
	5	☐ 在別人幫忙下，可自行完成一半以上的動作。
	0	☐ 需要別人幫忙。
九、大便控制	10	☐ 不會失禁，並可自行使用塞劑。
	5	☐ 偶爾會失禁(每週不超過一次)或使用塞劑時需人幫忙。
	0	☐ 需要別人幫忙。
十、小便控制	10	☐ 日夜皆不會尿失禁，或自行使用並清理尿套。
	5	☐ 偶而會失禁(每週不超過一次)或尿急(無法等待便盆或無法及時趕到廁所)或需要別人幫忙處理尿套。
	0	☐ 需要別人幫忙。
總　分		

附件三

運動能力診斷與訓練調整研究中心

訓練生理與健康實驗室 疾病調查表

<table>
<tr><td>姓 名：</td><td>出生年月：</td><td>身高 (cm)：</td><td>體重 (kg)：</td><td>性別：</td></tr>
<tr><td colspan="2">週運動頻率：
運動型態：</td><td colspan="3">持續時間：
☐ 30min ☐ 40min ☐ 60min ☐ > 1h</td></tr>
</table>

請據實回答以下問題：

1. 是否有心臟疾病 ☐ 是 ☐ 否
2. 是否有血液疾病 ☐ 是 ☐ 否
3. 是否有糖尿病 ☐ 是 ☐ 否
4. 是否有高血壓 ☐ 是 ☐ 否
5. 是否有氣喘疾病 ☐ 是 ☐ 否
6. 是否有癲癇症 ☐ 是 ☐ 否
7. 是否有肌肉疼痛 ☐ 是 ☐ 否
8. 是否有感冒症狀 ☐ 是 ☐ 否
9. 最近六個月是否有開刀手術 ☐ 是 ☐ 否
10. 其他：

1)________________

2)________________

3)________________

4)________________

簽名：________________ 日期：_____________

www.spdi.idv.tw

附件四

高齡者運動問卷

姓名________________　　　　　　　　出生年月日)____________

1. **家庭狀態(Family):**　　　　　　**生活狀態(Household): 現在我生活**

□ 單身　　　　　　□與雙親同住
□ 結婚　　　　　　□ 獨居
□ 離婚　　　　　　□ 與室友同居
□ (另一伴過世)　　□ 夫妻同住
　　　　　　　　　□ 與小孩同住

2. **教育(Education)**

□ 國中　　□職業學校　　□高中畢業
□大學畢業　　□ 研究所以上　　□ 其他 _____________

職業(Job)

□目前還有上班(工作)　　□ 退休
□職員　　□ 勞工　　□自有公司

工作領域

□ 自然科學　　□營養、家政　　□ 紡織、服飾、美容
□ 土木建築　　□ 工業、技術　　□ 五金、化學
□ 貿易經濟　　□ 教育、健康、社工產業　　□ 保全、司法人員
□ 出版業、藝術、哲學　　□ 行政、交通、旅遊　　□ 其他____________

3. **健康問題**

您是否有以下健康問題:

□ 心血管循環問　　□ 下肢關節疼痛、退化性關節炎(膝蓋、腳踝)

□ 帕金斯症　　□ 癲癇　　□ 中風
□ 阿茲海默症　　□ 憂鬱症　　□ 精神病
□ 神經系統疾病　　□ 其他有哪些 _________________________

經常使用的藥品

□ 降血壓藥　　□ 阿斯匹靈　　□ 安眠藥
□ 抗憂鬱症藥　　□ 消炎藥　　□ 阿茲海默症藥
□ 營養品　　□ 中藥(保養)　　□ 其他_____________

4. 生活習慣

我多經常閱讀報紙或看書	□ 每天	□ 每週少於 1 次
	□ 每週 3 次以上	□ 從不看報
	□ 每週 1~2 次	
經常的休閒活動 (每週至少 1 次)	□ 下棋	□ 圍棋
	□ 填字遊戲	□ 麻將
		□ 其他____________
是否有吸煙	□ 無	
	□ 有, 每日___支	
喝酒習慣	□ 每日	□ 每週 1-2 次
	□ 每週 3 次以上	□ 每週少於 1 次
喝酒的種類	□ 啤酒	□ 紅、白酒
	□ 罐 (□ 0,331 / □ 0,51)	□ 杯(0.25l)
	□ 藥酒(保利達)	□ 其他
	□ 杯(0.25l)	____________________

睡眠習慣(sleep)

平均每日睡眠時間	□ 超過 8 小時(more than 8 hours)
	□ 6~8 小時
	□ 少於 6 小時(less than 6 hours)
每日起床後的狀態	□ 總是有睡飽
	□ 大多時候有睡飽
	□ 有時候有睡飽
	□ 經常沒睡飽
	□ 總是沒有睡飽
您覺得您的睡覺品質如何? (sleeping quality)	□ 很好
	□ 好
	□ 普通
	□ 不怎麼好
	□ 差

5. 運動習慣 (Exercise habits)	您練太極拳有多久的時間了 ______	
	(您每週練習太極拳幾次?	
	□ 每週 1 次	
	□ 每週 2~3 次	
	□ 每週 3 次以上	
	每一次練習的時間	
	□ 30 分鐘	□ 60~90 分鐘
	□ 30~60 分鐘	□ 多於 90 分鐘
您除了練太極拳外，是否還有其他運動(	□ 是	
	□ 沒有	

	哪些運動，以及每週運動的頻率 □ 舞蹈 每週_______ 次 □ 體操 每週_______ 次 □ 游泳 每週_______ 次 □ 健走 每週_______ 次 □ 慢跑 每週_______ 次 □ 騎自行車 每週_______ 次 □ 健身房 每週_______ 次 □ 瑜珈 每週_______ 次 □ 其他 _____________ 每週_______ 次
您位打坐(靜坐) (Meditation experience?)	□ 會 □ 不會 何種靜坐方式? □ 動態形式 □ 靜態(坐姿) 您學靜坐有多久時間了_____ 平均每次靜坐多久時間?______分鐘
您平常會練氣功嗎? (Experience with Qi Gong?)	□ 會 □ 不會 您平均練一次氣功多久時間?_____分鐘 您練習的是哪一種形式的氣功?__________________ 您學這氣功已有多久的時間了?________________月
您騎過腳踏車嗎?	□ 有 □ 沒有

Well-being questionnaire prior to physical activity

自覺量表

NO__ _　　　　　　　　Date_________

目前我覺得自己身體狀態如何...	完全沒有				非常
	1	2	3	4	5
充分休息過了			✓		
舒適的					✓
高興的					✓
清醒的					✓
無力的	✓ 5				
放鬆					✓
緊張	✓ 5				

TCC_____　Coordination_____　Meditation_____　bike ✓

附件六

運動努力知覺量表 (RPE)

Borg-RPE-Scale

Borg-RPE-Scale	感覺判斷
6	完全沒有費力感覺
7	
8	
9	非常輕鬆
10	
11	輕鬆
12	
13	輕微費力
14	
15	中度費力
16	
17	費力 (重)
18	
19	非常費力
20	最大負荷

RPE = ratings of perceived exertion

Gunnar Borg (1962): Physical performance and perceived exertion. Schweden

Tests of within subject factor Omission mistakes

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
Omval	Sphärizität angenommen	42.068	3	14.023	2.144	.115
	Greenhouse-Geisser	42.068	2.089	20.135	2.144	.141
	Huynh-Feldt	42.068	2.652	15.861	2.144	.124
	Untergrenze	42.068	1.000	42.068	2.144	.174
Fehler(Omval)	Sphärizität angenommen	196.182	30	6.539		
	Greenhouse-Geisser	196.182	20.893	9.390		
	Huynh-Feldt	196.182	26.523	7.397		
	Untergrenze	196.182	10.000	19.618		

Tests of within subject factor Commission mistakes

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
Comval	Sphärizität angenommen	30.364	3	10.121	1.270	.303
	Greenhouse-Geisser	30.364	1.836	16.541	1.270	.302
	Huynh-Feldt	30.364	2.228	13.627	1.270	.303
	Untergrenze	30.364	1.000	30.364	1.270	.286
Fehler(Comval)	Sphärizität angenommen	239.136	30	7.971		
	Greenhouse-Geisser	239.136	18.356	13.027		
	Huynh-Feldt	239.136	22.282	10.732		
	Untergrenze	239.136	10.000	23.914		

Tests of within subject factor Hit RT

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	* Sig.
HiTRTval	Sphärizität angenommen	2533.684	3	844.561	3.509	.027
	Greenhouse-Geisser	2533.684	2.543	996.512	3.509	.036
	Huynh-Feldt	2533.684	3.000	844.561	3.509	.027
	Untergrenze	2533.684	1.000	2533.684	3.509	.091
Fehler(HiTRTval	Sphärizität angenommen	7220.138	30	240.671		
	Greenhouse-Geisser	7220.138	25.426	283.972		
	Huynh-Feldt	7220.138	30.000	240.671		
	Untergrenze	7220.138	10.000	722.014		

Tests of within subject factor Hit RT SD

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
HitRTSD	Sphärizität angenommen	1.828	3	.609	1.358	.274
	Greenhouse-Geisser	1.828	2.622	.697	1.358	.277
	Huynh-Feldt	1.828	3.000	.609	1.358	.274
	Untergrenze	1.828	1.000	1.828	1.358	.271
Fehler(Hit RTSD)	Sphärizität angenommen	13.457	30	.449		
	Greenhouse-Geisser	13.457	26.221	.513		
	Huynh-Feldt	13.457	30.000	.449		
	Untergrenze	13.457	10.000	1.346		

Tests of within subject factor Variability

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
Variablval	Sphärizität angenommen	18.321	3	6.107	1.274	.301
	Greenhouse-Geisser	18.321	2.428	7.545	1.274	.302
	Huynh-Feldt	18.321	3.000	6.107	1.274	.301
	Untergrenze	18.321	1.000	18.321	1.274	.285
Fehler(Variablval)	Sphärizität angenommen	143.751	30	4.792		
	Greenhouse-Geisser	143.751	24.281	5.920		
	Huynh-Feldt	143.751	30.000	4.792		
	Untergrenze	143.751	10.000	14.375		

Tests of within subject factor Hit block change

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
Hitblch	Sphärizität angenommen	.001	3	.000	1.338	.281
	Greenhouse-Geisser	.001	2.497	.001	1.338	.284
	Huynh-Feldt	.001	3.000	.000	1.338	.281
	Untergrenze	.001	1.000	.001	1.338	.274
Fehler(Hitblch)	Sphärizität angenommen	.011	30	.000		
	Greenhouse-Geisser	.011	24.973	.000		
	Huynh-Feldt	.011	30.000	.000		
	Untergrenze	.011	10.000	.001		

Tests of within subject factor Hit block change SE

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
HitblchSE	Sphärizität angenommen	.014	3	.005	1.606	.209
	Greenhouse-Geisser	.014	2.523	.006	1.606	.217
	Huynh-Feldt	.014	3.000	.005	1.606	.209
	Untergrenze	.014	1.000	.014	1.606	.234
Fehler(HitblchSE)	Sphärizität angenommen	.090	30	.003		
	Greenhouse-Geisser	.090	25.226	.004		
	Huynh-Feldt	.090	30.000	.003		
	Untergrenze	.090	10.000	.009		

Tests of within subject factor Detectability

Quelle		Quadratsumme vom Typ III	df	Mittel der Quadrate	F	Sig.
Detect	Sphärizität angenommen	,255	3	,085	,721	,547
	Greenhouse-Geisser	,255	2,428	,105	,721	,522
	Huynh-Feldt	,255	3,000	,085	,721	,547
	Untergrenze	,255	1,000	,255	,721	,416
Fehler(Detect)	Sphärizität angenommen	3,544	30	,118		
	Greenhouse-Geisser	3,544	24,284	,146		
	Huynh-Feldt	3,544	30,000	,118		
	Untergrenze	3,544	10,000	,354		

Data from the CPT test: Raw values and T-scores (score of the individual to the population average)

Val = value, T1 = Pre Exercise, T2 = Post Exercise, Om = omission mistakes, Com = commission mistakes, RT = Reaction time, SE = Standard Error, Variab = variability, Detec (d‘) = detectability, bl-cha = block-change

Table 1:Bicycle data

No	Om Val T1	Om Val T2	Om T-Score T1	Om T-Score T2	Com Val T1	Com Val T2	Com T-Score T1	Com T-Score T2	Hit RT Val-T1	Hit RT Val-T2	Hit RT T-Score T1	Hit RT T-Score T2	Hit RT-SE Val-T1	Hit RT-SE Val-T2	Hit RT-SE T-Score T1	Hit RT-SE T-Score T2	Variab Val T1	Variab Val T2	Variab T-Score T1	Variab T-Score T2
1	9	17	67.58	92.18	8	6	43.71	41.22	441.00	453.43	55.79	58.47	7.02	7.86	56.57	59.69	11.92	13.4	62.10	65.38
2	0	0	39.90	39.9	4	5	38.74	40.16	373.09	390.02	39.67	43.95	3.53	3.94	37.59	40.59	4.02	5.34	31.54	39.51
3	0	0	39.90	39.9	4	4	38.74	38.74	470.20	467.51	61.97	61.42	3.54	3.23	37.67	35.1	3.79	4.21	29.90	32.85
4	0	0	39.90	39.9	5	4	39.98	38.74	473.26	473.07	62.60	62.56	4.56	5.56	44.64	50.13	4.17	10.58	32.53	58.75
5	2	1	46.03	42.97	8	6	43.99	41.22	378.27	369.14	41.00	38.65	3.26	3.58	35.40	37.98	2.79	3.85	21.26	30.33
6	10	0	70.65	39.9	10	8	46.20	43.71	331.87	331.33	28.39	28.23	3.30	2.9	35.74	32.15	3.63	3	28.65	23.31
7	1	0	42.97	39.9	5	2	39.98	36.25	415.73	412.81	50.10	49.42	3.72	3.41	39.00	36.59	4.02	3.39	31.54	26.77
8	0	1	39.90	42.97	3	2	37.49	36.25	461.45	433.78	60.16	54.2	5.07	4.71	47.59	45.53	4.72	6.53	36.07	45.18
9	0	1	39.90	42.96	5	1	39.98	35.04	475.04	474.33	62.96	62.81	6.10	5.04	52.69	47.39	3.88	4.93	30.57	37.28
10	0	0	39.90	39.9	6	2	41.22	36.25	362.99	360.42	37.03	36.34	3.03	3.17	33.34	34.62	2.55	2.81	18.70	21.42
12	1	1	42.96	42.97	0	2	33.76	36.25	397.23	393.44	45.71	44.79	2.78	3.04	31.00	33.46	2.59	2.96	19.15	22.92

No	Detect(d') Val-T1	Detect(d') Val-T2	Detect(d') T-Score-T1	Detect (d') T-Score-T2	HIT-bl-cha-T1	HIT-bl-cha-T2	HIT-bl-cha T-score-T1	HIT-bl-cha T-score-T2	Hit SE bl-cha-T1	Hit SE bl-cha-T2	HIT-SE-bl-ch T-score-T1	HIT-SE -bl-ch T-score-T2
1	0.82	1.25	46.09	37.74	0.01	-0.02	50.90	43.31	-0.07	0.00	45.10	53.80
2	1.33	1.03	36.25	42.02	0.00	0.01	49.06	49.53	0.12	0.05	67.68	59.96
3	1.32	1.48	36.35	33.34	-0.01	0.00	46.23	48.07	0.00	0.04	54.00	58.69
4	1.04	1.32	41.74	36.3	-0.02	0.02	43.06	52.73	0.02	0.14	56.03	71.03
5	0.88	1.04	44.88	41.75	-0.01	0.01	45.80	51.55	-0.01	0.08	52.43	62.94
6	0.88	0.83	44.99	45.96	0.01	0.02	51.18	52.09	0.01	-0.01	54.97	52.57
7	1.04	1.55	41.80	63.08	0.01	0.01	50.76	49.65	0.00	-0.05	53.60	47.50
8	1.35	1.56	35.84	31.79	-0.01	0.02	46.83	53.12	0.00	0.13	53.72	69.75
9	1.04	1.86	41.77	25.95	-0.01	0.01	45.03	50.39	-0.04	-0.01	48.70	52.72
10	0.93	1.56	43.97	31.82	0.04	0.02	57.57	52.28	-0.01	0.07	52.54	61.61
12	2.15	1.55	20.23	31.83	0.00	0.01	47.64	50.52	0.01	0.06	54.78	60.34

Table 2: Meditation data

No	Om Val T1	Om Val T2	Om T-Score T1	Om T-Score T2	Com Val T1	Com Val T2	Com T-Score T1	Com T-Score T2	Hit RT-Val T1	Hit RT-Val T2	Hit RT T-Score T1	Hit RT T-Score T2	Hit RT SE-Val T1	Hit RT SE-Val T2	Hit RT-SE T-Score T1	Hit RT-SE T-Score T2	Variab Val T1	Variab Val T2	Variab T-Score T1	Variab T-Score T2
1	4	8	52.20	64.50	18	21	56.14	59.87	441.58	431.89	55.92	53.78	8.09	8.47	60.50	61.75	12.41	17.07	63.22	72.18
2	1	0	42.97	39.90	5	4	39.98	38.88	380.92	383.77	41.68	42.39	3.93	3.43	40.51	36.79	5.27	3.52	39.15	27.81
3	0	0	39.90	39.90	10	10	46.20	46.20	423.82	437.12	51.96	54.94	3.98	3.89	40.88	40.29	5.05	4.24	37.92	33.06
4	1	0	42.97	39.90	5	5	39.98	39.98	504.84	496.63	68.82	67.24	4.52	5.06	44.38	47.52	3.58	5.76	28.28	41.62
5	6	4	58.35	52.20	15	15	52.41	52.41	373.88	360.52	39.88	36.37	5.70	3.76	50.81	39.30	10.59	4.99	58.75	37.62
6	0	0	39.90	39.90	11	10	47.44	46.20	343.32	352.46	31.66	34.19	3.30	3.28	35.73	35.55	3.88	2.95	30.54	22.82
7	0	0	39.90	39.90	3	2	37.49	36.32	403.63	411.33	47.26	49.08	3.24	2.90	35.18	32.11	2.50	2.76	18.13	20.93
8	0	0	39.90	39.90	3	7	37.60	42.47	431.36	423.42	53.66	51.87	4.87	4.69	46.49	45.41	4.87	4.32	46.49	33.58
9	0	0	39.90	39.90	10	6	46.20	41.22	382.63	415.08	42.11	49.95	5.32	5.78	48.88	51.18	3.73	2.97	29.44	23.04
10	0	0	39.90	39.90	5	1	39.98	35.01	394.69	380.32	45.10	41.52	3.08	2.76	33.85	30.82	2.55	2.19	18.70	14.47
12	1	8	42.97	64.50	5	7	39.98	42.47	365.44	385.18	37.68	42.75	3.69	3.85	38.78	39.96	3.83	3.81	30.14	30.04
11	12	14	76.80	82.95	32	30	73.55	71.06	272.49	268.36	9.39	7.91	3.98	4.16	40.88	42.11	3.77	5.36	29.76	39.61

No	Detect(d') Val-T1	Detect(d') Val-T2	Detect(d') T-Score-T1	Detect (d') T-Score-T2	HIT bl-cha-T1	HIT bl-cha-T2	HIT bl-cha T-score-T1	HIT bl-cha T-score-T2	Hit SE bl-cha-T1	Hit SE bl cha-T2	HIT-SE bl-ch T-score-T1	HIT-SE bl-ch T-score-T2
1	0.34	0.18	55.32	58.53	-0.01	-0.01	45.45	46.49	-0.04	0.03	48.89	57.63
2	1.33	1.48	36.19	33.30	0.00	-0.02	49.21	44.20	0.09	0.01	64.16	54.37
3	0.70	0.77	48.35	46.97	-0.01	0.01	45.29	50.68	0.06	0.06	61.33	60.79
4	1.44	1.17	33.97	39.30	0.01	0.00	51.13	47.11	0.06	0.11	60.78	66.43
5	0.70	0.56	48.48	51.09	-0.01	0.01	46.80	51.42	0.05	0.05	59.18	60.16
6	0.79	0.97	46.72	43.19	-0.02	0.02	44.58	51.82	0.04	0.00	58.57	53.23
7	1.34	1.80	36.02	27.12	0.01	0.00	51.58	47.88	-0.05	0.03	47.48	57.60
8	1.52	0.93	32.56	43.95	-0.01	0.01	45.96	49.77	-0.02	0.01	50.99	55.10
9	0.71	1.14	48.24	39.94	0.01	0.02	50.73	52.33	-0.02	-0.03	51.37	49.57
10	1.04	1.87	41.71	25.63	0.02	-0.02	52.31	44.45	0.06	0.00	61.08	53.80
12	1.17	1.10	39.24	40.63	0.01	0.01	51.19	51.70	0.04	-0.02	58.09	50.77
11	-0.02	-0.20	62.44	65.95	0.01	0.02	51.61	53.83	0.02	0.12	56.39	68.50

Table 3: Tai Chi Chuan data

No	Om Val T1	Om Val T2	Om T-Score T1	Om T-Score T2	Com Val T1	Com Val T2	Com T-Score T1	Com T-Score T2	Hit RT Val-T1	Hit RT Val-T2	Hit RT T-Score T1	Hit RT T-Score T2	Hit RT SE-Val T1	Hit RT SE-Val T2	Hit RT-SE T-Score T1	Hit RT-SE T-Score T2	Variab Val-T1	Variab Val-T2	Variab T-Score T1	Variab T-Score T2
1	1	1	42.97	42.97	4	7	38.74	42.47	420.64	413.51	51.24	49.59	6.12	6.45	52.79	54.23	9.81	11.79	56.62	61.79
2	0	1	39.90	42.97	13	8	49.93	43.71	393.27	363.75	44.75	37.23	3.81	4.02	39.69	41.17	4.07	6.84	31.86	46.46
3	0	0	39.90	39.90	4	1	38.74	35.01	456.66	439.42	59.15	55.45	3.32	3.85	35.87	39.96	5.67	6.86	41.18	46.57
4	6	0	58.35	39.90	11	5	47.44	39.98	414.34	429.46	49.78	53.24	6.41	5.74	54.07	51.01	6.12	9.66	43.34	56.17
5	1	1	42.97	42.97	7	9	42.47	44.95	375.40	360.44	40.27	36.35	3.33	3.38	35.94	36.36	2.72	3.69	20.53	29.12
6	0	0	39.90	39.90	9	11	44.95	47.44	324.05	328.00	26.09	27.26	3.04	3.30	33.45	35.74	3.10	1.84	24.19	9.59
7	0	0	39.90	39.90	6	4	41.44	38.74	424.32	382.93	52.08	42.18	4.13	3.79	41.93	39.51	2.85	4.55	21.86	35.04
8	0	1	39.90	42.96	6	3	41.44	37.60	507.48	461.92	69.33	60.26	8.28	5.66	61.14	50.62	16.19	8.33	70.70	52.02
9	1	0	42.97	39.90	0	0	33.76	33.76	470.26	470.53	61.98	62.04	4.76	4.25	45.81	42.71	4.05	5.75	31.73	41.59
10	1	1	42.97	42.97	10	7	46.20	42.47	375.68	341.25	40.34	31.08	3.76	3.16	39.33	34.51	5.67	2.89	41.18	22.21
12	3	1	49.12	42.97	16	6	53.66	41.22	361.59	377.88	36.65	40.90	4.82	4.17	46.21	42.17	3.22	4.78	25.26	36.40
11	6	0	58.29	39.90	11	11	47.83	47.83	368.69	389.33	38.53	43.78	3.71	3.35	38.96	36.12	2.89	4.44	22.29	34.31

No	Detect(d') Val-T1	Detect(d') Val-T2	Detect(d') T-Score-T1	Detect(d') T-Score-T2	HIT bl-cha T1	HIT bl-cha T2	HIT bl-cha T-score-T1	HIT bl-cha T-score-T2	Hit SE bl-cha-T1	Hit SE bl cha-T2	HIT-SE bl-ch T-score-T1	HIT-SE bl-ch T-score-T2
1	1.18	0.93	39.00	44.00	0.00	0.00	48.27	48.27	-0.10	-0.10	41.54	41.54
2	0.61	0.83	50.12	45.97	0.00	0.01	48.31	50.20	0.02	-0.06	56.30	46.37
3	1.32	2.11	36.31	21.15	0.01	0.00	50.94	47.64	0.02	0.08	56.43	63.53
4	0.75	1.17	47.47	39.25	0.06	0.03	61.43	54.51	0.00	0.09	53.29	64.81
5	0.93	0.99	43.98	42.77	-0.01	0.00	46.40	49.15	-0.04	0.03	48.38	57.40
6	0.81	0.71	46.34	48.18	0.00	0.01	49.14	51.54	-0.04	-0.04	48.88	48.30
7	0.90	1.32	44.46	36.34	0.01	0.00	50.62	47.41	-0.03	0.02	49.48	56.06
8	1.02	1.76	42.13	27.76	0.03	0.01	54.80	50.54	0.06	0.12	60.47	67.83
9	2.15	2.16	20.24	20.13	0.00	0.02	48.21	52.98	-0.04	0.06	48.26	60.51
10	0.80	1.01	46.48	42.37	0.02	0.01	52.54	49.92	0.13	0.04	69.74	57.90
12	0.54	1.04	51.60	41.74	0.03	0.01	55.16	51.32	0.03	-0.03	57.01	49.42
11	0.58	0.68	50.75	48.78	0.02	0.01	53.41	49.81	-0.02	0.06	50.77	60.28

Table 4: Coordination data

No	Om Val T1	Om Val T2	Om T-Score T1	Om T-Score T2	Com Val T1	Com Val T2	Com T-Score T1	Com T-Score T2	Hit RT Val-T1	Hit RT Val-T2	Hit RT T-Score T1	Hit RT T-Score T2	Hit RT SE-Val T1	Hit RT SE-Val T2	Hit RT-SE T-Score T1	Hit RT-SE T-Score T2	Variab Val-T1	Variab Val-T2	Variab T-Score T1	Variab T-Score T2
1	6	3	58.35	49.12	4	5	38.74	39.98	462.82	446.59	60.45	57.01	6.91	6.56	56.11	54.68	11.16	10.56	60.24	58.68
2	0	1	39.90	42.96	9	9	44.95	45.27	364.98	363.32	37.55	37.11	3.71	3.53	38.96	37.60	4.41	3.82	34.11	30.10
3	3	0	49.10	39.90	18	11	56.78	47.44	402.28	418.28	46.93	50.69	4.99	4.16	47.16	42.15	5.75	5.46	41.59	40.14
4	0	0	39.90	39.90	1	1	35.04	35.01	461.10	444.84	60.09	56.63	4.44	3.22	43.93	35.01	3.82	3.17	30.12	24.83
5	0	3	39.90	49.12	11	12	47.44	48.68	364.80	348.02	37.51	32.97	3.39	3.22	36.50	35.02	3.31	3.09	26.08	24.11
6	42	0	169.06	39.90	12	13	48.68	49.93	332.73	322.73	28.64	25.69	3.43	3.31	36.75	35.76	3.34	4.65	26.29	35.61
7	0	0	39.90	39.90	5	5	39.98	40.16	416.21	404.52	50.21	47.47	5.23	4.20	48.44	42.40	4.95	3.08	37.40	24.08
8	0	0	39.90	39.90	2	2	36.25	36.25	500.69	456.50	68.03	59.12	5.20	4.86	48.25	46.38	4.67	3.94	35.76	30.98
9	4	0	52.20	39.90	8	9	43.71	45.27	471.06	419.98	62.15	51.09	5.84	5.37	51.47	49.16	4.87	3.28	36.94	25.78
10	0	0	39.90	39.90	8	5	43.99	39.98	388.03	370.57	43.46	39.02	3.03	2.85	33.32	31.70	2.52	2.70	18.44	20.38
12	0	0	39.90	39.90	1	2	35.01	36.25	382.06	391.32	41.96	44.27	3.36	2.86	36.24	31.72	3.63	3.77	28.68	29.74
11	13	6	79.88	58.35	32	26	73.55	66.09	285.89	289.66	14.01	15.28	6.57	4.49	54.73	44.22	15.22	4.16	68.96	32.51

No	Detect(d') Val-T1	Detect(d') Val-T2	Detect(d') T-Score-T1	Detect (d') T-Score-T2	HIT bl-cha-T1	HIT bl-cha-T2	HIT bl-cha T-score-T1	HIT bl-cha T-score-T2	Hit SE bl-cha-T1	Hit SE bl cha T2	HIT-SE bl-ch T-score-T1	HIT-SE bl-ch T-score-T2
1	1.34	1.61	35.96	30.74	0.00	-0.01	47.37	46.90	0.04	-0.10	58.02	40.83
2	0.88	0.71	44.91	48.22	0.01	0.00	49.83	48.93	-0.03	0.01	49.90	54.92
3	0.23	1.03	57.47	41.93	0.03	0.01	55.73	51.17	0.02	0.05	55.35	59.10
4	1.86	1.87	25.82	25.67	0.00	0.01	47.46	49.75	0.00	-0.01	53.74	51.80
5	0.61	0.76	50.12	47.16	0.03	0.01	54.90	49.85	-0.04	0.02	49.18	55.95
6	0.66	0.76	49.18	47.27	0.03	0.01	56.34	51.49	0.12	0.06	67.55	60.64
7	1.04	1.16	41.75	39.51	-0.01	-0.02	46.93	43.16	-0.07	-0.05	45.45	47.41
8	1.87	1.56	25.67	31.80	0.00	0.01	49.14	50.83	-0.03	0.02	49.25	55.40
9	0.82	0.80	46.08	46.48	0.01	0.00	51.31	48.96	0.02	0.03	56.14	56.90
10	0.80	1.17	46.41	39.22	-0.01	0.00	44.91	47.67	0.01	0.01	54.35	54.31
12	1.88	1.81	25.59	26.78	0.00	0.02	49.36	51.93	-0.01	-0.02	51.94	51.53
11	0.02	0.33	61.52	55.51	0.00	0.02	47.37	53.78	-0.12	0.05	38.63	59.85