THE EFFECTS OF SOUND-COGNITIVE TRAINING INTERVENTION TO THE SENSORY GATING ABILITIES AND WORKING MEMORY SKILL IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDERS SYMPTOMS

BY

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A thesis submitted in fulfilment of the requirement for the degree of Doctor of Philosophy in Health Sciences

Kulliyyah of Allied Health Sciences
International Islamic University Malaysia

OCTOBER 2020

ABSTRACT

Attention Deficit Hyperactivity Disorder (ADHD) is characterized by the inability of the brain to focus and to filter irrelevant stimuli, affecting working memory and sensory gating functions. To date, medication is prescribed to control ADHD symptoms, however, the prolonged use of these medications has shown some adverse effects for individuals with ADHD. Alternatively, two non-pharmacological approaches have been proposed to help reduce ADHD symptoms, which are sound therapy interventions and systematic working memory trainings. Despite the potential use of white noise in sound therapy to reduce ADHD symptoms, it has poor melody harmonization, thus preventing children with ADHD features from participating in long training sessions. To address this issue, the present study investigated the possible use of a combination of working memory trainings and sound therapy using various sounds, including white noise, waterfall, and Quranic recitation. The present study aimed to examine the effect of sound-working memory training intervention on sensory gating, working memory, and severity of ADHD symptoms in children with ADHD features in Kuantan, Pahang. The study was conducted in three phases. In Phase 1, the Swanson, Nolan and Pelham Teachers and Parents Rating Scale of ADHD symptoms (SNAP-IV) were cross-culturally translated into Malay (M-SNAP-IV). Additionally, the Sensory Gating Scale (SGS) was also developed. The M-SNAP-IV and the new SGS were psychometrically evaluated among 702 parents and were proven to be culturally suited and valid for use in Phases 2 (participants' selection process) and 3 (intervention). In Phase 3, 39 children aged 8 – 11 years old with ADHD symptoms participated, and these children were divided randomly into five groups [white noise + working memory training (n=8); waterfall + working memory training (n=8); *Al-Fatihah* + working memory training (n=8); working memory training alone (no sound stimulus) (n=8)], and one control group (n=7). The training groups received repetitive computerised working memory training for 4 – 5 weeks (10 – 13 sessions), while the control group did not receive any intervention. The Corsi test (untrained working memory test), M-SNAP-IV, and SGS were used as pre- and post-intervention testing. In general, some of the findings showed a significant increase in sensory gating abilities and working memory, and significant decrease of ADHD symptoms in the training groups. Furthermore, it was found that the combination of white noise and working memory training was the best method in improving working memory performance and sensory gating ability, and in reducing ADHD symptoms. The present study also found a significant high-negative correlation between SGS and M-SNAP-IV scores, indicating that the increase of SGS score (the severity of sensory gating deficits reduces) led to the decrease of the M-SNAP-IV score (the reduction of severity of ADHD symptoms). However, some of the findings were negative for SGS and M-SNAP-IV, for example, a significant improvement of M-SNAP-IV's post-intervention scores was shown in the control group, which was believed to be due to random effect. To conclude, the positive findings from the current study suggested that the sound-working memory training approach has great potential as one of the future alternative psychological and behavioural approaches for ADHD intervention.

خلاصة البحث

يتميز اضطراب نقص الانتباه مع فرط الحركة (ADHD) بعدم قدرة الدماغ على التركيز وتصفية المنبهات غير المتعلقة، مما يؤثر على الذاكرة العاملة ووظائف البوابات الحسية. يتم حتى الآن وصف بعض الأدوية للسيطرة على أعراض الADHD، ومع ذلك فقد أظهر الاستخدام المطول لهذه الأدوية بعض الآثار السلبية على الأفراد المصابين بالADHD. وبدلاً من ذلك، فقد تم اقتراح طريقتين غير دوائيتين للمساعدة في الحد من أعراض الADHD، وهما تدخلات العلاج الصوتي وتدريب الذاكرة العاملة المنتظم. على الرغم من الاستخدام الواعد للضجيج الأبيض في العلاج الصوتي لتقليل أعراض اضطراب الADHD، إلا أنه يتسم بضعف تنسيق الألحان، وبالتالي يمنع الأطفال الذين يعانون من أعراض الADHD من المشاركة في جلسات تدريبية طويلة. لمعالجة هذه المشكلة فقد بحثت الدراسة الحالية في إمكانية استخدام مزيج من تدريبات الذاكرة العاملة والعلاج الصوتي باستخدام أصوات مختلفة، مثل الضوضاء البيضاء والشلال وتلاوة القرآن. تهدف هذه الدراسة إلى فحص تأثير تدخل تدريب الذاكرة العاملة بالصوت على البوابات الحسية، والذاكرة العاملة، وشدة أعراض الADHD عند الأطفال الذين يعانون من أعراض الADHD في مدينة كوانتان بولاية باهانج. أجريت الدراسة على ثلاث مراحل: في المرحلة الأولى تمت ترجمة مقياس تصنيف سوانسون ونولان وبيلهام للمعلمين وأولياء الأمور لأعراض الADHD (SNAP-IV) تثاقفيا إلى اللغة الملايوية (M-SNAP-IV). بالإضافة إلى ذلك تم أيضا تطوير مقياس البوابات الحسية (SGS). تم تقييم مقياس M-SNAP-IV ومقياس SGS الجديد سايكومتريا بين 702 من الآباء والأمهات وتم إثبات ملاءمتهما ثقافيا والتحقق من صلاحيتها للاستخدام في المرحلتين 2 (عملية اختيار المشاركين) و 3 (التدخل). في المرحلة الثالثة شارك 39 طفلاً تتراوح أعمارهم بين 8 و 11 عامًا يعانون من أعراض الADHD، وتم تقسيم هؤلاء الأطفال بشكل عشوائي إلى خمس مجموعات [ضجيج أبيض + تدريب على الذاكرة العاملة (ن=8)؛ شلال + تدريب الذاكرة العاملة (ن=8)؛ سورة الفاتحة + تدريب الذاكرة العاملة (ن=8) ؛ تدريب الذاكرة العاملة وحده (بدون محفز صوتي) (ن=8)]، ومجموعة ضابطة واحدة (ن=7). تلقت مجموعات التدريب تدريبًا حاسوبيا متكررا على الذاكرة العاملة لمدة 4-5 أسابيع (10-13 جلسة)، بينما لم تتلقى المجموعة الضابطة أي تدخل. تم استخدام اختبار كورسي (اختبار الذاكرة العاملة غير المدربة)، ومقياس M-SNAP-IV، ومقياس SGS كفحص قبل وبعد التدخل. بشكل عام، أظهرت بعض النتائج زيادة كبيرة في قدرات البوابات الحسية والذاكرة العاملة، وانخفاض كبير في أعراض الADHD في مجموعات التدريب. علاوة على ذلك فقد وجد أن الجمع بين الضجيج الأبيض والتدريب على الذاكرة العاملة كان أفضل طريقة لتحسين أداء الذاكرة العاملة وقدرة البوابات الحسية، وفي الحد من أعراض الADHD. وجدت الدراسة الحالية أيضًا وجود علاقة ارتباطية سلبية عالية بين نقاط M-SNAP-IV و SGS، مما يشير إلى أن انخفاض نقاط M-SNAP-IV (انخفاض شدة أعراض الADHD) أدى إلى زيادة نقاط SGS (انخفاض شدة عجز البوابات الحسية). ومع ذلك فقد كانت بعض النتائج سلبية في مقياسي SGS و M-SNAP-IV، على سبيل المثال فقد تم إظهار تحسن كبير في نقاط ما بعد التدخل لمقياس M-SNAP-IV في المجموعة الضابطة، والتي يعتقد أنها بسبب التأثير العشوائي. في الختام، تشير النتائج الإيجابية للدراسة الحالية إلى أن لدى طريقة تدريب الذاكرة العاملة-الصوتي إمكانيات كبيرة باعتبارها أحد الأساليب النفسية والسلوكية البديلة المستقبلية لتدخلات الADHD.

APPROVAL PAGE

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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The thesis is dedicated to my beloved parents, husband and son for their patience, advices and faith.

"See the Begin, Feel the Shine"

ACKNOWLEDGEMENTS

In the name of Allah, the most gracious and most merciful.

First and foremost, I wish to express my deepest gratitude to the God, the Almighty, for His showers of blessings throughout my research work to accomplish this study successfully.

I wish to express my sincere gratefulness to my main supervisor, who has the substance of a genius, Assoc. Prof. Dr. Ahmad Aidil Arafat, for the incessant support for my PhD study and thesis writing, for his open-mindedness, inspiration, enthusiasm and immense knowledge even when the journey got hard and tough. Without his guidance and persistent support, this PhD study would not have been possible and would have never been accomplished.

I would also like to show gratitude to my co-supervisors, Dr. Sarah, Prof. Dr. Ramli, and Assoc. Prof. Dr. Zulfaezal, for their advice, comments and encouragement to make this study a success.

Getting through my PhD and thesis writing journey required more than academic support. Therefore, I wish to acknowledge the endless support and great love from my lovely husband, Mr. Abdullah Apandi, and my clever boy, Luqmanul Hakim, for listening to and, at times, having to tolerate me over these three and a half years.

I would like to pay my special regards to my one and only best friend, Afiqah. She kept me going on and this study would not have been possible without her inputs and constant encouragement.

Most importantly, none of this could have happened without my family support, especially from my lovely parents, Mr. Jusoh and Mrs. Mah Kelthom; thank you for supporting me spiritually and psychologically throughout my life.

Last but not the least, I would like to thank all my friends, colleagues, research participants, the parents, the teachers, and all the people whose assistance was a milestone in the completion of this study.

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LIST OF SYMBOLS

<	Smaller than
>	Larger than
%	Percent
α	alpha
=	Equal to
:	Ratio to
r	Correlation coefficient
≥	Larger or equal than
≤	Smaller or equal than
ms	milliseconds
dB	Decibels
n	Sample size
p	Significance value
η_2	Partial Eta Squared
d	Cohen's d
Hz	hertz
g	Normalized gain
X^2	Mauchly's test of sphericity
F	F-statistic (corrections)
df	Degree of Freedom

LIST OF ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
MBA	Moderate Brain Arousal
PFC	Pre-frontal Cortex
MPH	Methylphenidate
NIMH	National Institute of Mental Health
WM	Working Memory
DSM	Diagnostic and Statistical Manual of Mental Disorders
ODD	Oppositional Defiant Disorder
M-SNAP-IV	Malay version of Swanson, Nolan & Pelham – Teacher and Parent Rating scale for ADHD
SNAP-IV	Swanson, Nolan & Pelham - Teacher and Parent Rating scale for ADHD
SGS	Sensory Gating Scale
APA	American Psychiatric Association
WHO	World Health Organization
ICD-10	International Classification of Disease-system
HK	Hyperkinetic Disorders
HKD	Hyperkinetic Disorders
DA	Dopamine
CEM	Cognitive-Energetic Model
DD	Dynamic Developmental
SNR	Signal-to-Noise ratio
SPT	Self-performed tasks
VT	Verbal task
CRS-R	Conners Rating Scale-Revised
CPRS-R	Conners Parent Rating Scales-Revised
CGI	Conners' Global Indices
CTRS-R	Conners Teacher Rating Scales-Revised
CVI	Content Validity Index
I-CVI	Item level CVI
S-CVI	Overall-scale level CVI
P1	Pilot Study 1
P2	Pilot Study 2
ICC	Intra-Class Correlation Coefficient
EFA	Exploratory Factor Analysis
PCA	Principal Component Analysis
KMO	Kaiser-Meyer-Olkin
BTS	Bartlett's test of sphericity
FDA	Food and Drug Administration
EF	Executive Functions
EEG	Electroencephalography
CAEP	Cortical Auditory Evoked Potential
SGI	Sensory Gating Inventory
SIAPA	Structured Interview for Assessing Perceptual Anomalies
CPT	Continuous Performance Task
vsWM	Visuo-spatial working memory

SR	Stochastic resonance
ISI	Inter-Stimulus Interval
ANOVA	One-way analysis of Variance
RM-ANOVA	Repeated Measured ANOVA
SPSS	Statistical Package for the Social Sciences
IIUM	International Islamic University Malaysia
IREC	IIUM Research Ethics Committee
K-SADS-PL	Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime
CBCL	Child Behaviour Checklist
DISC-IV-P	Diagnostic Interview Schedule for Children – Parent version
CFA	Confirmatory Factor analysis
BM	Bahasa Malaysia
SSS	Skala Saringan Sensori
TAIS	Test of Attentional and Interpersonal Style
TAI	Trait Anxiety Inventory
PAS	Perceptual Aberration Scale
IQ	Intelligence Quotient
PEBL	Psychology Experiment Building Language
SD	Standard Deviation
SLM	Sound Level Meter
MATLAB	matrix laboratory software
LAseq	Long-term average
LAsmax	Maximum sound pressure level
TEOAEs	Transient Otoacoustic emissions
PTA	pure tone audiometry
MQF	Memory Quest Flex
PET	Positron Emission Tomography
fMRI	functional Magnetic Resonance Imaging

CHAPTER ONE

INTRODUCTION AND OVERVIEW

1.0 INTRODUCTION

This present chapter provides an overview on the background of this study, which involves three different aspects. The first aspect discusses the limitation of the pharmacological approach for the treatment of Attention Deficit Hyperactivity Disorder (ADHD). The potential solution for ADHD intervention using external sound stimulation (e.g.; white noise) through the concept of Moderate Brain Arousal (MBA) model and stochastics resonance effect is also discussed. The second aspect discusses the conventional methods of stochastic resonance phenomenon, and this is followed by the third aspect, which discusses the novelty of this PhD project and its significance. At the end of this first chapter, the structure of the thesis is covered.

1.1 BACKGROUND OF THE STUDY

1.1.1 The Limitation of Drugs Usage in ADHD Intervention

The Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common mental disorders, affecting 5% to 10% of children of the world population (Spencer, Biederman, & Mick, 2007); and 3.9% of the Malaysian population (Lai, 2014). ADHD is characterized by the inability of the brain to focus and the inability of the children to control their impulses by irrelevant stimuli. ADHD affects a lot of functions, including executive functioning (working memory and attention) (Klingberg et al., 2005) and neural inhibitory response (sensory gating) (Davies, Chang, & Gavin, 2009).

The pathophysiology of ADHD has been shown to be associated with the active release of the neurotransmitter dopamine, which is in charge of the human ability to