BRAIN AND BODY PERCUSSION; THE RELATIONSHIP BETWEEN MOTOR AND COGNITIVE FUNCTIONS

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Master's Thesis

Music Mind and Technology

Department of Music

25 September 2015

University of Jyväskylä

JYVÄSKYLÄN YLIOPISTO

Tiedekunta – Faculty Humanities	Laitos – Department Music Department
Tekijä – Author J. Riikka Ahokas	
Työn nimi – Title Brain and Body Percussion; The Relationship Between Motor and Cognitive Functions	
Oppiaine – Subject Music, Mind & Technology	Työn laji – Level Master's Thesis
Aika – Month and year August 2015	Sivumäärä – Number of pages 52

Tiivistelmä – Abstract

The focus of this thesis is the relationship between embodied motor rhythmic exercises (e.g. body percussion) and executive functions. Decades' long successful application of this method within general classrooms and in music education led to the hypothesis that body percussion could have a positive impact on core cognitive functions also referred to as *executive functions*. Two pilot experiments were conducted to test proper settings for investigating the above-mentioned relationship. Experiment 1 piloted the use of neuropsychological tests with pre- and post-measures of the Tower of London (TOL) neuropsychological test. Experiment 2 piloted the use of an electroencephalography (EEG) device with an auditory oddball paradigm.

Experiment 1 was a long-term study (2,5 months) and conducted in a regular elementary school. Participants of this study were fifth graders (average age: 11 years, n=24). Experiment 2 was EEG-laboratory pilot with one adult participant. Both experimental designs achieved encouraging results; benefits and disadvantages are discussed. TOL-results in Experiment 1 indicated positive impact on *planning skills* as the experiment group achieved better results post-training compared to the control group. Data-analysis in Experiment 2 indicated positive change in the MMN (mismatch negativity) amplitude (participant's ability to detect deviant auditory stimuli) post- (40 minute long) training.

Asiasanat – Keywords

Music education, Music and Motion, body percussion, rhythm, brain, executive functions

Säilytyspaikka – Depository	
Muita tietoja – Additional information	

To my son

Acknowledgments

The author would like to thank *Anu Penttinen* from the University of Jyväskylä's Faculty of Sport and Health Sciences for her expertise on consulting with the teaching of body percussion. The author would also like to thank *Juho Strömmer* from the University of Jyväskylä's Faculty of Social Sciences (Department of Psychology) for consulting with the neuropsychological tests. Experiment 2 would have not been executed without the help and expertise of *Jan Wikgren* from the Centre of the Interdisciplinary Brain Research (CIBR) at University of Jyväskylä, and the author is most obliged for that. During this project the guidance and consultation from *Mari Tervaniemi* (University of Helsinki and University of Jyväskylä) and *Tiina Parviainen* (University of Jyväskylä, CIBR) has been most valuable.

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1 INTRODUCTION

At the core of this thesis there rests three important aspects: movement of a human body, rhythm, and learning. These three concepts are studied in different contexts, through different theoretical frameworks. Do we need movement for learning? How important is our body in the learning process? And how important is rhythm for movement and learning?

In Finland, in the field of music education, there is a sub-subject called *Music and Motion* or *Music and Movement* (Juntunen, Perkiö & Simola-Isaksson, 2010), wherein the theoretical frameworks of Dalcroze and Orff are amongst the most popular. Within the subject of music and movement, the author has found a common ground for both typical -and differing (Special Educational Needs) populations. As rhythm is one of the most important core concepts of musical rehabilitation (e.g. Rhythmic Auditory Stimulation RAS of Neurologic Music Therapy)(Thaut, 2005), the methods that are developed for education could and should also be used in the context of rehabilitation.

Body percussion was chosen as the training method because it can be done without any extra instruments; the method only needs the participants themselves. It is suitable for small laboratory surroundings, and it can easily be moved into any preferred surroundings available.

This study aims to respond to questions regarding the connection between the action of body percussion and learning abilities / academic skills. To what extent may body percussion improve rhythm perception, attention, and cognitive executive functioning? The aforementioned was studied within the framework of *music education* (observation of possible change in rhythm production and perception abilities of participants) and by testing the executive functions with the *neuropsychological test battery*. A setting for a short-term study (with EEG –paradigm) was also executed with one participant; this experiment gave tools for further similar settings to be used in the future.

In light of the previous research regarding the relation of aerobic exercise to executive functions (Guiney & Machado, 2013; Chaddock, Pontifex, Hillman & Kramer, 2011) and the relation of motor performance to academic skills in children (Haapala, Poikkeus, Tompuri, Kukkonen-Harjula, Leppänen, Lindi & Lakka, 2013; Kujala, Krause, Sajaniemi, Silven, Jaakkola & Nyyssölä, 2012) this motor rhythmic exercise (body percussion) was expected to cause beneficial, restorative impacts on participants' executive functions. The hypothesis was that both short- and long-term settings would have positive impacts on chosen functions (planning and attention). As the subject has not been studied neuroscientifically before, this novel research approach was aimed at enriching both *practical* (e.g. by piloting short body percussion sessions as part of a school day schedule) and *research segments* (e.g. introducing a novel neuroscientific approach to study the impacts of embodied motor learning method) of music education.

For decades, music educators and elementary and secondary school teachers, have been encouraged to use rhythmic and embodied exercises to improve students' attention (Juntunen et al., 2010; Fross, 2000). This intervention has been used to improve concentration within the classroom, such as following instructions and completing tasks (Hannaford, 1996; Dennison, 2001). However, as a part of music education, body percussion is most commonly used as a tool to comprehend and learn rhythmic elements in music. In Finland, the subjects of *Music and Movement* (Musiikkiliikunta) and *Rhythmics* (Rytmiikka) use body percussion as part of a more advanced skill set; within these subjects, longer compositions are produced to be performed on stage.

Motor and cognitive functions share parallel central nervous system mechanisms (Kujala et al., 2012). The ability to move our body correlates with the most important cognitive functions (Guiney & Machado, 2013; Chaddock et al., 2011). Our motor and cognitive functions are intertwined (Haapala et al., 2013). In this study the cognitive functions needed for learning are defined as the executive functions (Streen & Strauss, 1998; Diamond 2012). *Learning abilities* are seen as the ability to execute these cognitive, executive functions. One of the motives behind this study was to support the ongoing debate regarding the importance of motor skills for cognitive functions and to underline the importance of knowledge in the capability to use one's own body.

2 LITERATURE REVIEW

2.1 BODY PERCUSSION

In Finland, under the subject music education, there is a sub-subject called Music and Movement. Body percussion is only a marginal part of the wide variety of different percussive rhythm exercises that are common for Dalcroze[1] or Orff[2]-oriented educators (teaching the subject 'Music and Movement') (Juntunen et al., 2010). The method itself can be described as a rhythmic, motoric, and a dance-like activity. Important parts of the function are attention and memory processes, as well as foot and arm coordination. Movements of various limbs of the body (slaps, taps, claps, stomps, finger snaps etc.) produce sounds with different amplitudes causing the shared rhythm (Fross, 2000).

Body percussion is a highly effective pedagogical intervention and learning support for teaching rhythmic patterns and meter. Rhythms can be accessed in echo exercises, call-and-response exercises, and these learned rhythms can be transferred into an image or note value, which are also read aloud. In this way, learning takes place on many different sensory levels. Learning a variety of musical forms (ostinato, canon, etc.) through the body is also rewarding (Juntunen et al., 2010). In instrumental studies, body-instruments prepare the student for proper instrument playing technique. Musical meter or structure could be first learned using the body and then transferred to the instrument. Dynamics, intonation and rhythmic stress can also be effectively moved from the body to the instrument. (Kivelä-Taskinen, 2008; Huttunen, 2013).

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[1] Dalcroze eurhythmics teaches concepts of rhythm, structure, and musical expression using movement. The application focuses on allowing the student to gain physical experience and awareness of music. Diverse training takes place through all of the senses, particularly kinesthetically.

[2] Orff Schulwerk combines movement, music, speech and drama into lessons that are similar to child's world of play. The approach is largely improvisational; songs contain ostinatos, are within singing range, and can be played in round, or ABA form.

From a variety of different Music and Movement exercises body percussion was chosen as the method for a few essential reasons. In addition to the abovementioned musical objectives, one of the aims of body percussion is to create more fluid connections between the limbs of the body (e.g. enhance motor abilities) (Fross, 2000; Kivelä-Taskinen, 2008). Body percussion training aims to improve the communication system between the limbs and the brain and as a result of that, also directly entrain cognitive and motor skills (Fross, 2000). Because the interest was to study the connection between motor and cognitive functions, the method retained desirable objectives for a research training method within itself.

Body percussion is literally percussion training with your body. It is embodied learning at its highest peak. Another essential, rather technical ground for choosing this method was that body percussion does not require any additional instruments than the participants themselves and therefore it can easily be moved into any desired setting (e.g. laboratory facilities or class-room environments).

Body percussion training develops individual sensitivity of the nervous system, knowledge of rhythm in relation to time and space, and individual self-expression. It also entrains auditory, visual and kinaesthetic concentration (Fross, 2000). Body percussion is typically performed in a group setting; one of the beneficial components of the action itself might be the group setting. Body percussions carried out in a group aid the development of social skills. At the same time, the students are able to express themselves with their own body and use the movements to form a picture of their own personality in relation to the rest of the group and the surrounding world. Stronger self-awareness also supports identity development (Fross, 2000).

The effectiveness of body percussion has been studied on participants with dyslexia (Colomino & Romero-Naranjo, 2014) and senile dementia (Romero-Naranjo, 2014). Publications on body percussion mainly focus on arguments related to rhythmic structures linked with coordination, and are still lacking a wide variety of other valuable disciplines like neurology, neurorehabilitation and neuropsychology. The applicability of this method should be more accessible in the domains of sports science, education and neurological, musical, and physiological therapies (Romero-Naranjo, 2013).

2.2 MUSIC AND MOVEMENT (MM)

Body percussion is a segment of a wider music education discipline called Music and Movement (MM). Although body percussion is still lacking an advanced research tradition, MM methods effectiveness has been studied quite efficiently in different theoretical domains.

Zachopoulou, Derri, Chatzopoulos and Ellinoudis (2003) studied the effects of Orff and Dalcroze activities (Music and Movement program) on rhythmic abilities with preschool children (*n*=72). Zachopoulou et al. (2003) used High/Scope Beat Competence Analysis as a measure, and concluded a significant improvement of the experimental group (*n*=34) over the control group (*n*=38). The training period lasted 10 weeks and included two sessions per week with a physical educator specialized in rhythmic instruction and in methods of Orff and Dalcroze. The control group participated in free-play activities. In their conclusions section the authors emphasized the awareness of the pleasantness of these exercises; children enjoyed participating and no special equipment was required.

Derri, Tsapakidou, Zachopoulou and Kioumourtzoglou (2001) and Zachopoulou, Tsapakidou and Derri (2004) investigated the effects of a music and movement programme with 4 to 6 year old children. Both studies concentrated on the possible impact the training might have on the motor skills of the children. In the first study by Derri et al. (2001) the control group did not have any controlled tasks; they did not participate in any organized physical activity programs while the experiment group was trained. The experimental group participated in 10-week period of music and movement programme. As a result, the experimental group had significantly greater improvement on galloping, leaping, horizontal jumping, and skipping (Test of Gross Motor Development). In Zachopoulou et al. (2004) the control group had equivalent, controlled task, as they followed the physical education programme for two months. In this study the data analysis indicated that the music and motion programme group improved significantly in jumping and dynamic balance (assessed with the test MOT (Motoriktest fuer vier-bis sechsjaehrige kinder)(4–6) compared to the control group.

The focus of the current study is on the ability of music and movement methods to enhance cognitive functions. Cheung (2012) concentrated on the method of music with movement with patients with moderate dementia. The experiment group differed significantly from the two control groups in *memory functions* (memory storage, delayed recall) and *depressive symptoms*. Cheung (2012) also found that music with movement interventions could lead to improvement in global cognition, verbal fluency, anxiety and agitated behavior. The effects lasted at least six weeks post-intervention (Cheung, 2012).

Behavioural self-regulation, also defined as inhibitory control, is one of the most important skills children develop during their childhood. *Inhibition* is also one of the core cognitive functions (also referred as *executive functions)*. This ability enables us to plan, monitor, and guide our own actions in relation with the external world. Winsler, Ducenne and Koury (2009) studied the impacts of a music and movement programme on 3 to 4 year old children (*n*=89). Forty-two of the participants were currently participating in music and movement classes and, 47 had not had structured early childhood music classes. Children were tested with self-regulation tasks, selective attention tasks, and their ability in "private speech" was also transcribed and categorized.

Children participating in the music and movement classes performed better in the tasks compared to the control group. In their report, the authors concluded that in addition to the improved motor inhibition skills and the increased use of humming and singing in self-regulation, such musical experiences most definitely have profound impacts on children's future academic career and life management.

2.3 EXECUTIVE FUNCTIONS

There is a wide and diverse body of research concentrated on the relation of musical training to *intelligence.* The possible long-term effects of musical engagement to IQ (Schellenberg, 2006), as well as the comparison with non-musical activities (Schellenberg, 2004) have gained a lot of attention.

In order to look further, beyond general intelligence Roden, Grube, Bongard, and Kreutz (2014) examined the effects of long-term (18 months) extended music education programme on *working memory performance* (core executive function) with children aged 7 to 8 years. Compared to the control group that received extended natural science training as a control task, the experiment group improved its performance significantly throughout the 18-month procedure, especially in One-syllable Word Span, Counting Span and Colour Span Backwards-tests (Roden et al., 2014).

In this study *learning abilities* are seen as abilities to execute certain cognitive functions needed in learning (Streen & Strauss, 1998; Diamond, 2012). Executive functions are a theorized neuropsychological neural system that controls and manages other cognitive processes that are crucial in learning and functioning at higher cognitive levels. These functions mature at different rates during the developmental cycle. One of the main motives behind the music and movement method body percussion is to improve executive functions (e.g. attention). The three core executive functions are *inhibition* (selective attention), *working memory* and *cognitive flexibility*. Higher-order functions, such as reasoning, problem solving and planning are built from these core functions.

The aim of Experiment 2 was to study the impact of body percussion training on executive functions with brain imaging technique electroencephalography (EEG). Working Memory (WM) and selective attention seem to share, or have an overlapping neural basis. The prefrontal- parietal system of WM overlaps the prefrontal-parietal system of attention (Diamond 2013). According to Stuss (2011), frontal lobes are tightly connected to attention.

One of the primary aims of body percussion training is to enhance motor coordination. According to Michel (2012), executive function components (working memory, timing measures of inhibition, and switching) correlate substantially with motor coordination. Children with and at risk of developmental coordination disorders have been found to show inferior performance in the domain of working memory, attention, and inhibitory skills; also, tasks that have high demands on planning, monitoring, call for continuous adaptation or sequencing, and/or have to be performed under speed or speed and accuracy instructions. Michel states in commentary to an article by Rigoli, Piek, Kane and Oosterlaan (2012) that "of particular interest are the specific association between motor coordination performance, and the timing measure (but not the accuracy measure) of the response inhibition task" (p. 971).

Physical training has been found to have positive impacts on executive functions. Diamond (2012) states that it might be so that "exercise alone may be less effective in improving children's EFs than activities that involve both exercise and character development (e.g., traditional martial arts) or activities that involve both exercise and mindfulness (e.g., yoga)" (p 3). Diamond (2012) also wanted to indicate the importance of *motivation* for the possible improvement. In the article Diamond (2012) hypothesized that the most beneficial programmes would be the ones that require and directly challenge the EFs. She suggests that the training should be something that would support the functions indirectly by reducing children's stress or improving their ability to handle stress, increasing their joy, helping them feel that they belong and that others are there for them, and improving their physical fitness.

Sportsman (2011) studied the development of musical skills and behaviors associated with executive functioning (shifting, inhibition, updating and attention). In addition to the neuropsychological and music educational objectives, the aim was also to widen the knowledge of the benefits of musical training, in this case with underprivileged children. The study provided evidence that musical training can be one tool to train executive functions that are crucial for both school and life management.

Bialystok and DePape (2009) studied the relationship between bilinguals, musical performers, and participants whom did not belong to either one of the latter groups. As the connection between bilingualism and high performance in executive functions tasks has been acknowledged before, they wanted to find out whether musical engagement and professionalism would have an impact on executive functions. Bialystok and DePape (2009) concluded that extent musical training enhances executive control, execution of nonverbal spatial tasks and that it also enhances control in specialized auditory tasks.

2.3.1 Methods of Assessment

According to Chan, Shum, Toulopoulou and Chen (2008) executive functions are sub-divided into cold and hot functions depending on the nature of the specific function. Functions that could be described logical or mechanical, such as verbal reasoning, problem-solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilization of feedback, multitasking, cognitive flexibility, and the ability to deal with novelty are referred as cold. The functions more involved with emotional content (experience of reward and punishment, regulation of one's own social behavior, and decision-making involving emotional and personal interpretation) are regarded as hot functions.

There are many tests and evaluation procedures, based on few predominant neuropsychological theories. For instance the *N-back* test wherein the participants concentrate on memorizing previous (1 or more steps back) stimuli, is based on Goldman-Rakic's working memory-model (Chan et al., 2008). Executive functions tests related to Stuss and Benson's (1986) tripartite theory are *Wisconsin Card Sorting Test* (WCST) and *Trail Making Test* (TMT). These tests assess frontal lobe-related 'cold' functions like mental task shifting (Channon, 1996). In articles by Chan et al. (2008) and Chaytor, Schmitter-Edgecombe & Burr (2006) the authors discuss the need for more extensive, naturalistic methods and measures to enable the assessment of the cognitively holistic features of executive functions. Antonio Damasio and his research group developed the *Iowa gambling task* (Bechara, Damasio, Tranel & Damasio, 2005), which assesses the 'hot' executive components involved with emotions and social behavior. Damasios theory is called the Somatic marker hypothesis.

Tower of London (TOL) test that was used in Experiment 1 is a variant of *Tower of Hanoi*- puzzle originating back to 1883 (or even earlier according to some eastern legends) (Hinz, Klavzar, Milutinovic & Petr, 2013). The theoretical frame for the TOL test is in the supervisory attentional system (SAS) model. According to this model, the regulation of human actions (both mental and physical) involve two systems, contention scheduling (allows us to prioritize the order of routine actions) and supervisory attentional (regulating novel tasks). TOL-test assesses planning-skills.

In Chaytor er al. (2006) and Chan et al. (2008) the ecological validity and actual verifiability of different assessment procedures has been discussed critically. As these functions enable our ability to operate efficiently in different contexts (such as in school or work), laboratory settings might not be the most ecological environments to make assessments. Executive functions are like all human functions; combined and intertwined. Therefore assessing just one function, detached from its 'natural' environment can be argued to have rather little to do with the actual ability to execute the function in real life (Chan et al., 2008; Chaytor et al., 2006).

Clinical use of these different executive functions tests as assessment tools is established e.g. in diagnosing medical disorders (Arbuthnott & Frank, 2000; Chan et al., 2008; Channon, 1996; Chaytor, 2006; Forbes, 1998; Zook, Davalos, DeLosh & Davis, 2004). For example, the Test of Variables of Attention (T.O.V.A), which is an assessment tool to measure attention, is commonly used in diagnosing Attention Deficit Hyperactivity Disorder (ADHD) (Forbes, 1998).

In addition to the neuropsychological test procedures, *neuroscientific* ERP (event related potential) paradigms have been used as a tool to assess executive functions. Greimel, Trinkl, Bartiling, Bakos, Grossheinrich & Schulte-Körne (2015) studied selective attention (early stages of auditory information processing) with auditory oddball paradigm. Results indicated a significant difference between the experiment (non-medicated major depression (MD) diagnosed adolescents) and the control group, as the experiment group tended to show longer N100 (negative response occurring approximately 100 ms after auditory stimulus onset) latency. Their study supported previous research on MD by concluding that they detected a connection between major depression and dysfunction of selective attention.

Putkinen, Tervaniemi, Saarikivi & Huotilainen (2015) reviewed their former longitudinal ERP- studies. In their research both *neuroscientific* (ERP) and *neuropsychological* (NEPSY-II battery) measures were used to study the effects of formal and less formal musical training on executive functions. Putkinen et al. (2015) concluded that their article presents behavioral and ERP evidence for enhanced development of executive control over attention in school-aged musically trained children. They also wanted to emphasize the high importance of this ability outside the musical domain.

In this current study, after researching various possibilities for assessment measures, a combination of both neuropsychological and -scientific measures was hypothesized to be the most optimal.

2.4 EVENT-RELATED POTENTIALS, MISMATCH NEGATIVITY

Experiment 2 of this thesis makes use of an *electroencephalogram* (EEG) device. Related literature with the designed setting (oddball paradigm) and findings (event related potentials / mismatch negativity amplitude) are reviewed in this section. As the Experiment 2 was a pilot of one possible setting, different approaches and also related findings for future perspectives are discussed in the current section. In this study the interest was to study the impacts the training might have on executive functions, and *attention* was chosen as one the functions to be concentrated on.

Attention, rhythm perception and sound discrimination accuracy can be studied by recording electrical expectancies in certain scalp/brain areas of humans with EEG. EEG detects electrical activity in the brain by using small, flat metal discs (electrodes) attached to scalp. EEG has good temporal resolution, which is required to measure the responses caused by perception and attention in the human brain, as the electrical reactions to different stimulus are extremely fast. In addition to the superior temporal abilities of the measure, another reason for choosing EEG instrumentation for this thesis project was that in many disciplines EEG serves as a basic research method.

One approach to study attention-related responses with EEG is to use event-related potentials (ERPs). *Event related potentials*, or *evoked potentials*, are neural responses to specific events, which are extracted from the raw EEG data. Luck, Woodman and Vogel (2000) concluded that ERPs and functional neuroimaging techniques are "beginning to serve as high-tech reaction time measurements" (p 2). The body of research that focuses on attention-related mechanisms with ERPs is well established. Greimel et al. (2014) used event-related potentials as a measure to study major depression –diagnosed adolescents' *selective attention*.

A popular approach to study attention-related mechanisms is to concentrate on a response occurring 300ms after the onset of stimulus (often referred as P3 or P300).

As the body percussion training primarily trains rhythm assimilation skills, one approach could be to study changes in rhythm perception. Jongsma, Desain, Honing and Van Rijn (2003) and Jongsma et al. (2005) studied rhythm perception differences between musicians and non-musicians with Evoked Potential measures.

Foucher, Otzenberger and Gounot (2004) used a combination of fMRI- (functional magnetic resonance imaging) and EEG- devices to observe the brain regions supporting interaction between cortical arousal and attention during the conditions of detection, observation and rest. In their study, arousal was positively correlated with right dorsal-lateral prefrontal and superior parietal cortices, closely overlapping regions involved in the maintenance of attention. Combining these two brain-imaging techniques has been found effective in the studies of human attention.

In Experiment 2 of this thesis the data analysis was conducted by averaging the signal from the fronto-central electrode channels of the EEG- cap. The frontal lobes are connected to cognitive executive functions (Stuss & Alexander, 1999; Stuss, 2011). In addition to the connection between cognitive executive functions and frontal lobes (Stuss, 2011), humor, affect, and awareness have strong associations with the frontal lobes (Stuss & Alexander, 1999).

The oddball paradigm is an experimental design very often used with ERP studies. In this design, repetitive audio/visual stimuli are infrequently interrupted by a deviant stimulus. Altered stimuli (deviance) could differ from standard in timing, amplitude, color or shape. This deviant stimulus awakes a response that is often related to participants' attention, which is a central executive function. With oddball paradigms *mismatch negativity* (MMN)- amplitude is one of the most observed responses together with P3.

In auditory oddball paradigms, human listeners are presented with standard and deviant stimuli, and deviants evoke a negative transient response not observed for the standards, peaking after about 150–200ms, which has been labeled as the mismatch negativity (MMN). MMN represents the brain's automatic process involved in encoding of the stimulus difference or change. Attention plays a primary role in modifying MMN-elicitation (Sussman, 2007).

The MMN is regarded as an index of auditory discrimination accuracy, an attention-related response to auditory information (Näätänen, Pakarinen, Rinne & Takegata, 2004; Näätänen, Paavilainen, Rinne & Alho, 2007). MMN is thought to reflect the output of a pre-attentive memory-based comparison process (Pakarinen, Takegata, Rinne, Huotilainen & Näätänen, 2007). Kretzschmar and Gutschalk (2009) used the auditory oddball paradigm to investigate attention-related responses with MEG (Magneto encephalography) device. They detected a new independent attention-related response, separate component, which they labeled *sustained deviance response,* which, according to the authors, needed to be considered in the evaluation of data obtained with the auditory oddball paradigm.

There are various approaches in relation to event related responses. As the field of research and sentiments can differ considerably between authors, for this thesis, it was important to examine review articles as well. The existence of response occurring 100-200ms after auditory stimuli onset is quite indisputable, but interpretations of the response/s differ. Tome, Barbosa, Nowak and Marques-Teixeira (2014) reviewed 2764 papers to study the components of N1 (negative peak after 100ms of stimulus) and N2 (200ms) hoping to suggest normative values to the field of neuroscience regarding these components. According to their study, one of the most prominent AERP (auditory event-related potential) components studied in last decades were these two negative responses. N1 reflects auditory detection and the later N2 attention allocation, and phonological analysis. Tome et al. (2014) suggested, that in auditory processing experiments the most feasible experimental paradigm would be the *oddball paradigm* (first described by Ritter & Vaughan in 1969).

In MMN elicitation related responses are N2b and P3. According to Tervaniemi (2001) N2b and P3 responses that occur right after MMN reflect higher cognitive processes connected with the conscious detection and evaluation of deviance sounds. With trained musicians MMN, N2b and P3 responses seem to be stronger (Tervaniemi, 2001;). In MMN paradigms P3 is strongly related to explicit knowledge (Van Zuijen, Simoens, Paavilainen, Näätänen & Tervaniemi, 2006); when the participants are asked to direct their attention, the elicitation of P3 after MMN is very clear.

In this thesis, *MMN-amplitude* was chosen as the ERP measure to study the effects body percussion training might have on attention-related responses in brain. As Experiment 2 was done in collaboration with and tutelage was provided from CIBR (Centre of the Interdisciplinary Brain Research), it relied heavily on the expertise of the centres' researchers.

3 THE CURRENT THESIS: BRAIN AND BODY PERCUSSION

This interdisciplinary thesis project started in year 2012. For the first year it mainly concentrated on surveying suitable possibilities and references for the project; as the resources were modest, quite minute, that needed to be taken into consideration. The objective was to design a setting that could assess the effects induced by embodied rhythmic exercises of music and motion and to investigate the possibilities as extent as possible. Therefore *neuropsychological and -scientific* approaches were chosen as the main theoretical frameworks. The author's background is in music education, so the primary step was to obtain information of these abovementioned (neuropsychology and neuroscience) second disciplines. This was achieved by studying EEG instrumentation and analysis, cognitive neuroscience and neuropsychological fundamentals. Within the limits of resources and the time frame (two years) this project aimed to determine the feasibility of such research setting.

Body percussion was chosen from the wide selection of music and movement methods for multiple reasons. First, it is a method that is used for concentration, and to improve students' attention. Second, it is embodied learning at its highest peak. And third, the training does not require any additional instruments and therefore it can be moved into any desired surroundings available. *Executive functions* were chosen as a measure because the interest was to study the impact training might have on learning abilities/the mechanisms that enable our ability to learn.

Music and movement methods seem to have positive impacts on core executive functions, such as *inhibitory control* (Winsler et al., 2009) and *memory functions* (Cheung, 2012). Practical knowledge of the efficacy of the method of body percussion (Fross, 2000; Kivelä-Taskinen, 2008; Juntunen et al., 2010; Ahokas, 2012) supported further study. There were substantial grounds to formulate a hypothesis: Body Percussion exercise was presumed to have positive impact on executive functions.

After one year of collating, exploring and assimilating the possibilities of completely novel disciplines (neuroscience and psychology), the research setting had reached a point where it could be assumed to be optimal in terms of a pilot test. The optimal setting would have consisted of neuropsychological and scientific (brain-imaging) measures to *one homogenous population.* Due to time and resource limitations the possibility to pilot both of the designed measures together turned out to be impossible.

Body percussion, and its relation to neuropsychology still lack an advanced research tradition, and therefore any reference on suitable test-battery could not be determined from the previous research. In this current experiment, the effect of body percussion was investigated on two executive functions, *planning* and *attention*. *Planning* (neuropsychological test Tower of London) and *attention* (auditory oddball-paradigm with EEG) tests were executed before and after short- and long- term periods of body percussion training sessions.

The ability to *plan* is built from the core executive functions of inhibition, working memory and cognitive flexibility. Tower of London test is designed to specifically assess planning skills (assessing *inhibition and working memory*) (Welsh, Satterlee-Cartmell & Stine, 1999; Zook, Davalos, DeLosh & Davis, 2004). The particular Tower of London- test trial used in this procedure was chosen from the open source (free) PEBL-environment with consulting help from the Jyväskylä University's Faculty of Social Sciences (Department of Psychology).

The test trial was chosen on the grounds of few properties; it should obtain progressive difficulty and the number of assignments in one trial has to reach a requisite level but the total length of the test could not be more than 10 minutes. The time limit was set as the aim was to not cause any additional stress for the participants, and the whole study procedure (testing and training) had been planned to be executed as part of the normal school day. A short but effective test-procedure was designed to maximize ecological validity of the study.

A long-term study (Experiment 1) was executed from January 2014 to March 2014 in Jyväskylä, Finland. One class of 11-year old students from University of Jyväskylä's Teacher Training School, Jyväskylän Normaalikoulu (*n*=24) participated in the study. The experiment group (*n*=12) participated in weekly 10 - 20 minute body percussion sessions while the control group (*n*=12) had the possibility to participate in common music classes or recess. Test-battery was included with rhythm midi-tapping test and the neuropsychological Tower of London test, and was executed before and after the two and a half month training period.

The material for the long-term body percussion training was designed, composed and executed by the author. The training was planned out in a way that the movements (slaps, taps, claps, stomps, finger snaps etc.) would retain optimum amount of beneficial components (e.g. bilateral movements, crossing of the bodies median lines) (Kivelä-Taskinen, 2008; Juntunen et al., 2010; Fross, 2000). One important variable in the planning process was to take the groups' level of performance into account. The body percussion sessions needed to be planned in a way that would motivate the children to participate as effectively as possible.

Before every session, a new short two-voice ostinato was composed and brought to the group, and towards the end of the period the whole piece was structured (see Appendix 1). The participants and a fellow trainer (professional drummer Eeli Niemelä) participated in the editing of the piece. In that way the participants were gaining some experience about composing and collaborating in a group, and this active participation also gave them the feeling of authority, which is known to cause higher levels of motivation and satisfaction: motivation and satisfaction being one of the core elements of effective learning (Zachopoulou et al., 2003).

To meet the demands for ecological validity (Chan et al. 2008; Chaytor, Schmitter-Edgecombe & Burr, 2006), the test-battery was built as efficient as possible. The working hours for 11 year olds in school are long, and this study aimed not to cause any undesired additional stress for the participants. As the execution of the tests (also a midi-tapping test was executed before the neuropsychological Tower of London test) was planned to happen on the same premises as the training (in the school premises) during the school day, the length of the procedure per participant could not be too long. Running through the tests came down to approximately 15-20 minutes per participant.

Selective attention was included in the core executive function of *inhibition.* Short-term effects of an intensive 40-minute long body percussion training on attention were measured with EEG. Due to time and resource restraints, the brain measure had to be tested separately (Experiment 2) with dissimilar (compared to Experiment 1) sample (adult participant, n=1). Collaboration with CIBR (Centre of the Interdisciplinary Brain Research) enabled the pilot in Experiment 2, as the availability of EEG-instrumentation could not be provided on behalf of the music department. Collaboration with the centre deepened the interdisciplinary nature of this project. Cooperation was also invaluable in terms of instruction and tutelage in relation to the paradigm design and analysis.

Even though there was no possibility to study the long- term effects with EEG, there was an interesting opportunity to pilot a short-term effects-procedure with brain measures. The pilot study (Experiment 2) for a possible ERP/MMN- setting with EEG was executed in June 2014 in collaboration with the CIBR at the premises of Jyväskylä University Psychology Department Laboratory. The pilot-participant was a 35-year old professional music therapist and the body percussion procedure was designed and conducted on behalf of Orff-based music and movement teacher from the Faculty of Sport and Health Sciences in Jyväskylä University. Body percussion training was executed next to the EEG recording laboratory. That way the participant was able to move as smoothly as possible from the EEG recording to training and vice versa.

These two measures, neuropsychological and scientific, were experimented separately. In addition to the practical feedback of the functionality of these apparatuses in such context (current thesis' aims), experiments also provided feedback and data about the functionality, and possible differences between short- and long-term setting procedures. In terms of piloting a suitable setting, it was also essential to have the possibility to pilot the short-term effect-procedure; as the method of body percussion is quite often used as 'warm up', short-term setting could be one of the approaches in the future as well.

4 EXPERIMENT 1: EXAMINING THE LONG-TERM EFFECTS OF BODY PERCUSSION

In Experiment 1 the objective was to study the impacts of a 2,5 month long body percussion training period on participants planning skills. One purpose was to pilot the usability of a computerized open source neuropsychological test-battery in a research setting that would allow the participants to function as normally as possible during their school day. The aim was also to test the functionality of short body percussion sessions between the demanding school hours; and as it turned out, observe the inclusion of one student with special needs within the experiment group. This study also gave preliminary ideas of the control groups' optimal task for future perspectives.

4.1 METHODS

4.1.1 Apparatus

The research setting consisted of measures of executive functions test (computerized planning skills test Tower of London) and a computerized (midi-tapping) rhythm production test. Tower of London (TOL) experiment was provided by PEBL (Psychology Experiment Building Language, http://pebl.sourceforge.net/) TOL-test battery. The chosen TOL-test consisted of 12 trials. Participants were asked to arrange piles of blocks with minimum amount of moves to achieve the sequence of target stacks (see Figure 1). The test was designed to become progressively more difficult and include further move restraints. Participants were not given time restraints to solve the tasks.

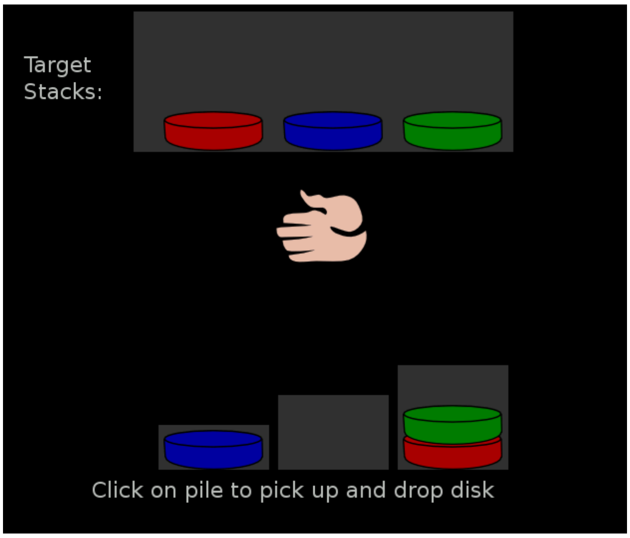

Figure 1. Example of the Tower of London test interface.

4.1.2 Participants

Students in the class were 5th graders (all aged 11 or 12), all together 24 students. They had substantial differences in musical abilities. Few participants were given regular music training outside school, but the majority of the group did not have music as hobby. The concept of body percussion was familiar to the group as the use of body percussion is part of the school's music education curriculum. One participant in the experiment group had special needs.

The class was randomly separated into two groups: one half participated in the body percussion trainings (experiment group *n*=12)(Figure 2), and the other half participated in regular music lessons and recess (control group *n*=12). Since the class was associated with the University of Jyväskylä's Teacher Training School, parents of these pupils had agreed on certain research and teacher training practices to be undertaken during lessons, and therefore additional ethics permission for conducting such research was not required.

Figure 2. Experiment group, Riikka Ahokas and Eeli Niemelä

4.1.3 Stimuli

Body percussion training was designed to achieve multiple different music educational objectives. The movements were designed to hold desirable and elegant amount of cross-lateral movements in order to attain the benefits behind these embodied multitask-exercises. The experiment group was challenged in their rhythmical abilities throughout the training. Towards the end, the piece got longer and the children were to memorize longer and longer periods of the collective composition.

4.1.4 Procedure

Tests were executed before and after a two and a half month period of weekly body percussion sessions (10-20 minutes per week). All parts (tests and training) of the setting were executed on school premises. Training was executed inside the participants' own classroom, and computerized tests in a smaller teachers chamber next to classroom. As the training was organized partly on participants' music lesson and partly on recess, that defined the control groups task: the control group was taking part in their regular music lesson and recess, while the experiment group participated on the body percussion group.

The structure of the lessons took quite standard shape as the training progressed. As the time frame was limited, participants were given small rhythm ostinatos, and they were also able to and encouraged to create their own rhythms, which towards the end of the period were structured as a whole piece (approximately 2 minutes long) (sheet-music of the piece can be seen as Appendix 1). The training was conducted and designed by the author. The group and the fellow trainer Niemelä assisted in the teaching and also took part in the composition process.

4.2 RESULTS

In order to find out about the impact the body percussion training might have on planning skills, pre- and post- scores of Tower of London test were analyzed. Means of the scores of the experiment group (n=12) were compared with the control group's (n=12) results.

The control group (CG) received a higher average in the TOL scores than the experiment group (EG) in the pre-test (EG: M=6.33/12, CG: M=6.75/12). After the two and a half months training period, both groups received a higher mean than in the pre-test. However, in the post-test the experiment group obtained a higher mean than the control group (EG: M=7.58/12, CG: M=7.33/12) (see Figure 3.).

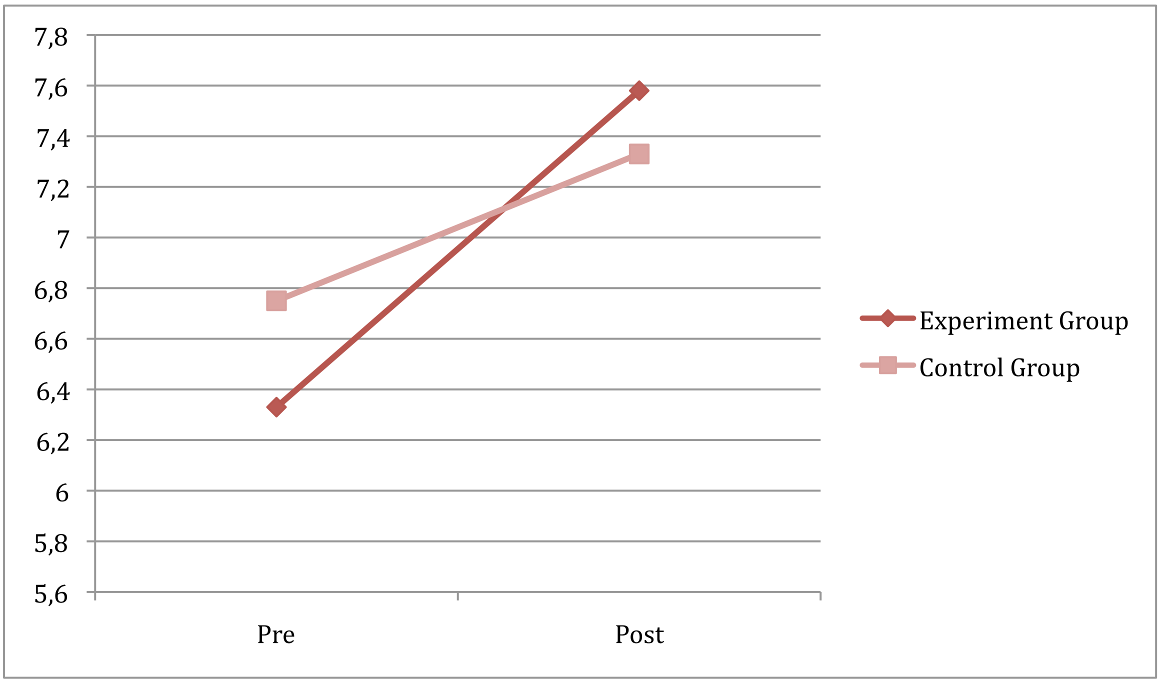

Figure 3. Results of the TOL-test

Paired-samples *t*-tests were conducted to compare experiment and control groups scores from pre- and post-conditions. With the experiment group there was a significant difference in the scores for pre (*M*=6.33, *SD*=2.19) and post (*M*=7.58, *SD*=1.98) conditions: *t*(11)=-2,21, *p*<.049. The difference was not significant with the control group for pre (*M*=6.75, *SD*= 1.71) and post (*M*=7.33, *SD*=1.44) conditions: *t*(11)=-0.86, *p*=.41. This indicates that with the experiment group the improvement from pre- to post- training conditions was significant. As seen in Figure 3, the experiment group achieved steeper improvement in their performance compared to the control group.

In order to find out whether there was a significant difference in the starting and ending points between the two groups, an independent *t*-test was conducted. There was no significance difference between the pre-conditions: $t(22)=-0.52$, $p=.61$, and the difference between post-conditions was also not significant: $t(22)=0.35$, $p= .73$.

The special needs participant from the experiment group improved in the TOL-test performance from very weak (3/12) to average (7/12) level. Furthermore, clear improvement of the fluidity of her limbs was detected.

4.3 DISCUSSION FOR EXPERIMENT 1

Experiment 1 supported the body of research (Winsler et al., 2009; Cheung, 2012) concentrated on the effectiveness of music and motion programmes. Research setting included one extensive method from music and motion (Kivelä-Taskinen, 2008; Juntunen et al., 2010; Fross, 2000), and therefore it also gave promising results of the usability (both scientific and practical domains) of the method of body percussion in such school environmental settings. Body percussion was proven to be a suitable method of choice for this setting, as the timeframe was tight and the use of more extensive music and motion programmes was not possible.

The participants were tested before and after the training period with *two* computerized tests (midi-tapping test with rhythm repetition tasks, and a neuropsychological test). That allowed the researcher to observe and monitor the participants before starting the training group. The first test in the test-battery, rhythm-test, required a lot of attention as the participants were asked to repeat rhythms after only one example. The possible effect of a rhythm production test to the TOL- test performance was not measured in any way. As stimulating tasks, also referred to as warm-ups, are known to improve sequential tasks (e.g. improve reaction time) (McMorris, Swain, Laude, Smith & Kelly, 2006) or reduce errors in surgical tasks (Pugh, 2012), the highly demanding rhythmical task prior to TOL-test might have been stimulating for both groups.

The open source (free) PEBL-environment, which hosts the TOL-test (Welsh et al., 1999; Zook et al., 2004) proved to be simple and useful. In addition to the data from the computerized test, throughout the training period valuable reflective conversations with the classroom teacher and a fellow trainer (professional percussionist) were made. One participant from the experiment group achieved full scores (*12* out of 12 trials) from the post-TOL-test, and as the lowest score for post-test was 4/12, and average score for the whole group *7.46*, participants result was remarkably good. According to the classroom teacher, this participant had substantial skills to set the pace of his movements right in sports.

The experiment group had one participant with special needs whose participation widened the scope from a typical to an inclusive teaching setting. This participant had difficulties in communication skills and the symptoms of mutism. Direct eye contact was lacking and the participant excluded themself automatically from the group. Body movements were slower and the participant was lacking some overall natural fluidness in body movements. It was noted that the first test from the battery (rhythm-repetition task) was extremely hard for the abovementioned participant, as it required fast reflexes as well as high level of attention. As mentioned above, this participant improved the performance of TOL-test from very weak to average level and during the training period gained an easier flow to body movements.

This participant was very easily excluded from the group both on participants own choosing, and group's own initiative. Children in the experiment group where obligated to perform together, which was demanding for the experimental group from time to time. Notably, the division between boys (n=6) and girls (n=6) was strong. The body percussion training gave the class an obligation, but also possibility, to play together, as a group. The training period improved experiment groups assimilation skills.

This study design permitted the participants to function normally during their school day. They did not have to move into any unfamiliar laboratory surroundings that might potentially affect the ecological validity of the research. The training was executed as part of their normal school day schedule, and in that way it was hoped not to cause any undesired, additional stress for the participants.

When the participants gave feedback about the training period it became quite obvious that they would have enjoyed it more (and would have been more motivated, and the training would have been more effective) if the sessions would have been at least 10-15 minutes longer. In further use of this setting, the amount of high-quality training performed by professionals should aim for a standard of 40 minutes on a weekly basis. Preferably the training could be executed twice a week.

The functionality of body percussion sessions carried out as a part of the normal school day was tested in practise and turned out to be an efficient approach. Small, stimulating and motivating rhythmical motor sessions during school day might give the children beneficial support for academic achievements they have to face every day. The results of this study gave positive reference of the usability of this exercise inside typical classroom environments.

4.3.1 Future perspectives

As mentioned above, the open source (free) PEBL-environment where the TOL-test was provided was proven to be easy and convenient to use. In future perspectives more advanced use of the whole PEBL environment with the help of professional consultants (neuropsychologists) could be reasonable. PEBL includes hundreds of computer-based tests that are adjustable, and the tests can be coded to fit specific research requirements. The environment provides efficient data in Excel files that can be further analyzed with more extensive statistic programs (e.g. Matlab or Past), or Excel. Depending on the test, the environment returns multiple different variables from the conducted trials (e.g. object times in milliseconds) that are useful. However, if the environment is to be applied in future research frameworks, the clinical reliability of the chosen test-battery has to be verified on behalf of neuropsychology professionals.

In future, more extensive use of other executive functions measures has to be considered. In addition to the pre- and post- measures, further settings should include also a follow up (in between, and later a follow up) with the designed test battery. In Experiment 1, due to resource limitations (time limit for the whole setting was rigorous) it was possible to only pilot one trial of the chosen TOL test.

Executive functions are crucial to our most important cognitive abilities (Streen & Strauss, 1998; Channon, 1996; Michel, 2012; Diamond 2012; Stuss 2011; Bialystok & DePape 2009; Diamond 2013; Stuss & Alexander 2000; Gilbert & Burgess, 2008) and as the interest is to examine this embodied motor rhythmic exercise's ability to enhance academic skills, these functions could serve as an comprehensive measure of such possible enhancement. It is possible to assess executive functions (that are indirectly and directly related with our ability to assimilate external and internal information) through a wide variety of neuropsychological tests (Chan, Shum, Toulopoulou & Chen, 2008) that should be utilized more extensively (proper test-battery) in the future.

In the current research, Experiment 1 allowed participants to function normally during their school day, and that turned out to have both pros and cons. In terms of ecological validity, the setting achieved its goal, but on the other hand the tight time limit reduced the possibility to use the neuropsychological test-battery sufficiently (extensively, using a wider test battery with different tests, and the middle point and follow up measures). In future, in similar projects, there should also be much greater contribution on behalf of the school. In general, the co-operation with the school to ensure high ecological research validity requires a great effort, both from the institution (school) and the scientists' side.

An optimal setting would include both brain-imaging and neuropsychological measures (e.g. combining the methods from Experiment 1 and Experiment 2). In future perspectives the neuropsychological testing could be executed on the same premises (laboratory) as the measures with brain imaging devices. Part of the testing could remain as part of a normal school day schedule for participants.

The idea of having short body percussion sessions within the demanding school hours turned out to be a success. As the method can be utilized on the spot without any extra instrumentation, this pilot supports further use of these exercises. The author's aim in the future perspectives is to develop more practical implementations of the method to be used inside regular classroom environments for general classroom teachers. As the method of body percussion seems to share a common ground with rehabilitation (e.g. RAS (Rhythmic Auditory Stimulation) training from Neurologic Music Therapy) and music and movement exercises seem to have positive impacts on executive functions, the usability of this method in the domain of *special education,* is of great interest to the author. These exercises could be used as a tool to train children with for example dyslexia or math related problems.

In Experiment 1 the control group's task was to participate on their regular music lessons and/or recess during the time the experimental group was receiving tuition in body percussion. For this design and setting, the task seemed appropriate enough. However, for future perspectives the control task could be defined more specifically as some activity without motor training, or other activities that would lack the involvement of rhythm.

5 EXPERIMENT 2: EXAMINING THE SHORT-TERM EFFECTS OF BODY PERCUSSION

The purpose of Experiment 2 was to pilot one possible brain-imaging method (electroencephalography) and to gain practical knowledge of a setting executed in laboratory premises (body percussion training was executed next to the EEG-measure room). The aim was also to design and test auditory oddball paradigm and evaluate its functionality in such setting.

5.1 METHODS

5.1.1 Apparatus

The EEG-paradigm to measure short-term effects on *attention* was piloted at the University of Jyväskylä's Department of Psychology laboratory. The EEG-instrumentation provided by the laboratory was a Brainvision Recorder, using 21 electrodes. Auditory oddball- paradigm was designed with E-Prime 2.0- programme.

5.1.2 Participant

In the EEG-pilot the participant was a 35-year old professional music therapist.

5.1.3 Stimulus

The 40 minute long body percussion training was designed and conducted by Orff-based music and movement teacher Anu Penttinen from the Faculty of Sport and Health Sciences at the University of Jyväskylä. In the auditory oddball paradigm the stimuli sound was a clap sound.

5.1.4 Procedure

The short-term study was designed and piloted in collaboration with the Centre of the Interdisciplinary Brain Research (CIBR) at the University of Jyväskylä in June 2014. Pre- and post- of 40 minute body percussion training the participant's electrical brain response amplitudes to standard and deviant audio-stimuli were recorded with EEG equipment. To maximize ecological validity, both testing and training were executed in laboratory premises.

In this design, the audio stimulus was a handclap sound, and the oddball effect altered lengths of breaks between the claps. Standard stimulus (regular duration of breaks between the claps) was 500ms from the onset of the clap-sound to another, and the deviant stimulus (the change) was either 400 or 600ms. The procedure consisted of randomly mixed 50 deviant and 50 standard stimuli-sounds, altogether 100 claps. The participant was asked to count the possible changes they might hear. In this way, the participant was asked to point their attention to the deviant (altered lengths between claps) stimuli.

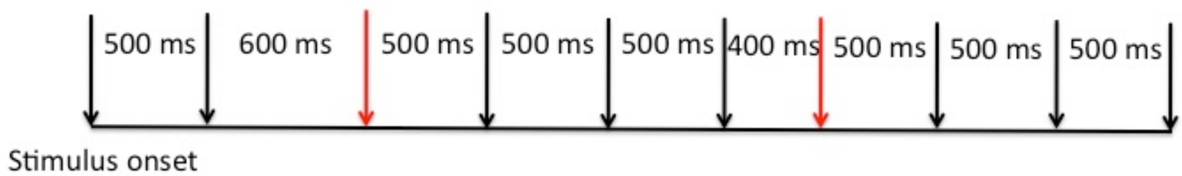

Figure 4. The oddball-procedure of Experiment 2. Red arrows indicate the deviant stimulus (altered length between clap-sounds).

5.2 RESULTS

In order to find out about the possible impacts of the 40 minute body percussion training, pre-and post-training data was analyzed. The analysis was conducted by averaging the signal from the fronto-central electrode channels (Fz, F3, F4, Cz, C3, C4). The average of all the channels served as a reference. Grounding was done with an electrode at the forehead, just above the bridge of the nose. The eye movement artefacts were removed by ICA (independent component analysis) method. At both deviant and standard stimuli-points (see Figure 4), the event related responses were calculated by averaging the EEG signal from the 100ms to the 400ms stimulus onset.

The first two rows of Figure 5 represent the differences in standard and deviant responses in pre- (first row) and post- (middle row) conditions. Visual estimate would be that compared to the before-condition, after- EEG recording would present more sedate responses to both (standard and deviant) stimuli.

The third row represents the response of both conditions to deviant stimulus. MMN (mismatch negativity) amplitude seems to be stronger after the training (blue being pre- and red the post-setting). The strong negative response occurring at approximately 120 ms in the post-setting (red line) indicates that the training might have had a positive impact on participants′ automatic brain processes, which are involved in encoding of the stimulus difference. Also the closely related responses occurring right after MMN (N2b and P3) can be seen in the third row.

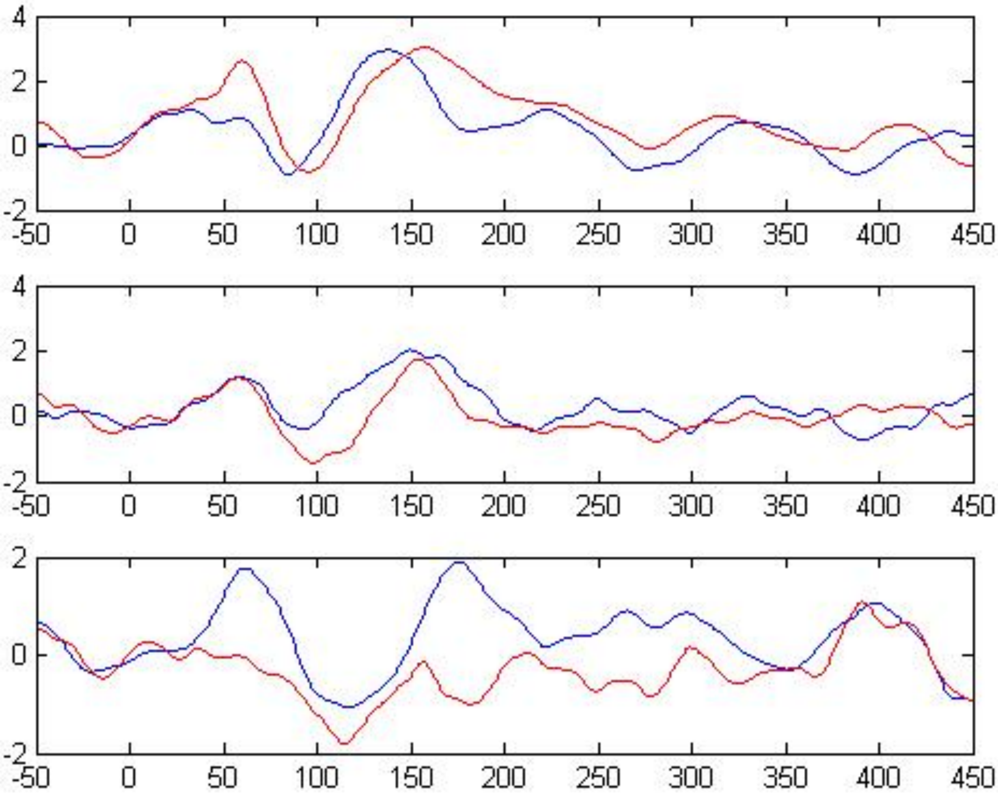

Figure 5. Above the fronto-central channels are pooled together. The *x axis* displays the time elapse in milliseconds, whereas the *y axis* displays the magnitude of positive- negative action of the responses. First two rows are before- and after-findings, blue being standard- and red the deviant- stimuli. Third row represents the difference curves between the pre- and post settings, blue being pre- and red the post-setting.

5.3 DISCUSSION FOR EXPERIMENT 2

This thesis project started from practical observations of a method found to be effective with both typical (Fross, 2009; Kivelä-Taskinen, 2008; Juntunen et al., 2010) and special (Ahokas, 2012) education populations. This method of music and motion seemed to have a positive effect on learning abilities both directly (by improving the ability to learn difficult rhythmical structures) and indirectly (exercises improved students cognitive and motor skills); the aim was to investigate the phenomenon as extensively as possible.

Executive functions were chosen as the measure to explore the phenomenon. After extensive literary reviews and cognitive neuroscience and neuropsychology studies, a possible preliminary design was composed. This ('optimal') setting had both *neuroscientific* and psychological measures to assess the impacts. EEG was chosen as the neuroscientific method for its temporal attributes and because it was easily accessible (the design could be repeated easily).

The oddball paradigm was designed with E-Prime 2.0- programme with the consulting help from CIBRs researchers. The audio file (clap sound) was provided on behalf of the author. On the whole, Experiment 2 relied heavily on the expertise of the professionals at the Centre of the Interdisciplinary Brain Research. As can be seen from the data-analysis (Figure 5) in this particular case the training seem to indicate positive impact on participants ability to direct attention towards altered auditory information (deviant stimulus). In this particular case the MMN amplitude was stronger after the 40 minute body percussion training.

The body percussion training was extensive and performed by high standard professionals. As the author, participant and trainer all participated in the 40 minute training, it can be considered as a group setting (as in Experiment 1). Body percussion training was easily moved to laboratory surroundings, so the results indicate a positive direction in the design.

5.3.1 Future Perspectives

To be able to maximize the potential of the pilot setting in Experiment 2, the number of participants should be at least 20 (10+10). In the future, a repetition of this setting with a sufficient number of participants could be reasonable.

The number of different approaches concentrated on ERP research is extensive, and the possibilities for different procedures almost infinite. Mismatch negativity is a response with appropriate references; it is quite widely used in music research (Putkinen et al., 2015) and related with *executive functions* (Toyomaki et al., 2008). Therefore, in the future, it might most certainly be appropriate to continue on detecting changes in the MMN-amplitude.

The setting in Experiment 2 assessed immediate effects of the body percussion training and therefore it could be considered as a reliable measure of the short-term impacts. MMN has been used as a measure to assess long-term impacts of musical training as Putkinen et al. (2015) demonstrated in their research. Putkinen et al. (2015) studied the impacts of formal musical training and less formal musical activities on maturation of brain responses related to sound discrimination and auditory attention. On the grounds of their research, it could be suggested that the mismatch negativity would be suitable also for a long-term setting.

As discussed earlier, other brain-imaging methods have also contributed to the body of research related to attention. Foucher et al. (2004) used a combination of fMRI and EEG in their study. In addition to the temporal data (via EEG) such an approach allows the experimenters also gain access to the spatial view of these functions in brain.

MEG (Magneto encephalography) device has similar temporal qualities as EEG. For resource-related aspects the device was not even considered as a potential measure for this project, but the designed oddball paradigm of this current study could also be used with MEG (Kretzschmar & Gutschalk, 2009).

6 COMBINED RESULTS FROM EXPERIMENT 1 AND EXPERIMENT 2

The aim of these experiments was to measure the impacts of body percussion training both in long-, and short-term domains. In Experiment 1 the objectives were to pilot the usability of computerized open source neuropsychological test-battery, experiment a research setting that would allow the participants to function as normally as possible during their school day and test the functionality of short body percussion sessions between the demanding school hours. Whereas the objectives of Experiment 2 were to pilot one possible brain-imaging method (electroencephalography), to gain practical knowledge of a setting executed in laboratory premises and design auditory oddball paradigm and evaluate its functionality in such setting. Both of the studies (Experiment 1 and Experiment 2) were fragments of an optimal setting. An optimal setting would consist of brain measures and a neuropsychological test-battery for one homogenous population. The main methods and measures (MMN, neuropsychological tests, body percussion training in both school- and laboratory- settings) were experimented comprehensively in this study.

In terms of piloting a neuropsychological test procedure as a part of school day routine, Experiment 1 reached its objectives. Although the test results indicated a favorable trend post-training (Figure 2) for experimental group, the verifiability of statistical analysis ($p < .05$) can be challenged. This was due to a small sample size (n=12) and the fact that the control group also advanced in their performance post-training period. Nevertheless, the results for Experiment 1 were excellent, as the experiment group achieved superior results compared to control group after the 2,5 months of body percussion training.

Piloting the setting in a school environment was productive in multiple ways. Experiment 1 brought both practical and technical knowledge of research conducted and closely involved within a normal school day schedule. As the participants were not forced to move into any laboratory surroundings it most definitely reduced the additional stress caused by the study and that had a positive impact on the ecological validity of the design.

By piloting the neuropsychological and scientific measures in Experiment 1 (neuropsychological executive functions test) and Experiment 2 (EEG, oddball, MMN- findings) this project achieved its objectives (of designing a setting that could assess the effects induced by embodied rhythmic exercises of music and motion). In addition to those objectives, both chosen methods seem to produce findings induced by the method of body percussion. Due to small sample size, insufficient test-battery and other time and resource- related constraints, quantitative results might lack the statistical verifiability, but both of the pilots produced valuable material about the piloted methods and measures.

It could be stated as a conclusion that the optimal setting would include these measures (psychological tests and brain imaging) both integrated in a setting for one homogenous population. Test and training procedures ought to be more extensive than in this current study, but the measures and results of this current study can serve as a baseline and indicator about the future possibilities. Especially MMN (mismatch negativity) has potential as one of the future perspective measures. Pilot in Experiment 2 and references (Wang, Sawada, Ikeshita, Negoro & Kishimoto, 2008; Toyomaki et al., 2008) are supportive for further study with MMN.

In addition to the scientific contributions, Experiment 2 also returned empirical data about collaboration with EEG-laboratory facilities and personnel. Also, the collaboration with a music and movement professional was beneficial in terms of practical implementations of the method of body percussion. Results from both of the settings indicate a promising direction in the design. Longer timeline with pre-, mid- post-, and follow-up measurements could gain ground towards more inclusive setting. Time and resources would bring more possibilities also into the training itself and more diverse music and movement interventions could be used.

Different suitable measures were studied and investigated thoroughly during this project. As the experiments in this study were pilots for measures, future perspectives and conclusions are most important. On the grounds of these examinations and experiments, the author came to the conclusion that neuropsychological executive functions assessment procedure and auditory oddball paradigm for either EEG or MEG (brain imaging methods with similar temporal advantages) could be suggested to be potential measures for future perspectives. The further use of these methods and designed setting could be reasonable and is also of high interest to the author.

7 EPILOGUE

This thesis has implications that will contribute to the domains of music-, special-, and special music- education. There is substantial amount of evidence regarding the benefits of musical training (Fross, 2000; Derri et al., 2001; Zachopoulou, 2003; Zachopoulou, 2004; Roth & Wisser, 2004; Schellenberg, 2004; Thaut, 2005; Schellenberg, 2006; Kivelä-Taskinen, 2008; Bialystok, 2009; Winsler, 2009; Juntunen et al., 2010; Scott, 2011; Sportsman, 2011;Cheung, 2012; Romero-Naranjo, 2013; Colomino & Romero-Naranjo, 2014; Romero-Naranjo, 2014; Roden et al., 2014;Putkinen et al., 2015), and the importance of motor abilities (Dennison, 1994; Hannaford, 1996; Fross, 2000; Thaut, 2005; Smith & Gasson, 2008; Kivelä-Taskinen, 2008; Juntunen et al., 2010; Diamond, 2012; Kujala et al. 2012; Michel, 2012; Piek, Dawson, Rigoli et al., 2012; Guiney & Machado, 2013; Haapala et al., 2013; Romero-Naranjo, 2013; Colomino & Romero-Naranjo, 2014; Romero-Naranjo 2014) to cognitive functions. Music and movement methods, such as body percussion, retain both of these beneficial components: diverse physical movement, and music. Therefore body percussion could be regarded as an optimal research method for a body of research concentrating on the relationship of motor and cognitive functions.

One interesting approach to study the phenomena could be to concentrate on the actual mechanisms *behind* the improvement. Body percussion requires a lot of touch and contact towards on the participants' body. With exceptional, e.g. SEN (Special Educational Needs) populations, who often suffer from weak or altered knowledge of the body, this exercise is excellent training for improving the sense of the outlines and dimensions of the body. Touch in general induces pleasure by inducing higher dopamine levels (Maruyama, Shimoju, Ohkubo, Maruyama & Kurosawa, 2012; Field, 1999), and that might be one of the reasons behind the effectiveness of this method. With body percussion, rhythmic entrainment is connected to better self-awareness in general: as you learn to use your body more efficiently the awareness of oneself increases (Fross, 2000).

Taking cognitive enhancement into account, the method, body percussion and multiple other percussive rhythm exercises used in music education share a beneficial common ground with music therapy. Neurologic Music Therapy (NMT) Cognition Training Techniques share similar goals with music education (Thaut, 2005). This study aims to reinforce the unrecognized and unexplored common ground between these two important professions, music education and music therapy.

There is a rhythm in our body; there is a rhythm in our mind. In our actions rhythm is present, thus it could be suggested that our rhythmical abilities and cognitive functions are connected.

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Appendix 1

Normaalikoulu 2014

Gimme one!...two!...three!

lopetukseksi kehän kiertävä clap