

**The affects of exercise and brain plasticity, discussed in relation to  
Functional oriented Music Therapy;  
a theoretical study**

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Exam essay in cognitive science 10p, spring 2007

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## **Preface**

I had an interesting conversation with my neighbour, Isabella, who is a newly graduated functional oriented music therapist, this winter about the brain's ability to rebuild after injuries. Isabella was reflecting over that even if the Functional oriented Music Therapy (FMT) method has yielded many positive results in many adepts (i.e., the patient), more research is required in this field. Seeing it from my point of view as a student in cognitive neuroscience, I could only agree. All fields within health care are in need of more research in order to make further progress and stronger grounds for which treatments to use.

Just beginning the sixth and final semester in my studies, I soon had to choose the subject of my examination essay, and Isabella's idea to make a study of the functional oriented music therapy method appealed to me. I decided to try to find some theoretical aspects which could help in explaining what the FMT - method actually does to the adept.

To become more acquainted with this therapy method, I was invited by Isabella to come to a meeting for functional oriented music therapists. The meeting was hosted by Solveig who has ten years of experience with FMT, and who has met people with a broad array of problems. Solveig has also tried to make continuous video recordings with each adept, which most functional oriented music therapists do, to see their progress, and she has also been trying to see patterns of progress both within and between subjects.

In the meeting Solveig put forward, amongst other things, an evaluation report from the manager for disabled in Västra Götalands region, Mikael Forslund, written evaluations from her adepts, as well as her own thoughts. Mikael Forslund acknowledged that both project reports, as well as patients' reports, have shown positive results and that these results points towards that FMT could be a functioning alternative treatment method. However, there are no national evaluations of the effects the method has had for different groups of patients, and therefore we can not, at this moment, submit any general grounds for medical referral.

A man with Multiple Sclerosis writes: “My experience of music therapy is very positive, for example, increased ability to coordinate body movements. Lately I have noted an improved wide sight, this probably depends on that while playing on both sides of the body simultaneously, one must keep a central eye focus. To summarize it all, the music therapy has meant very much for me”.

As to Solveig’s own experiences: “I have meet people in the ages between four and seventy five, some have played for many years, and others for shorter periods. The problems for the adepts have been very varying. With the FMT- method it is possible via the play in codes and development criteria to give a clear view of the problems which limit the player. From this view I work as a therapist in a systematic way for the player to develop and progress. I note that children and elderly have had similar problems in their movement patterns. The playing has made it possible to improve their learning, which has been confirmed by teachers and relatives. When using the FMT- method the adept starts with what they can do, and they are accepted for who they are, and they become stimulated to experience a change in their body which enables them to carry out more tasks themselves. This makes their everyday life easier, which means much to the individual. FMT- therapists make use of the healthy part in a patient and keep that as a reference point, and then strengthen the weaknesses and in this way minor the problems for the participant.”

Solveig announced that the FMT- method could be a part of an interdisciplinary professional team to a more general extent: 1) In school; as a complement to the traditional education to get an early contact with those children who have problems when starting school. 2) In health care to maintain functions and/ or develop the player so that the need for care will not become so large. “Within rehabilitation and elderly care, I think there is also a need for FMT- treatment, which can be a possible way to a faster recovery”, Solveig writes.

I would like to thank Isabella and Solveig for their inspiration and introducing me to the subject. I would also like to thank Katja, Sakari, and Antti at Högskolan i Skövde for good advice and supervision.

Josefine Carlsson, 2007-05-20.

### **Abstract**

This essay examines which role functional oriented music therapy, which is supposed to help sensorimotor development, can have in schools and in health care. To find this out, research about what kinds of effects exercise can have on academic achievements and in recovery from brain injuries has been brought up. The research concerning academic achievements was conducted with school children; some children without difficulties, some with sensory integration problems, and some with motor skill difficulties. In addition to this, research about the brain structure superior colliculus, which lies behind sensory integration, is also brought up.

The results showed that children who were given more exercise had significantly better scores in academic skills than the children with normal academic education. Thus, it might be reasonable to practise functional oriented music therapy in schools, both as helping general development, but also for children with different types of difficulties.

The research concerning exercise and injuries has made clear that the adult brain can change via neurogenesis, plasticity and cortical reorganization. These three aspects are important when practicing a skill or when recovering from an injury. Exercise has been shown to affect these three aspects positively and can therefore also aid the recovery from injuries.

Thus, there seems to be many theoretical aspects supporting the FMT- method. However, the question is if the results of one treatment form can generalize over such a wide range of injuries and defects that the FMT –adepts usually have. It is therefore also discussed if further experiments on the FMT-method could help make it a more effective tool for rehabilitation.

**Keywords;** Functional oriented music therapy, exercise, sensory integration, neurogenesis, plasticity, cortical reorganization.

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## **1. Introduction: The functional oriented music therapy method**

The functional oriented music therapy method was developed by Lasse Hjelm during his work at the Folke Bernadottehemmet, Uppsala between the years of 1975 and 1989 (Hjelm, 2005). Hjelm worked as a music pedagogue for ordinary school classes, and also as a leader for many musical study circles, when he was first invited to a closed psychiatric hospital that now wanted to start integrating the patients to an open form of care through musical study circles. In 1975 Hjelm was asked to lead music lessons for children with different motor disabilities, and also with cerebral pares, at the “Folke Bernadotte” home. However, the children had a wide range of different difficulties, some of them even tied up in their wheel chairs as they could not hold up their own body. Hjelm then started working with each child individually, and he saw the sessions no longer as music lessons where the child practiced to learn an instrument, but a chance to enhance the bodily development, with the music as a mean to get there (Hjelm, 2005).

Hjelm used drums as the instrument for the children to play with while he played the piano along side the child. Each adept started out with the base drum and, as their stability and movability increased, they were given more drums to play on. (Hjelm chose to use the word adept as he thought of them neither as pupils nor as patients). Eventually Hjelm also started playing in music codes to indicate the level of development of the child, and as the child developed further, he played more and more complicated codes. The playing in codes also helps in becoming independent of one specific therapist, so that if one therapist is ill, another therapist should be able to take over the adepts (Hjelm, 2005).

In the interaction with the children, and also aided by the theories of development Hjelm read, he tried to see what each child needed to enhance. Hjelm then tried to adapt the playing to the adept’s level of difficulty and tried to help develop the adept

further from that point. The interaction with different adepts while also reading development theories seems to be the way Hjelm evolved the method it self.

The FMT - method is described to be an interaction between the adept and the therapist, as a dialog on instruments; the therapist plays the piano, while the adept plays drums or sometimes a wind instrument. The therapist is never giving any verbal instructions, instead, the therapist is playing a tune on the piano and then the adept is answering with playing the drums ([www.fmt-metoden.se](http://www.fmt-metoden.se) 2007-05-10). Through playing certain combinations, with thoroughly arranged settings of the drums and other attributes, the adept's motor activity and perception is altered in a functionally developing process. Functional oriented music therapy uses about 30 music codes to stimulate the body's natural development. Thus, different music codes are played when exercising different types of body movements, this is shortly described below. The therapist sets the level of the music codes to the functional abilities that the adept already has, and continues from there. An adept plays twenty minutes once a week, to give the adept time to process and develop what is new (Hjelm, 2005).

The FMT- method works from a perspective that the work and recovery has to come from the body, via perception, to the brain (Hjelm, 2005). The idea of using drums is that a toneless instrument is easy for anyone to use, but also that it is giving vibrations important for the tactile perception. Thus, even here we see that it is not only about auditory sensations. Therefore, the functional therapists also use different kinds of drumsticks, with different shape, size, and weight (Hjelm, 2005). The wind instruments are a good complement for doing breathing exercises, for example, playing short and long tones on a wind instrument develops the use of lungs.

As mentioned above the music codes that the therapists play are being used at different levels. The first few codes are low level exercises, for adepts with severe difficulties, and also used to introduce new adepts to the drums and the interaction with the therapist. The

codes are then continuously getting more complicated, and the adept learns to start playing at both sides of the body simultaneously, and also with their hands crossed over the drums. The development of motor actions like that can seem self evident, but are holding back those who have not been able to develop such movement patterns (Hjelm, 2005).

Another side of the FMT- method is music for children in preparatory school, called “MUISK”. These music sessions are conducted with a group of children, and are not meant to be seen as therapy. The point is rather, again with minimal verbal information, to let the children develop the motor skills and let the children’s own imagination be a source for movement accompanied by music. Children at preparatory school age, Hjelm (2005) writes, are at very different levels of development, and therefore it is important to start the motor skill enhancement training before deficits in motor skills become a problem for the children in school. Also, in MUISK, the functional oriented music therapists can use different music codes to enhance auditive- and motor control, and to improve stamina (Hjelm, 2005).

The FMT – method has been used to rehabilitate adepts with a wide range of different medical backgrounds, placed into four different categories; 1) Natal injury (i. e. Cerebral Pares), muscular disorder, brain injury, and stroke. 2) Learning disability, behaviour disorder, autism and autism spectrum syndrome, psychic disorder, and dementia. 3) Specific functional difficulties like reading- and writing difficulties, dyslexia, dyscalculia and concentration disorder, and DAMP/ADHD and Asperger syndrome etc. 4) In the last category there are adepts who have chosen to participate in FMT – sessions, thus, without specific diagnose or problems ([www.fmt-metoden.se](http://www.fmt-metoden.se) 2007-05-10).

### **1.1. Theoretical background**

The FMT-method aims to create a space for structured sensorimotor development within a frame of comfort, without any demands of achievements. This

structured perceptual- and motor treatment should influence the natural development of motor-, perceptual-, cognitive- and emotional functions based upon the adept's capacity. However, the self-made initiatives from the adept are the ground for all personal development, thus, this is stimulated in the musical interplay between therapist and adept ([www.fmt-metoden.se](http://www.fmt-metoden.se) 2007-05-10).

The underlying idea of the FMT- method is that it is a neuro-muscular treatment. The treatment increases the activity of neurons, enhancing cognitive abilities, and movement and body- stability. The method assumes that both these aspects of the body are mutually important for each other. A goal is to create structural memory-paths in the brain, through the reactions in the interplay with the therapist, which can organise movement patterns for the benefit of the individual. This type of approach makes the method available for all ages and has proven to be successful for a variety of groups with different disabilities ([www.fmt-metoden.se](http://www.fmt-metoden.se) 2007-05-10).

Hjelm (2005) stresses to view the human as a whole, emphasizing the importance of a good body posture during the session. If the adept does not have a good sense of balance, or muscle strength to hold up the body, it is important that the chair and the placement of drums can be adjusted to aid this. In the rehearsal of different movements it is important to go through the whole spectra of spatial awareness. The adept may be sitting, but play on one side at the time, both sides simultaneously, crossing the right hand over the body's "middle line" to the left field, and this should expand one's movements over different spaces. This seems important also for perception; Hjelm (2005) writes that perception is about putting oneself into relation with the surroundings. The most rehearsed perceptual parts in the FMT- method are the tactile and auditory, and it is not hard to understand the message we can only change with input to the body and then further to the brain, not the other way around.

## **1.2. Aims**

The announcement by Solveig, that the FMT-method should become a part of an interdisciplinary team, is the reason why I bring up the following two theoretical aspects; that exercise improves cognitive abilities for children with learning disabilities, and that exercise can help people with different types of injuries, following from accidents or neural disease, to recover and maintain a better every day life. Thus, my aim is to find out if these theoretical aspects have any support in scientific research. As will be revealed throughout the essay, the following are the main themes in this essay: 1) Does exercise improve academic achievements? 2) Does exercise help recovery from injuries?

## **2. Does practice improve academic achievements?**

There are both earlier and more recent studies of whether exercise improves academic achievements. I will focus on two that seem relevant in the context of the FMT-method.

### **2.1. Effects of sensory integration and motor training on academic achievement**

Ph. D. A. J. Ayres reported in 1972 a study of a remedial program. The aim of Ayres's study (1972) was to test the hypothesis that children with learning disabilities and sensory integrative dysfunction who participate in remedial activity, especially designed for their dysfunction, will score better than children with the same type and degree of problems that participate in normal academic work instead.

The participating children were first given a battery of neuromuscular pre-tests; Southern California Sensory Integration Test (SCSIT), the Illinois Test of Psycho-linguistic Abilities (ITPA), the Wide Range Achievement Tests (WRAT), and the Slosson Oral Reading

Test (SORT). The remedial activities were adapted to each child's special needs, such as activating righting reflexes and balance reactions to normalize postural mechanisms, and tactile stimulation to normalize general brain functions and give a somatosensory basis for motor planning and lower the level of excitation. Thus, inputs to muscles, joints, and skin were carefully planned (Ayres, 1972). However, no extra training in language or "eye exercise" was given, except for what was necessary for the activity.

The experimental group had remedial activity for 25- 40 minutes a day, five days a week, and for five to six months. The children in the control group received the same amount of time of classroom experience instead (Ayres, 1972). The pre-tests revealed five types of hypothesized syndromes of dysfunction. Disorders in 1) postural, ocular and bilateral integration; 2) praxis; 3) functions of the left side of the body; 4) form and space perception; and 5) auditory-language function (Ayres, 1972). Each child was assigned a score based on the degree of difficulty in each of the five syndromes.

Ayres (1972) examined an experimental and a control group with generalized dysfunction, and also an experimental and a control group with auditory- language problems. From the group with general dysfunction, 30 children from the experimental group were selected and matched with 30 children from the control group. From the group with auditory- language problems, 12 children from experimental and control group were matched and selected (Ayres, 1972). There was no major differences between the matched groups. The largest difference was that the experimental group was on average four and a half months older, a disadvantage for this group because the younger children gained academically more in the pre-tests than the older children did (Ayres, 1972).

After the intervention, the children were tested again. The results from the WRAT subtests and the total of the SORT showed that the scores of the experimental group with generalized dysfunction were better than of its matched control group, however, the

results were only significant in the WRAT reading and WRAT total scores. The results from the experimental group with auditory- language problems also proved to be better than its control group, but the results only reached statistical significance on the WRAT reading test and on the SORT test. The results from SCSIT and ITPA showed statistical significance where both the experimental groups differed from its respective control group (Ayres, 1972).

Ayres (1972) suggest that the study indicates that the experimental groups scored academically better than their respective control groups because of the practice in sensory integration enhancement. The sensory integrative processes take place in the brainstem and basic brain research, Ayres (1972) writes, suggests that the brainstem is important when organizing auditory and visual processes. The most common difficulties and disorders in children with learning disabilities are immature postural reactions, poor extra ocular muscle control, poorly developed visual orientation to the close environment, difficulties in the processing of sounds into perceptions, and a tendency towards distractibility. All these suggest an inadequate sensory integration in the brainstem (Ayres, 1972).

The experimental group became better in both reproducing an auditory sequence and in reading skills, than the control group, and Ayres (1972) suggests that increased reading skill may be related to improvement in auditory memory. The sensory inputs enhanced the somatosensory systems and affected the brain in such a way that the integration between sensory-, visual-, and auditory modalities became a natural part of the gross motor experiences. The mechanisms for these integrative processes exist in the brainstem, thalamus, and cortex (Ayres, 1972). Children with sensory integration deficits also have difficulties in integrating sensorimotor information from the two sides of the body, but normalization of postural mechanisms in the midbrain is hypothesized to enable better cortical interhemispherical communication, and the problem decreases (Ayres, 1972).

To summarize, Ayres writes (1972) that the remedial program has shown to be statistically successful, and that the effectiveness is due to both matching treatment with dysfunction, and that the children in the experimental group and the control group were matched. In Ayres experiment, sensory integrative activity helped in improving academic achievements. However, I find that the study and its conclusions would have been more helpful if Ayres would have described more thoroughly the sources of the “basic brain research”. Ayres (1972) self noticed a lack of research in the field; that differences in research results might be caused by operative variables which are not well controlled in the experiments as they are not recognized by researchers. However, Ayres seems to get support from a more recent Swedish study, similar to the one of Ayres, reported by Ericsson in her Ph. D. essay.

Ericsson (2003) reports the Bunkeflo project which started in 1999. The background of this project was an education program called MUGI, motor development as a ground for learning. In the MUGI program all six-year olds from three preparatory schools had one hour of motor training each week under the supervision of the school’s physical education teacher. At the age of seven, when they started school, children were offered to continue having the motor training if needed and for as long as they needed it. The MUGI program showed, from an evaluation, to have positive effects on the children’s motor control, perception, and ability to remember details (Ericsson, 2003).

The aim of the Bunkeflo project was to contribute more knowledge about the relation between motor skills and cognition, that is, to see if improved motor skills affected attention and academic skills. The main research questions (Ericsson, 2003) were as follows:  
1) Will extended physical activity and motor training in school affect children’s attention? 2) Will extended physical activity and motor training in school affect children’s academic

achievements? 3) Will extended physical activity and motor training in school affect children with deficits in motor control and attention?

Physical education and motor training was made a daily subject since 1999 for the children in the school involved in this project. Children with any difficulties in motor skills were also offered even more practice to develop, thus, these children had physical activities six times a week in school. The differences between children were being studied between school year one and three for children born between 1990 and 1992. As the project started in -99, the two intervention groups had Physical Education and physical activities five times a week, and also one extra lesson for those who needed it. Intervention group 1 and 2 consisted of children in school year one, respectively school year two. The control group, pupils in school year three, only participated in the school's regular physical education with two lessons each week (Ericsson 2003). Thus, the only difference in the children's school situation was the extended physical activity for the intervention groups.

All the pupils' reading development, across the children's ages, in school year one and two were documented using a reading development test called "LUS" (Ericsson, 2003). In a similar way the results from the national tests in Swedish and mathematics were obtained. Also in school year three the pupils were given a word and reading test. Motor skill observations were made using MUGI observation schemata. Finally, a questionnaire concerning the children's attention called "Conners' questionnaire" was answered by the teachers and the parents (Ericsson, 2003).

Ericsson (2003) describes the relationship between motor skills and attention. The results showed that pupils with attention difficulties in both intervention groups improved in motor skills. However, pupils with attention difficulties in the control group did not improve their motor skills noteworthy. Thus, this indicates that extended physical activity and extra motor training in school seems important also for attention deficits, when it comes to

their development in motor skills (Ericsson, 2003). The results from the study show that 68% of the children with difficulties in attention also have motor skill deficits. However, the study cannot confirm the hypothesis that the pupils' attention should improve with more physical activity and motor training. In school year two, there were differences in attention between the intervention groups and the control group, but the differences were small and did not show in school year three. A possible problem could be that the data were dependent solely on a questionnaire, and no other tests. Therefore, it is hard to tell whether the pupils' attention was affected or not by the extra physical activity (Ericsson, 2003).

The hypothesis that children's achievement in Swedish and math will improve with increased physical activity and extra motor training was supported by the results (Ericsson, 2003). Both intervention groups showed significantly better results than the control group in the national tests of Swedish, and the differences were especially large in writing and reading. Similar results were found in the national tests of mathematics, where the intervention groups scored better than the control group. The differences were significant in mathematics in total, but especially in spatial understanding and number conception/ thinking proficiency (Ericsson, 2003).

For pupils with motor skill deficits, the results showed that pupils from the intervention groups again performed significantly better than the control group in the national tests, both in Swedish and in mathematics. In school year two, the differences between intervention groups and control group were the larger the bigger difficulties in motor skills the pupils had at the start of the project. Thus, motor training seems to be the more important the larger difficulties in motor skills the pupils have, also for academic achievements (Ericsson, 2003).

Ericsson (2003) predicted that because there were differences in academic achievements between pupils with good motor skills and pupils with poor motor skills in both

interventions groups and control group, a motor skill observation at the school start could be useful as a pedagogic instrument to predict achievements in Swedish and Mathematics for the first three school years. The conclusions were restricted to the early school years because no follow up study has been made to make such generalization able (Ericsson, 2003).

Since the study contained pupils from only one school, Ericsson (2003) is also careful about making generalized statements of large populations of young school children. The extra physical education might have had positive effects in, for instance, social aspects, which in turn could have had a positive effect on the pupil's studies. Even so, the results of the study are positive, and whether there is a direct or indirect effect, this is enough reason to give more physical education than only twice a week for young school children, and especially to those with motor skill deficits (Ericsson, 2003).

## **2.2. The neural basis of sensory integration**

Multiple sensory systems enhance the chances to detect valuable information and decrease doubt about our perception. Sensory modalities appear to be functioning independent of each other, but this is a false assumption (Stein, Wallace & Stanford, 2000). Experiments show that when given both visual and auditory stimuli at the same time, the response latencies can be reduced, thus the two modalities are influencing each other (Stein et al., 2000).

Although multisensory integration has been behaviourally studied, there has been little information about the neural grounds. However, the superior colliculus in the cat has in recent years been used as a model to explore these processes (Stein et al., 2000). Research in superior colliculus (SC) in the cat has given some insights to the principles of how the brain synthesizes several sensory inputs and how this can help guide behaviour. Similar principles are also believed to operate in higher order cross-modality perceptions (Stein et al., 2000).

The SC receives input from several sensory modalities and then produces coordinated orienting movements, based on stimuli from eyes, ears, head and body. The stimulus' location is then represented topographically, and the result is a map-like arrangement of sensory representations (Stein et al., 2000). Cross-modality topographical maps are important for synthesizing cross-modality information when many types of modality inputs are available. The neurons in the SC that operate this synthesizing process are an important part of the output pathways of the SC that connects to the brainstem's motor circuitry (Stein et al., 2000). An integration of stimulus from several modalities can cause a major increase of impulses, and when the stimuli are from the same event, temporarily and/ or spatially, this leads to a response enhancement. However, if the stimuli are from different events, occur at different times and in different locations, there is a decrease in response, so called response inhibition (Stein et al., 2000).

SC neurons only produce cross-modality integrative activity if input from an area in cortex, called the anterior ectosylvian sulcus (AES), has been received. The AES is an association area composed of visual, auditory, and somatosensory regions (Stein et al., 2000). Temporarily deactivating the AES in experiments, thus eliminating these inputs to the SC, has shown that the SC creates a heavy suppression of multisensory integration. Thus, the SC is dependent on the inputs from AES (Stein et al., 2000). The association cortex AES does not only control the multisensory integrative inputs in the SC, but also influences the attentive and orientation functions that the SC transfers (Stein et al., 2000).

Stein et al. (2000) bring up the discussion whether sensory integration is something we are born with, or is learned as the individual gains more sensory experience. It was claimed in the early and mid 20<sup>th</sup> century that sensory modalities were well established at birth, but that associations among them must be learned. More recent research suggests that these associations are innate and that a newborn can perform complicated forms of sensory

integration (Stein et al., 2000). However, regardless of this discussion, specific modality experiences in the early stages of life can make a change in later use of other modalities. In experiments when surgically opening the eyelids in very young mammals, the visual experience, occurring earlier than normally, disrupts the normal auditory dominance. This early visual experience even disrupts the ability to gain normal preferences for sounds specific for the individual's species (Stein et al., 2000).

The SC of the newborn cat is immature, and the receptive fields in early SC neurons are very large. For example, visual receptive fields (RF) cover much of the contralateral visual field. As the cat grows and matures, all the receptive fields shrink to only pick up stimuli from a more narrow spatial location, and gaining a tuning more like the one of an adult. If similar developing processes are present also in humans, it might explain observations that having visual and auditory stimuli at the same spatial location becomes more and more important as the infant matures (Stein et al., 2000).

As mentioned before, topographical maps are important for synthesizing cross-modality information. The various sensory maps also have to become spatially matched, aided by increasing and decreasing projections in each modality. The spatial alignment in sensory maps is important in the SC to gain a meaningful multisensory integration (Stein et al., 2000). As mentioned before, it is critical for the response enhancement to receive spatially coincident stimuli and for the response inhibition the stimuli needs to be in different spatial locations. This enhances the ability to notice related events as meaningful and to decrease the attention to unrelated events Thus, a misalignment in these topographical sensory and motor maps can have a negative effect on our behaviour, as a misalignment alters our sensory integration which our behaviour depends on (Stein et al., 2000).

The development of a refined auditory map seems to need early visuo-auditory experience. It is believed, according to Stein et al. (2000), that the altered sensory input which

follows from motor output is linking the experience to produce a topographic register between motor and sensory maps. Memorized information is then used to maintain map alignment as the body, head, and eyes move position. In experiments, animals have been raised with an earplug in one ear, and this earplug disrupts the normal ability to gain a balanced computational map of auditory space in the SC. However, the auditory map is still very similar to the one found in normally raised animals. It seems as if the brain is capable of making up for the auditory loss by using the visual map as a reference and then calculates the input from each ear to produce a matching map of auditory space (Stein et al., 2000). However, at blindness in the animal a rough auditory map is still developed, which suggests that only later refinement in auditory RFs is dependent on coincident visual input (Stein et al., 2000). However, there is no complete research of the development of multimodal RF properties to know exact which factors that determine which sensory map that serves as a reference to the others (Stein et al., 2000). Although this is uncertain, the alignment of sensory map registration enables a modality independent relationship of sensory and motor maps in the SC (Stein et al., 2000).

## Summary

The studies reported by Ericsson (2003) and Ayres's (1972) show similar results. These results indicate that there is a positive answer to the question; does practice improve academic achievements? Children, both with and without difficulties in motor ability, do improve in academic skills with more motor practice. While Ayres (1972) writes more about the underlying brain functions necessary for the improved academic skills, that there has to be a well functioning sensory integration, Ericsson (2003) makes no such claims. Superior colliculus is the location where sensory integration seems to occur. Stein et al. (2000) have explained some of the principles that rule the superior colliculus in both adults and during development, such as the importance of time and space relations, the AES, and

topographical maps. These principles and brain structures govern our sensory integration and thus our experiences and actions. The improvement in the functioning of the superior colliculus due to training might partially explain the enhanced achievement of pupils who received motor training.

### **3. Does exercise help to recover from injury?**

As mentioned previously, the FMT - method takes on many seemingly different patients. Some of these are adults, injured later in life. To know whether these persons can recover with functional oriented music therapy we will first have to reach the answer to at least the following three questions. 1) Is it possible for the adult brain to change? 2) Is it possible that the adult brain can change with exercise? 3) Is it possible for the adult brain to recover after an injury?

#### **3.1. Is it possible for the adult brain to change?**

It was earlier thought that, once a human was adult, the brain could not change. Therefore evidence of neurogenesis was in the mid 70's still doubted. The thought was that mature neurons would have to replicate to lead to neurogenesis, which was seen as incredible (van Praag, Zhao & Gage, 2004). Studies in the 80's showed that there is a peak in the increase in the neurogenesis in songbirds at the time of year they acquire singing, and that adult chickadees have an increase in neurogenesis correlating with their seed- storing period (van Praag et al., 2004). These results raised the possibility that new growth of neurons might have a functional role in the adult mammalian brain, which led to a greater interest from scientists (van Praag et al., 2004).

In the 90's it was found, through culturing stem cells, that it is likely that in the living brain a population of immature stem cells proliferate and differentiate, which results in neurogenesis (van Praag et al., 2004). Thus new neurons can appear in the adult brain and rise from stem or neural progenitor cells (NPC) that exist throughout the central nervous system (van Praag et al., 2004). Local factors restrict the production of new neurons to the olfactory bulb and the hippocampus. And the only two areas in the adult brain where neurogenesis has been observed, are the sub ventricular zone (SVZ) of the anterior lateral ventricles that give rise to cells becoming neurons in the olfactory bulb, and in the dentate gyrus of the hippocampus, a brain region important for learning and memory (van Praag et al., 2004). However, these immature cells can not be isolated only from the SVZ and the olfactory bulb, but also from non-neurogenic areas such as substantia nigra, spinal cord, cerebral cortex, corpus callosum, and the optic nerve. In culture, these isolated cells can grow into neurons, which suggest that there is a potential of neurogenesis throughout the whole brain, but that there might be inhibitory mechanisms preventing it to occur in the living brain (van Praag et al., 2004).

The neurogenesis in the SVZ and the olfactory bulb is ruled by a number of environmental, pharmacological, hormonal, and genetic factors. The increase of the neurogenesis has been correlated with cognitive and mood improvements. However, the functional importance of new cell birth remains unclear (van Praag et al., 2004). A variety of environmental, behavioural, genetic, and neurochemical factors can influence the proliferation and survival of newborn cells. Treatments and manipulation which enhance the production of new cells have also been used to enhance cognition and mental health, while states such as stress and depression have been correlated with a reduced number of new cells (van Praag et al., 2004).

Van Praag et al. (2004) write that several growth factors are known to affect adult neurogenesis, such as: basic fibroblast growth factor (FGF-2), brain-derived neurotrophic factor (BDNF), and insulin-like growth factor I (IGF-I). Exercise results in increased levels of all the named growth factors above, and thus, also in enhanced neurogenesis. Studies on mice show that mice with different genetic makeup also have different levels of neurogenesis. Some mice might show a high level of cell proliferation but a low level of cell survival, while some mice have the reversed pattern, and some mice have high or low levels in both. Interestingly, the mice with low levels, and also low levels in neuronal differentiation, do not perform as well on spatial learning tasks as mice with the highest proliferation levels (van Praag et al., 2004).

Studies in the end of the 90's showed that stress in adult rodents and primates can reduce the level of proliferation. Adult neurogenesis has also been shown to decrease with age in rodents (van Praag et al., 2004). Neurogenesis levels change in some CNS diseases, for example, ischemia, and restricted blood flow increases cell proliferation in both SVZ and DG. The increase in cell proliferation is dependent on FGF-2. CNS injuries can also provoke neurogenesis in otherwise non-neurogenic regions such as cortex (van Praag et al., 2004).

To summarize, neurogenesis is a process of cell proliferation, migration, differentiation, integration and survival. Neurogenesis occurs in the olfactory bulb and the hippocampus in all those mammals that have been studied. This process is highly regulated by experience and disease, and genetics and aging are two key factors. Thus, Van Praag et al. (2004) describe which factors affect new growth of cells in the adult brain, which indicates that it is possible for the adult brain to change. However, it is not only a new growth of cells that is important in differentiations in the adult brain, but also synaptic plasticity and the brain's ability to reorganize structural maps to improve in different motor skills and more.

### **3.2. Is it possible that the adult brain can change with exercise?**

In standard laboratory housing conditions animals are kept in large cages, while an enriched environment includes nesting material, toys, and possibility to voluntary exercise and physical activity, such as running wheels for mice. Behavioural and molecular effects of enriched environment show an enhancement of survival of newborn neurons in the adult mouse hippocampus. In a later study, components such as learning and exercise were isolated and studied one by one (van Praag et al., 2004). Voluntary exercise in a running wheel showed an enhanced survival of newborn neurons in the dentate gyrus. Learning a hippocampus-dependent task called the Morris water maze did not influence cell proliferation or neurogenesis (van Praag et al., 2004).

van Praag et al. (2004) write that it is still unclear whether exercise is the critical component, or if there are other additional unique features in enriched living. Enrichment of the environment increases new cell survival in the DG but does not affect cell proliferation, while physical exercise increases both. However, neither of these affects neurogenesis in the SVZ. The effects may be similar but the underlying mechanisms for changes in cell genesis may be different.

#### **3.2.1. Animal studies on exercise and plasticity**

A large number of studies of cortical and subcortical plasticity of sensory and motor systems in adult mammalian brain have been made, and Kaas (2000) reports on some of them, including a classical example of cortical plasticity, which will be described later on. That sensory and motor maps in the brain of adult mammals are highly plastic means that changes in input and activity in modulating systems together with attention can produce slow or even immediate changes within systems so that also receptive field sizes, locations, and map topography changes. The rapid instantaneous changes are usually able to change back

pretty quickly, but can also strengthen synaptic activity and become more persistent. Some types of reorganizations take weeks to months to emerge, and there can be a massive reactivation after, for example, the loss of a limb or a stroke. Major reactivations like these depend on broad sprouting and axon growth to form new connections (Kaas, 2000).

Reorganization in sensory and motor maps in the adult brain may improve sensorimotor skills when practicing a task. Changes can also be produced by longer, localized sensory or electrical stimulation, which affects neurotransmitters, local growth of axons and dendrites, and alteration in synaptic strength (Kaas, 2000). Reorganization has been shown in cortical areas such as motor- and sensorimotor-cortex, but also in subcortical areas such as in thalamus and the brain stem. However, because of the horizontal connections, the cortical areas seem to be more modifiable than the subcortical areas are (Kaas, 2000).

Even if many studies have been done, only few regions of the brain have been thoroughly studied (Kaas, 2000). A large number of studies have concentrated to the hand map in primary somatosensory cortex of monkeys because there are some technical advantages. The representation in the primary somatosensory cortex is especially precise and the area representing the hand in primates is large, and in some primates this area is also exposed on the surface of the brain. This allows alterations in the cortex to be observed even with relatively less advanced measuring methods (Kaas, 2000). Changes produced by injuries are also easier to observe as they produce larger changes than learning. Alterations from an injury assume new neuronal growth (which has been described above) rather than synaptic strengthening as in learning (Kaas, 2000).

Recanzone (2000) describes evidence of long-term and short-term plasticity that follow from changes in stimuli pattern and practicing skills. Recanzone (2000) describes a study of cortical plasticity following operant conditioning in the somatosensory cortex of adult owl monkeys. The monkeys were trained in a tactile discrimination task using only a

small skin area of one finger. In the study, both the behavioural improvement of performance, and also relating the performance to the cortical representation responding to the skin area of the finger used in the task, was measured. The monkeys were trained to remove their hand when detecting frequencies above the standard of 20 Hz from a tactile stimulator. In the beginning, the monkeys could only discriminate larger differences but later also discriminate differences of only 1-2 Hz (Recanzone, 2000).

The representation in somatosensory cortex of the trained skin surfaces was increased compared to the untrained skin. Also the receptive field on trained skin was much larger than on untrained skin surfaces. It was also found that there were a greater number of neurons responding to stimulation on the trained finger compared to untrained finger or untrained monkeys (Recanzone, 2000).

The large representations of the trained skin and the correlated activity across neurons indicate, according to Recanzone (2000), that the population of cortical neurons became very selective in response, and responded synchronously to the same input relevant for the tactile task. Most likely there was an increase in encoding the stimulus frequency in the crucial neuron population (Recanzone, 2000). This resulted in better information on the stimulus frequency and thus improved performance in the task.

Some pharmacological studies suggest that acetylcholine (ACh) is crucial for cortical neuronal response changes (Recanzone, 2000). Direct stimulation of the nucleus basalis, which contains neurons that release ACh in the cerebral cortex after the onset of a stimulus, provokes a similar enhancement of neuronal response as a trained stimulus does. Thus, neuromodulatory elements might be required for these changes in the cortex (Recanzone, 2000).

Recanzone (2000) also describes studies, in both somatosensory and auditory cortex, where it was found that attention is important to change cortical representations.

Monkeys performing, and attending mostly to, an auditory task were also given tactile stimulation. However, the monkeys only showed changes in the auditory cortex, but not in the somatosensory cortex. This effect is believed to occur because the monkeys only attended to the auditory stimuli. Attending to a stimulus activates the neuromodulatory circuits such as just ACh, thus attending to a stimulus is seemingly necessary to change the cortical representations, however, this was not tested (Recanzone, 2000).

### **3.2.2. Exercise and plasticity in human cortex**

Using functional imaging techniques it has been shown that also in human cortex reorganization through training occurs. An example is that those who play guitar, violin or other similar instruments have a larger cortical activation from stimulation on the finger tips of their left hand than non-playing persons (Recanzone, 2000). Similar results were also obtained by Pascual- Leone, Dang, Cohen, and Brasil-Neto (1995). However, Pascual- Leone et al. (1995) also found that when letting people merely think of playing the violin, i.e., mental training, this can produce larger cortical activation in the left hand than normal.

Predictions from animal studies often apply on studies of humans as well. Previously described animal studies would in an experiment with blind Braille readers suggest that Braille readers would have increased representations in the finger pads they use for reading compared to a non- Braille reader, blind or sighted (Recanzone, 2000). Using scalp evoked potentials and transcranial magnetic stimulation of the sensorimotor cortex in both test persons and control persons gave evidence supporting the predictions. There is an increased representation of the fingers used most for the reading in both motor- and sensorimotor cortex.

In each case of cortical plasticity there is an increased representation of the trained stimuli, but because the size of an adult cerebral cortex is fixed, these data imply that

other cortical surfaces will decrease to make space for the expanding representations of cortical surfaces. Data from primarily animal studies suggest that practice at one task will change the cortical representations in favour of that skill and at the expense of another, untrained skill (Recanzone, 2000). However, this does not mean that learning something will necessarily result in forgetting something else, but the simple fact that unpractised skills degrade over time.

Clearly there are still anatomical and functional limits of the cortical reorganization and all neurons are not so easily changed. The medial geniculate body (MGB) in *ventral* division contains the most sharply frequency tuned neurons. Studies of this area do not show as large plasticity as the MGB *medial* division, which has more broadly tuned neurons (Recanzone, 2000). These results suggest that two parallel pathways exist in the auditory system, one being more easily affected by conditions and the other almost immune to such effects. Naturally, this is a survival force; the cerebral cortex has to maintain a good balance between all the necessary information for everyday life to take place and task specific information to improve (Recanzone, 2000).

According to van Praag et al. (2004) exercise can change cell survival and cell proliferation in the adult brain, but seemingly only in some parts of the brain. Kaas (2000) and Recanzone (2000) report that changes in input and activity in modulating systems can, together with attention, produce slow or even immediate changes within systems so that also receptive field sizes, locations, and map topography changes. Recanzone (2000) also reported evidence supporting predictions from animal studies, which often apply on studies of humans as well. Thus, there is research suggesting that it is possible for the adult brain to change with exercise and skill practice.

### **3.3. Is it possible for the adult brain to recover after an injury?**

As mentioned previously, alterations from an injury assume new neuronal growth (Kaas, 2000). Slowly emerging alterations, occurring over hours, weeks, and even months, involve mechanisms like activity dependent effects on the expression of genes. This expression of genes can lead to neurotransmitter regulation and release of factors altering the growth of dendrites and axons (Kaas, 2000). The recovery after an injury can be different in each case, described next is an example of reorganization and reactivation of somatosensory cortex.

One of the now classical demonstrations of cortical plasticity, according to Kaas (2000), is sectioning the median nerve to the skin of the thumb-half of the palm in monkeys. This provokes a reorganization of hand representation in primary somatosensory cortex. Sectioning the median nerve deprives about half of the hand representation of its normal source of activation. Some neurons in the deprived area immediately gain new receptive fields, probably because of disinhibition. However, most reactivation increases gradually over a few weeks until all deprived neurons are as responsive again to tactile input as before (Kaas, 2000). The reactivation comes from inputs in the hairy back of the hand, and the cortical recovery comes from inputs in regions formerly devoted to the palm surfaces of fingers 1-3. After the injury, these regions now become activated by the back side surfaces of the hand of fingers 1-3 (Kaas, 2000).

Additional anatomical studies have shown that nerves from each digit come together in a separate cluster of neurons in the cuneate nucleus. However, input from the back side and the palm side surfaces of the same finger come together in the same cluster of cells. This means that there is only a limited rewiring or potentiation of local connections in the cuneate nucleus needed for the neurons responsive to the palm skin to become responsive to the skin of the back of the hand (Kaas, 2000). Thus, reactivation of some of the deprived

neurons occurs in the cuneate nucleus. However, the outcome in cortex is not just simply to switch neurons in the cuneate nucleus from input source from the palm skin to the backside of the hand. It seems that the reactivation of neurons is relatively weak in the cuneate nucleus, but the signals are being relayed and potentiated in thalamus and then again relayed and potentiated in cortex. The potentiation is believed to depend on NMDA receptors and also aided by down-regulation in GABA expression. When chronically blocking NMDA receptors in an experiment, the reactivation and reorganization is prevented. The down-regulation of GABA in the deprived cortex follows the reduced neural activity (Kaas, 2000).

This now classical demonstration of effects of damage on the median nerve in monkeys leads to a number of conclusions, amongst these, the two below that Kaas (2000) also presents. First, subcortical structures are clearly plastic. The reactivation of the large hand subnucleus by preserved inputs from the back of the hand after a section in the median nerve presents strong evidence for subcortical plasticity. Second, the structure in cortical and subcortical maps may be different at different levels. The adjustment of inputs from skin of the back of the hand to skin of the palm in the cuneate nucleus appears to become larger in following levels.

This demonstration of cortical and subcortical reorganisation is only a small part of all the evidence from many studies (Kaas, 2000). Results that deactivation of nerves caused by injuries or damage is followed by reactivation from still existent inputs has been observed in several studied adult mammals. Kaas (2000) writes that reactivation increases gradually after an injury, until all deprived neurons are as responsive again to tactile input as before. It is likely that damaged regions can reactivate aided by input and potentiation of close by regions. Thus, the research described by Kaas (2000) indicates that the adult brain can recover after an injury.

## Summary

In the beginning of this section I posed the question: does exercise help to recover from injury? To find this out I had to ask another three questions; 1) is it possible for the adult brain to change? 2) Is it possible that the adult brain can change with exercise? 3) Is it possible for the adult brain to recover after an injury? The fact that the adult brain can change, via stem cell proliferation and differentiation, resulting in neurogenesis, was described by van Praag et al. (2004). It has also been shown that the brain can change via plasticity and map reorganisation when exercising or practising a skill. Recanzone (2000) confirmed that this goes for all mammals observed, including humans. Kaas (2000) finally supported the view that reactivation can occur after injury, in the classical study all deprived neurons became fully functioning, and thus, that the adult brain can recover after damage. Seemingly the mature brain is not totally fixed in function and organization but rather prepared for changing at input alterations, and from the research shown above I think we can conclude that it is likely that exercise can help the recovery from an injury.

## **4. Discussion; FMT and the empirical evidence**

In the preface I brought up an announcement for the FMT- method to play a complementary important role in an interdisciplinary professional team to a more general extent. The question is which role the FMT- method could play in both the school world and also in the field of health care. To answer this I first had to find out whether exercise improves academic achievements and if exercise helps recovery from injuries?

The studies described by Ayres (1972) and Ericsson (2003) both concern school children. While Ayres (1972) describes the differences in children with generalized dysfunctions and children with auditory- language dysfunctions, Ericsson (2003) describes

differences in normal school children and in children with motor skill problems. Even if Ayres (1972) specialized the exercise for each child's needs, and Ericsson (2003) only reports on general physical education, they both reach the conclusion that all children with extra motor training made more progress in academic achievements than the children with no extra motor training.

The FMT- method is described in the introduction to have a sensorimotor developing approach to help their adepts. Also according to Ayres (1972), a dysfunction in sensorimotor integration is a cause of the difficulties in children participating in her study. Stein et al. (2000) report only on deficits occurring in sensorimotor integration when altering a sensory modality per see. However, neither Ayres (1972) nor Ericsson (2003) directly report about children with any specific modality dysfunction. Ayres (1972) had a study group composed of children with auditory – language dysfunctions, but it is not clear if the dysfunction was due to some degree of deafness or not. Assuming then that the problems of the children with dysfunctions really are caused by a lack in sensory integration, the research from Stein et al. (2000) certainly makes an interesting discussion.

Stein et al. (2000) stress the importance of having coincident stimuli for a response enhancement. It seems to me possible that a misalignment in the topographical maps could result in a response inhibition instead. If so, the child would have problems in piecing together the inputs from the surroundings, which could leave the child confused and also unable to interact with the environment. Perhaps a deficit in the AES, or not properly specialized receptive fields, would have a similar effect. Obviously, these thoughts are here only speculations, but as said earlier, very interesting to discuss in relation to the FMT- method. If the FMT- method can help gaining better sensory integration, it could then help the child to interact better with its environment, and therefore in the end also learn better in school.

Taking together the conclusions made from Ayres (1972) and Ericsson (2003) that exercise does improve academic achievements, it is reasonable to say that the FMT-method can be a part of the school system. For the children with only extra need of motor training, the research from Ericsson (2003) supports the sessions of “MUISK”, described in the introduction. Stein et al. (2000) do not mention whether exercise could somehow strengthen sensory integration or not, but if assuming Ayres’s (1972) approach, there is support for FMT- sessions for children with special needs. However, this also assumes that the FMT-method really helps and trains the things shown to be working in previous studies.

To find out if it is reasonable to keep the FMT in health care, I first had to find out whether exercise can help recovery from injury. The viewed research by van Praag et al. (2004), Kaas (2000), and Recanzone (2000) indicate that the mature brain is not totally fixed in function and organization but rather prepared for changing at input alterations and practicing skills, also to regain activity in injured nerves. I think it is thus reasonable to conclude that exercise can help the recovery from an injury. However, if the FMT- method offers the exercise required is still difficult to say. As mentioned in the preface, Mikael Forslund pointed out that there are no national studies saying which specific improvements the FMT-method means, for each specific group of patients.

However, let us make a little thought experiment; assume that the above discussion is true, that the children described in Ayres’s (1972) study have a dysfunction in sensory integration and that the children with these deficits are being helped by the FMT. If these dysfunctions in brain structure and behaviour are not only due to an error in development but can also be caused by car accidents or a stroke, then theoretically, the FMT-method should be able to help this patient group as well. Thus, it is also reasonable to say that the FMT-method can be a part of health care. However, this might then only be for those with development, motor, and sensory problems.

#### **4.1. Possible problems for the FMT- method**

The FMT- method is described to take on many types of patients. Thus, a possible problem for the FMT- method is the wide range of deficits in the patient groups, and the next question for the FMT- method to examine is whether one treatment's results can generalize over a wide range of problems. To make any conclusions on this issue, I believe a theoretical study is not enough, but there is a need for specific experiments to find out about the more specific connections between the treatment, different problems, and recovery.

Hjelm (2005) reports a few studies done with patients with autism, dyslexia, schizophrenia, rheumatism in muscles and soft tissue, exhaustion depression, and patients in need of crisis rehabilitation. However, what I miss in these reports is the comparison to general statistics about each patient group. For example, the children with infantile autism responded more and more to the music codes in the FMT- method and were later in life diagnosed with ADHD, but there is no comparative statistics on how many children diagnosed with infantile autism, and who have not received exercise with the FMT-method, which were later in life diagnosed as ADHD.

The patients with rheumatism in muscles and soft tissue expressed having less pain, but even if one woman stated that she had taken less medication, there is still a lack from the therapist's side to report whether the adepts could stop taking other treatment forms. The adepts' subjective comments about the FMT-method seem to be alike whether they have any sort of diagnosed difficulties or if they have just chosen FMT- exercise because of curiosity. Utterances like; "I sleep better", "I feel generally more relaxed", and "I am starting to take more initiatives", are reported by many adepts. The therapists are also evaluating the adepts' movement patterns. However, even if the therapist is trained to do such an evaluation, it is still a subjective evaluation.

Hjelm (2005) suggests that the patients treated also have had barriers hindering their development of the nervous systems, and in releasing these barriers with FMT treatment a further maturation of the nervous system will aid the patient to progress in their initial diagnosis. However, this reasoning only leads back to whether the FMT- method can generalize over a wider range of difficulties than just motor and muscular development. To know the answer to that, more thorough studies looking at both subjective and objective aspects need to be conducted.

I believe there is a delicate balancing between subjective and objective aspects. A strength for the FMT- method is starting from the level of the adept, and if the result is that the adept experiences positive changes, then why should scientific scepticism of what is not yet described with underlying processes result in questioning the experienced well being of an adept? However, when it does come to evaluating the underlying causes of the effect, the subjective experience has to be combined with objective tests. There is a need of more objective evaluations of the therapists' reports as well, to know whether it is the method in itself doing the work, or perhaps only the encounter with the therapist. Hjelm (2005) describes a study where twelve adepts met two different therapists, and none of the adepts reacted differently to the two therapists. The conclusion of the study was that it is the method creating the improvement and not the therapist self.

However, if we take the well known placebo-effect into account, the results remain uncertain. For some people the mere experience of meeting a therapist in a comfortable environment can have a positive effect. A classical example of the placebo effect is that if a person receives medication not containing any substance to improve a problem, the person can still experience a positive improvement in the belief that the medicine is working. In Kirsch and Sapirstein's (1999) analysis 75 % of the improvement from the actual drug can, for the average patient, also be obtained from a placebo effect. Kirsch and Sapirstein (1999)

write that placebo treatments can produce changes in pain, anxiety, depression, alertness, tension, sexual arousal, drug withdrawal symptoms, aggression, asthma, and hypnotic responses. Placebo effects are seemingly produced by specific response expectancies, and other reasons like classic conditioning, therapeutic relationship or other general expectancies can not be counted for improvement (Kirsch and Sapirstein, 1999).

The placebo effect can be estimated by taking the placebo response minus the non-treatment response (Kirsch and Sapirstein, 1999). Thus, if possible, to conduct experiments where the placebo effect is estimated might be a good way to find out for which patient types the FMT-method is effective.

#### **4.2. Future questions**

I have no doubt that the functional oriented music therapy, and other similar treatments, have a bright future. Seemingly, the FMT-method is effective both within school and in health care. However, as we have seen throughout this essay it is not clear which types of patients are really helped by the treatment. I think the future question for the FMT-method is who to prioritize.

The FMT-method is initially developed with and for people with sensorimotor problems. And even if the method has proved to work on some patients that are not diagnosed with sensorimotor problems, it is still uncertain if the method applies for all the patients with no sensorimotor problems. Maybe adepts who are psychically ill, for example, can be given better help somewhere else, or for relaxing purpose have some kind of music study circles like MUIISK, or like the ones Hjelm led before he started working at the Folke Bernadotte home. A reorganization in how much time is spent on which adepts could lead to devoting more time for the adepts with development problems and motor/perception integration difficulties, which seemingly is the target group.

I believe it is important to specify care and education to fit a person's needs to gain the biggest improvements. Thus, to make the FMT- method as effective as possible there is a need for further experiments for each type of patient, where questions like if it works and how it works are stated. The FMT- method emphasizes the importance that the adepts are given time to assimilate what they have learnt in each session. However, looking at Ericsson's study (2003), there was a difference between those who had physical education only two hours a week to those with five hours a week. Maybe this is a good place to start an experiment; to see how the amount of time of FMT-treatment affects each adept and different types of patients. Other combinations could then be added to the study, maybe by taking example from Recanzone's study (2000) about braille readers, and the study from Pascual-Leone et al. (1995) about violin players. These seem to relate to the FMT- method since Hjelm (2005) also claim that the use of different drums is supposed to enhance the tactile perception. Thus, if possible, transcranial magnetic stimulation could be additionally used as a testing advice before start having the FMT-therapy and after a certain time of using the method. Hence, such a study could contain both subjective and objective measures, which seemingly could take also a placebo effect into account. An overall study or perhaps a number of small studies should thus be able to help make the FMT-method even more effective.

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