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MUSIC AS THE GOAL OF TRAINING AND MEANS OF REHABILITATION: EVIDENCE FROM BRAIN SCIENCE

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ABSTRACT

During the past three decades, our knowledge about brain functions and its structures underlying music perception, performance, and emotions has accumulated relatively quickly. Cortical and subcortical brain areas involved in these musical functions have been identified using various techniques and paradigms.

In the present talk, I will introduce recent findings revealing enhanced brain mechanisms during long-term musical training, as well as by informal music activities at home. Furthermore, I will present examples of how casual music activities, such as music listening and singing, can be used in neurological rehabilitation to promote health and wellbeing in patients and their family members.

In sum, these findings promote the use of music in formal and informal settings across the whole life span in healthy participants, as well as with individuals with special needs.

1. INTRODUCTION

During the past 30 years, pioneering knowledge about the neural basis of musical activities has been acquired in several complementary empirical and methodological frameworks. The earliest endeavors aimed at determining the brain functions involved in music-sound perception and cognition in healthy adult participants. Thereafter a developmental approach was also adopted. In parallel, investigations on musical expertise were started.

Currently, these lines of research are still active, but they are appended by systematic studies on music emotions and preferences as a newly established field of neuroaesthetics. Importantly, findings in all these fields of neurosciences of music are systematically used in applied settings in education and rehabilitation.

In the following, the basic brain functions and structures of music processing will be described (Section 2), and followed by key findings in music development (Section 3) and music rehabilitation (Section 4). The paper will end with general conclusions.

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2. MUSIC IN THE BRAIN

All sounds are perceived via neural transfer from the inner ear and subcortical nuclei to the auditory cortices in the temporal lobes in both left and right hemispheres. In the case of music, this sound-specific activation of primary auditory areas in the upper part of the Sylvian fissure is necessary, but not sufficient for an elaborated musical perception to form, and emotions to emerge. It needs to be supplemented by further neural activation in the brain areas governing cross-modal (e.g., audio-visual and audio-motor) processes, focused attention, and regulation of emotions and alertness [1]. Since these functions are determined by highly distributed neural networks which occupy many brain areas, it is safe to say that for intentional and emotional music listening we need most parts of our brain. In the case of music performance this is even more apparent – then the cerebellum and sensory as well as motor cortices also need to be active and in sync.

3. DEVELOPMENT OF MUSIC SKILLS

3.1 Studies on adults

Knowing now which parts of the brain are activated by music listening and performance, we can ask what are the brain areas that can be shaped by musical expertise.

Initial findings in this area emphasized neuroplasticity as observed in the primary sensory areas in the cortex - particularly in the auditory [2] and in the somatosensory [3] areas. These brain responses were stronger in musicians than in laymen and, importantly, stronger in those musicians who started their training early (before the age of seven) than in those who started later.

More recently, these findings were replicated using several brain research methods on both brain function and brain structure [4]. Additionally, they were augmented by results indicating that musicians are not “a homogenous group of experts in sound and motorics”. Instead, they display different structural brain indices and neural auditory responses as a function of their background in training, for instance, with regard to the primary instrument and music genre they are most attached with [5, 6].

These studies on adult musicians were considered as an interesting window to the outcome of neuroplasticity in the music domain. Yet, they unfortunately left unanswered whether there was a neurocognitive readiness already present in the brains of those "musicians-to-be" prior to their training. In other words, could it be that the musicians in general, and the early starters in particular, had some skills which motivated their parents to pursue musical training' For instance, they display sensitivity to music in general, accurate discrimination and error detection in pitch and rhythm, preference to sing or play any instrument, or even a non-instrument like a table or a box.

3.2 Studies on children

When studying children and their development during music training, we are able to complete initial investigations to the onset of the music training. By these means, we can determine the "kick-off" level of their neural and behavioral functions, and can compare that to "control" children who have hobbies with a comparable frequency and intensity as the musically oriented children, but without the involvement of sound-related actions. These recordings are conducted first before the training onset, and second, after the commencement of the training (e.g., after 6 or 12 months).

In the first studies in this field, however, this opportunity was not used. Yet, these pioneering findings strongly indicated that already after a relatively brief 1-year training program, music had enhanced timbre-specific brain responses to the child's own instrument [7] implying training-induced modulation of the auditory brain activity. Due to these strong findings, follow-up studies were started. In these studies, the participating children were either randomly allocated into music activities or other (e.g., painting, theater) activities [8]; or, they were recruited from children who were randomly allocated into different music programs [9].

These studies point strongly towards the following conclusions: First, music training facilitates the auditory (perceptual, cognitive) and motor functions which are crucial to music perception and performance, namely, auditory, motor, and neural transfer between the left and right hemispheres [9]. Second, even informal, familial music activities at home, such as singing, dancing/moving with the music, listening to music, etc.; can modulate brain indices reflecting attentional functions [10].

4. MUSIC REHABILITATION

If music activities can boost a healthy, normally developing brain as the previous subsection documented, would it also be feasible to assume that music can "repair" brain functions after brain damage? This has been the assumption and justification for various kinds of music therapy and music rehabilitation for some time. However, only recently has this assumption received systematic scientific support. One of these successful initiatives with neurological patients will be introduced below. Further evidence to support the use of music in clinical settings, particularly in patients with memory disorders, will be given in the talk.

4.1 Music listening in neurological rehabilitation

A stroke, a sudden disorder in the blood circulation in the brain, can cause various perceptual, motor, and/or cognitive impairments. Thanks to the neuroplasticity of the brain, those impairments can be rehabilitated and sometimes even fully recovered; however, symptoms often remain and may even lead them to retire.

Since any neurological rehabilitation is most effective right after the damage, it was our intention to look for a treatment which is readily available after hospitalization. Music listening was the most obvious choice - readily available and cheap to implement. We recruited 60 patients who had had an acute stroke and randomly assigned them to three groups: 1) music listening (experimental group), 2) audio-book listening (control group with non-musical auditory stimulation), 3) standard care (control group). Their recovery was followed by a multitude of testing in listening [11], neuropsychological functions [12], and brain activity, [13] as well as interviews [14].

It turned out that the patients who were guided to listen to their favorite music for about one hour a day for two months had the fastest recovery as indicated in the cognitive tests for attention and memory. Additionally, the patients guided to listen to music or audio books had less confusion and depression, so, in other words, their emotional recovery was advanced compared to patients who belonged to the control group (with standard care but no further rehabilitation on top of that).

5. GENERAL CONCLUSIONS

During past two-three decades, our knowledge about the brain functions underlying music activities has accumulated relatively quickly. Currently, we are at the stage of finding and evaluating ways to improve brain functions by using music, e.g., with children and with neurological patients. We can predict that music has a great potential to facilitate emotional and cognitive functions on various groups of participants with special needs in learning and rehabilitation.

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