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Fundamental Sensory and Motor Neural Control in the Brain for the Musical Performance

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Abstract

Music has beneficial power physically and psychologically. Among Integrative Medicine (IM), music therapy (MT) has been useful, and authors have continued research for IM, MT, and piano-playing. Most pianists do not consider the movement of their fingers, because the memorized process is transformed into automatic action. The function may involve the neural signals from the superior parietal lobule to the primary motor area and dorsal premotor cortex, which is called the sensory-motor transformations. The supplementary motor area (SMA) in the frontal lobe seems to be involved in the function of beat-based timing, expression, and activity of musical behavior.

Keywords

Integrative Medicine, Music Therapy, Superior Parietal Lobule, Sensory-Motor Transformations, Supplementary Motor Area, Piano-Playing

Abbreviations

IM: Integrative Medicine; MT: Music Therapy; SMA: Supplementary Motor Area

From a holistic point of view, Integrative Medicine (IM) has been developed worldwide [1]. Music has beneficial power to human beings physically and psychologically [2]. Authors and colleagues have managed various IM activities in the Shikoku Division of Integrative Medicine Japan (IMJ) and developed music therapy (MT) for years [3,4]. Several recent topics concerning MT, piano-playing, brain mechanism, and neuroimaging will be described in this article [5].

A comparative study using EEG was conducted among listening to neutral music, happy music, and control for 62 subjects [6]. As a result, happy music showed the efficacy of reducing anxiety and elevated functional connectivity of the right temporal lobe and occipital lobe. For brain research, the important condition requires three functions, correct sensory input, correct processing and determination, and output to the correct movement. Regarding this point, other cases with impaired dysfunction exist. For example, Parkinson's disease has involuntary

movements, and cerebral palsy has both contractions of flexor and extensor muscles simultaneously. If dystonia movement in the hand may be found for a pianist, it is difficult to play the piano smoothly [7,8].

When playing various music on the piano, most pianists do not consider the movement of their fingers, in which the movements are almost reflexive [9]. The reason would be that the memorized process is transformed into an automatic action [10]. The function may involve the neural signals from the superior parietal lobule to the primary motor area (M1) and dorsal premotor cortex, which is called the sensory-motor transformations [11] (**Fig-1**). Furthermore, this mechanism also contributes to the situation where a pianist can play a new music piece smoothly that is encountered first time [12].

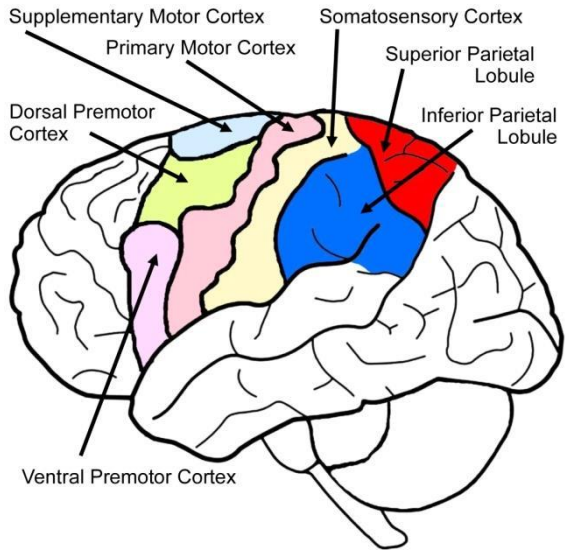

Fig-1: Various area for sensory-motor transformations in the brain function

During playing the piano, each movement of the fingers is a single action of raising, spreading, and pushing the keyboard down. However, this performance is integrated into a huge and complex movement along the time axis using 10 fingers [13]. Continuing independent operations in the correct order is called "series operation". This is to arrange a variety of actions in the correct order along the time axis [14]. Such function has been related to a certain area in the cerebrum. Its responsive area would be mainly the primary motor area (M1) and supplementary motor area (SMA, supplementary motor cortex) in the frontal lobe [15]. This area can contribute to the actual mechanism for complex and delicate movement for playing the piano. The function is thought to be stocking images of several actions together and executing the program in the correct order. SMA has been known as the crucial center for managing the planning of the program and performing the execution during playing the piano and listening to the music [16]. Music performance needs combined perspectives processing in visual, auditory, spatial, motor, and emotional domains. By integrating these multimodal factors, the SMA network may construct the internal expression of music performance.

As to the research of finger exercise, the changes in the excitability of M1 and SMA were investigated for 28 normal subjects [15]. The results showed the activity of increased M1 and decreased SMA. Consequently, it supposes the function of each of MA and SMA. In other words, rather strong exercise seems to give M1 protective efficacy and it gives opposite influence to SMA situated just adjacent to M1. SMA can work actively when starting new and complex movements, but on the other hand, it does not provide remarkable function when performing familiar movements one after another. Therefore, it is suggested that SMA contributes to the piano performance when the finger moves like never before in contact with a new music piece [16]. From the above, it is considered that SMA may have two functions. One is the start and control of complicated operations, and in particular, to build a program for what kind of operation is performed at adequate timing. The second is to switch the movement, which is considered to contribute to the creation of new complicated movements and procedures based on the memory conventionally already stored.

Several recent reports are found concerning the function of SMA. Regarding the research of neuroscientific field, investigations of musical creativity have brought the involved mechanisms of motor regions [17]. They include SMA, premotor cortex, posterior inferior frontal gyrus, which seem to be implicated for high level capacities concerning motor sequencing. As to regular rhythm in music, the presence of the background was studied for non-human primate. By maintaining the rhythm of visual

metronome, neural activity of SMA was recorded. SMA showed regular rhythmic gamma band bursts (30-40Hz) suggesting the existence of internal tempo center [18]. Consequently, SMA may have a role of dynamic metronome for rhythm and clock for total time. Regarding the brain mechanism composing creative music, comparative study was conducted between musicians and non-musicians for measuring evoked activation by functional magnetic resonance imaging (fMRI) [19]. The results showed that musicians revealed larger activation of the SMA, dorsolateral prefrontal cortex and anterior cingulate cortex. From these, SMA may play a role for the expression and activity of musical behavior. Music improvisation has been the complex creative behavior. Brain activity during improvisation was investigated using fMRI [20]. Compared with pre-learned certain melody for control piece, music improvisation showed stronger node activity in SMA, lateral premotor cortex, dorsolateral prefrontal cortex and Broca's area.

In summary, recent neuroimaging topics were introduced. Among them, SMA seems to be involved in the function of beat-based timing, expression and activity of musical behavior [21]. Research on music, MT, and piano performance from empirical, theoretical, and practical perspectives has been developed [22]. In the future, it will reduce people's mental stress and contribute to happiness of the people.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

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