A Literature Review on Music Supported Rehabilitation

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Abstract

Music is common and widespread in human's social life. The music perception is related to multiple brain activities. Recent researches on neuroscience are trying to use specific music as an invaded approach on areas of after stroke rehabilitation or rehabilitation for Parkinson's Disease (PD). As the principles of the neuroscience is becoming more and more clear, some state-of-the-art techniques are introduced to explain the deeper reasons of the behaviours, and how we could better use music to help rehabilitation in some neuro-related diseases.

Keywords: Aphasia, Stroke, Parkinson's Disease, Music

1 Introduction

1.1 Pathology

Diseases like Aphasia or Parkinson's Disease (PD) are caused by pathological change in brains.

1.1.1 Aphasia

Aphasia is most often caused by stroke, but any disease or damage to the parts of the brain that control language can cause Aphasia.[5]. A research shows that when some parts of the left brain been damaged, it would be very likely to cause the Aphasia.[10]

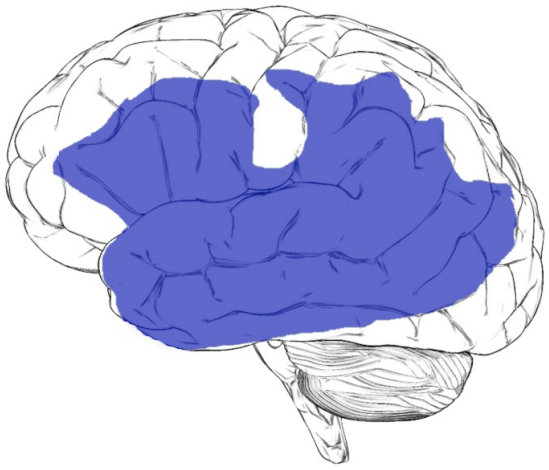

Figure 1. Regions of the left hemisphere that can give rise to aphasia when damaged[10]

The area includes two important parts of the language function including Wernicke's area[2] and Broca's area[15]. The major characteristics of different types of aphasia according to the Boston classification is shown below.

	Speech Repetition	Naming	Comprehension
Broca's Aphasia	Moderate-severe	Moderate-severe	Mild difficulty
Wernicke's Aphasia	Mild-servere	Mild-servere	Defective
Global Aphasia	Poor	Poor	Poor

Table 1. Major characteristics of different types of aphasia according to the Boston classification[16]

1.1.2 Parkinson's Disease (PD)

Parkinson's Disease (PD) is a disorder of the motor system caused by dying cells in Substantia Nigra[6], which behaves as an important dopamine regulator in the Motor System.[11]

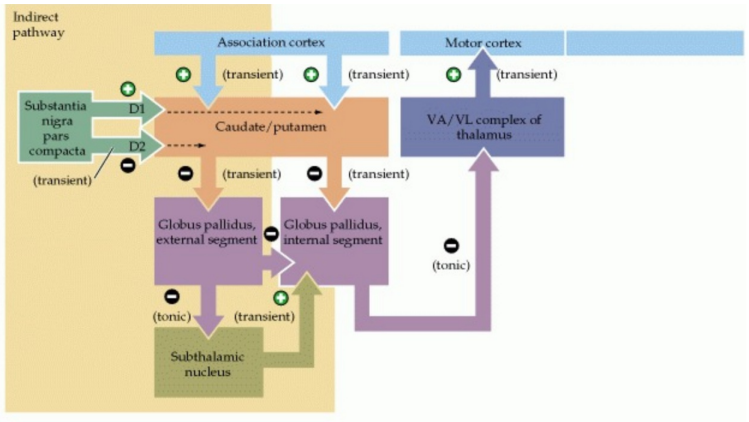

Figure 2. Circuits of the Basel Ganglia[17]

The most obvious symptoms of PD patients are shaking, rigidity, slowness of movement, and difficulty with walking. The disorder of Substantia Nigra makes people almostly impossible control the motor system like normal people.

1.2 Pitch and Beats of Language

When talking about the similarities between the Music Perception and Language, it's obvious to find that both of them have properties of pitch and beats. From the linguistics' points of view, these properties other than consanants and vowels are called Suprasegmentals, which includes stress, tone, word juncture, and etc.[14]

A series of iconic tone letters based on a musical staff was devised by Yuen Ren Chao in 1930 and adopted into the International Phonetic Alphabet.[4]

Figure 3. Register tone[4]

We also find a similar concept in linguitics called Mora comparing to the beats in the music, which is a unit in phonology that determines syllable weight.[22]

These provide the theoretical basics on converting language into music.

2 Related Work

2.1 Melodic Intonation Therapy (MIT)

Based on the the reasons of Aphasia, an obvious way is to stimulate related neoros. A transcranial Direct Current Stimulation (tDCS)[21] method is introduced to stimulate the Broca's area have a positive effact on Broca's Aphasia Rehabilitation. One major problem of the tDCS solution is that tDCS is not accurate, which could not provide stable effects on patients.

For Broca's Aphasia, a lot of patients are still able to perceive music and sing properly.[19] In that case, music could provide a solution for recovering patients' speech ability by trying to make people understanding speech by music perception. The Speech-to-song illusion[8] gives an example that when repeating a sentence with the same pitch and beats continuously, people would try to process the auditory information with the music perception instead of language perception.

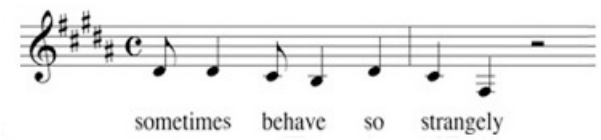

Figure 4. Speech-to-song illusion[8]

The Melodic Intonation Therapy (MIT)[1][19] uses both phonetic and physical signals to strengthen patients' language ability by music perception.

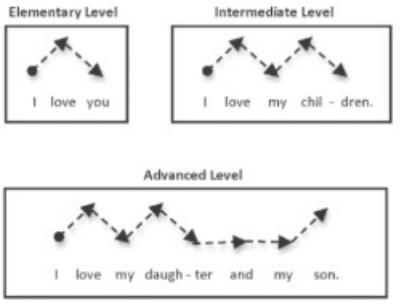

Figure 5. A phonetic labeled English example for MIT[1]

Both interventions' post-treatment outcomes revealed significant improvement in propositional speech that generalized to unpracticed words and phrases; however, the MIT-treated patient's gains surpassed those of the control-treated patient. Treatment-associated imaging changes indicate that MIT's unique engagement of the right hemisphere, both through singing and tapping with the left hand to prime the sensorimotor and premotor cortices for articulation, accounts for its effect over nonintoned speech therapy.[19]

2.2 Rhythmic Auditory Stimulation (RAS)

The motor cortex is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements.[13] Deep Brain Stimulation (DBS) is introduced to cure Parkinson's Disease by using artificial stimulation to take the role of Substantia Nigra.[7] But taking surgery in the Midbrain is risky. It also requires the stimulation signal more accurate to decrease the side effects.[3]

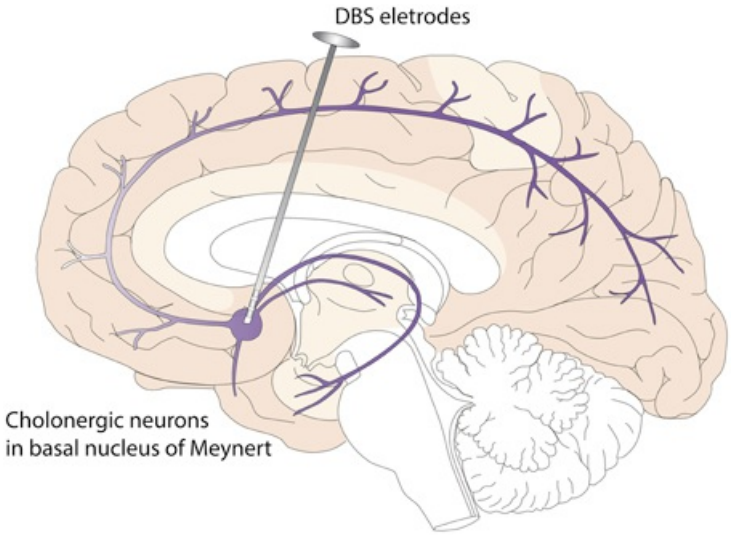

Figure 6. Drawing of DBS electrodes deep in the brain (side view)[23]

The music perception process is also connected to the motor system in the brain.[12] We also found some examples that with the help of music, the perception system could temporarily take the role of Substantia Nigra.[18]

The Rhythmic Auditory Stimulation (RAS)[20] is an artificial approach to enhance this effect. By playing rhythmic music, the perception of music makes the patient motor with the beats, which makes patients much easier to move. A recent research makes the SEP hypothesis[9] to explain the phenomenon.

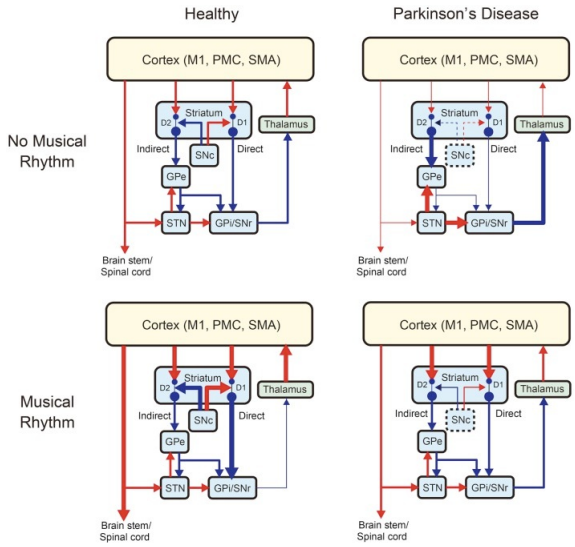

Figure 7. SEP hypothesis schematic model[9]

3 Conclusion

The Music Supported Rehabilitation introduces some invaded approaches on areas of after stroke rehabilitation or rehabilitation for Parkinson's Disease (PD), which produces some positive and stable results on rehabilitation. The process of figuring out the reasons behind the Music Supported Rehabilitation make we better understand human's brain from a cognitive way, which makes we introduce better treatment on neuro-related diseases.

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