SO YOU THINK YOU CAN DANCE OR NOT?

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INTRODUCTION

Music is the science or art of ordering tones or sounds in succession, in combination, and in temporal relationships to produce a composition with unity and continuity. This phenomenon has a variety of functions, and responses, but dancing to music is the concentration of this research. Music is said to have originated in Africa from simple rhythmical movements like toe tapping and hand clapping. It influences human behavior and mood through perception, involving the nervous system and connecting physiology and psychology. Dance is unique because it requires precise timing of several hierarchically organized actions, carried out through many effectors based on the individual's experience in dance training and creativity. Listening to music, affects sets of complex brain processing systems, like sensory-motor processing and functions related to memory, cognition and emotion. There is no single music center within the brain, because different aspects of music activate different regions of the brain. The brain regions break down the various components of a musical piece to provide an output of specific rhythmical patterns of motion. The research topic tries to answer the question on the presence of a difference in the brain activity of a professional dancer and an unprofessional dancer. Listening to music requires at least three basic motor control functions: timing, sequencing and spatial organisation of movement. These functions mediate complex behaviours, which are controlled and interpreted by several cortical regions, sub cortical regions, motor areas and most importantly, mirror neurons, by converting incoming sensory information into motor instructions and actions[2, 6, 9, 10]

How dance results from music

The deep relationship between music perception and movement generation begins with the tapping of the feet and the fingers which has evolved into a complex combination of specific patterns of body movements known as dancing. Dancing depends on the timbre of the music, but in general it is instinctive because of the emotional and psychological affiliation with music. Music relays a cognitive connection with the ability to gather emotion from motion. The pairing of a particular emotion to a melody is the same as combining certain spatiotemporal features. Recruiting the insula, which is a neural relay between the limbic and motor systems, does this motion-emotion activity. The question "How does dance result from music?" is answered by the philosopher, Leonard Meyer who argued that music sets up sonic patterns and regularities that compel us to make unconscious predictions about what comes next and some interpret this through dance if not mentally. This tells us that human beings posses the ability to make sequential series of movements with accuracy and creativity not only to deliver specific patterns, but also to make new ones. This creative act comes from thinking as well as making movements that are learned. Sensory awareness receives new impulses to movement that arise in the heat of the moment and the musical accompaniments improve timing, rhythm and coordination.[1,2, 13]

How dance results from Brain activity

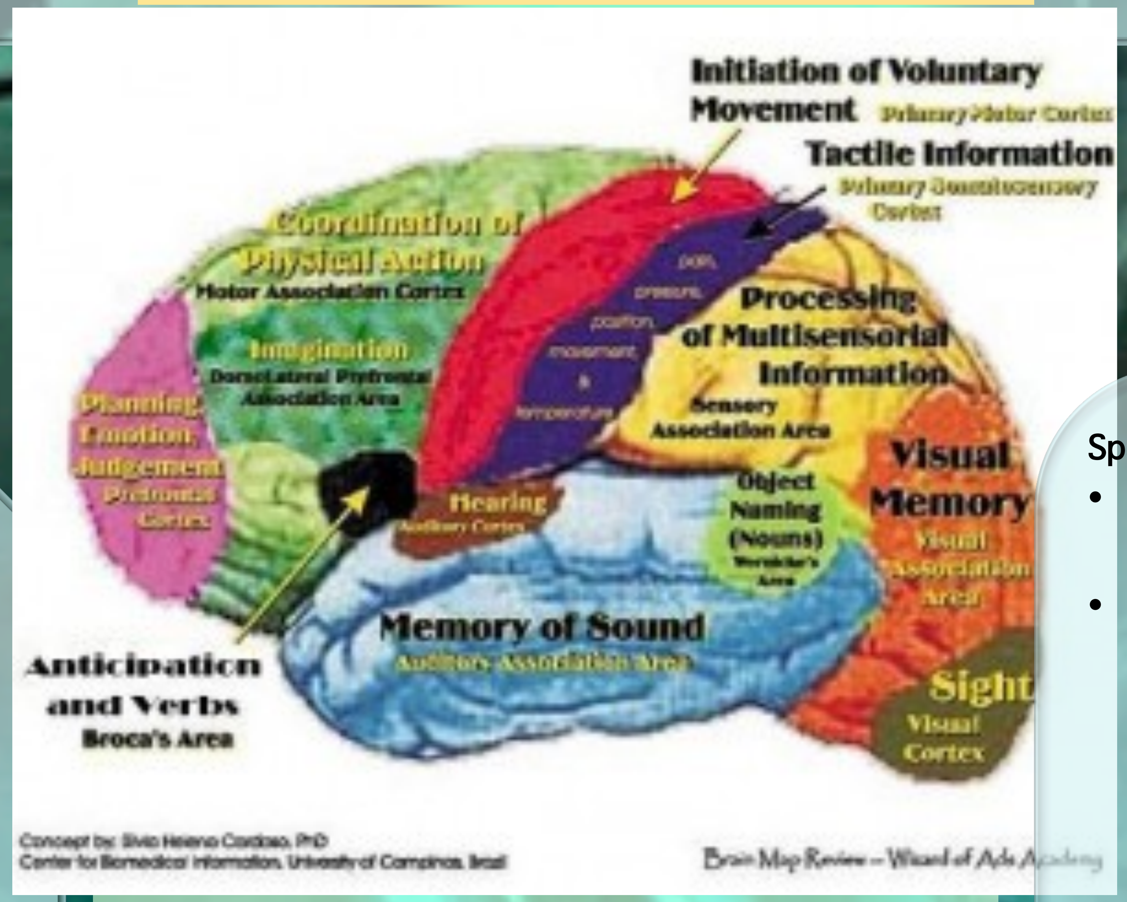

Fig.3 Modified from Lieff, Jon, M.D. "Music Training and Neuroplasticity." *Jon Lieff MD*. http://jonlieffmd.com/blog/music-training-and-neuroplasticity

Timing:

- The basal ganglia and possibly the SMA are used for interval timing at longer timescales and control of specific motor parameters
- The basal ganglia is active during actions like: finger tapping
- Patients with Parkinson's disease prove the involvement of the basal ganglia in movement timing due to damaged basal ganglia and impaired movement timing.
- The cerebellum controls motor timing at shorter timescales, perception, feed forward control, error correction and movement prediction. [8,11]

Rhythm:

Just like music, a single brain region does not control motor timing.

- dPMC, lateral cerebellar hemispheres and the prefrontal cortex are involved in the perception and reproduction of complex musical rhythms
- The cerebellum controls sequence learning and integrates individual movements into unified sequences
- The pre-SMA and SMA organize or chunk complex movement.
- The premotor cortex is involved in tasks that require the relatively complex sequences, and contributes to motor prediction.
- Damage to the left or right hemispheres compromise tapping of rhythmic patterns.
- Rhythmical patterns of easy to memorize tones are related to the left hemisphere areas, while difficult tones are related to the right PMA and the cerebellum.[1,3]

Spatial organization:

- The dPMC plays a role in the learning of spatial trajectories.
- The basal ganglia, SMA, pre-SMA, cerebellum, the premotor and prefrontal cortices, help in the production and learning of movement sequences, but their specific contributions and the way they work together are not yet clear.
- The interaction between the frontal cortex and basal ganglia aid in the learning of movement sequences.
- The basal ganglia contribute to well-learned sequences .
- Mirror neurons convert incoming sensory info into motor instructions or actions and mediates complex behaviors like imitation or awareness of actions performed by others during Choreographing
- Visual and auditory stimulus activate the mirror neurons.[11]

Music and Brain Activity

Daniel Levitin of McGill University and his colleagues carried out an experiment that showed brain patterns of activity while listening to music as well as patterns of activity within the brain that is unique to music. The control group listened to non-musical tunes while the experimental group listened to a musical piece.

- The first discovery: both groups showed similar brain activities in similar areas such as, the auditory areas of the thalamus, the temporal cortex of the right hemisphere and both sides of the right parietal cortex.
- The second discovery: presence of activity in the premotor cortex that is associated with the planning of movement.
- The third discovery: Within the main auditory centers of the brain, the thalamus and the temporal cortex, play critical roles in processing music.
- The fourth discovery: The different pitches of music are represented by different regions of the brain, arranged in an orderly and predictable fashion going from high to low like the keys of a piano. The sulcus or fissure of the temporal cortex produces pitch and represents different sounds.

Activity within the brain regions tracked the aspects of musical structure over time similarly in all individuals despite the level of musical training. [2,9]

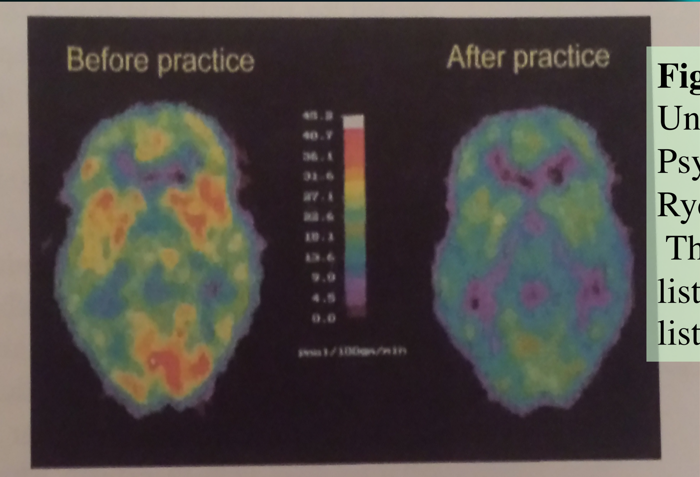

Fig.1 Modified from Custom Publication for the University of Alberta "Psychology 104: Basic Psychological Processes."(2013) McGraw-Hil Ryerson.
This image compares the brain activity when listening to music and when there is no music to listen to[3].

Neuroscientists Anne Blood and Robert Zatorre at McGill University proved that people listening to pleasurable music have activated the limbic and paralimbic regions of the brain, that are connected to euphoric reward responses, like during sex, eating good food and taking addictive drugs. Those rewards come from the gush of a neurotransmitter called dopamine within the nucleus accumbens. Another brain region activated due to emotion and music association is the amygdala. Music also involves the recollection of melodies and expectations about rhythm and harmony and thus involves the frontal and prefrontal cortices.[2,9,10]

Fig.2 Modified from Kahawidance.org 'Kahawi Dance Theatre', 2015. This image shows a scenario where the Mirror neurons take action in the mimicking and learning of movement. They remain active as long as a movement is being observed and fire the exact same way while doing a dance routine or observing someone else do a dance routine so it does not explain the difference in brain activity of a dancer and a non-dancer, but is the reason why dancers move to music and are able to pick up a choreography.

CONCLUSION

- Music and dance are particularly pleasurable activators of the sensory and motor circuits known as mirror neurons.
- High-level control of sequence execution involves the basal ganglia, PMC, cerebellum, dorsal premotor cortex and SMA.
- Fine-grain correction of individual movements controlled by the cerebellum.
- The limbic and paralimbic regions, the nucleus accumbens and the amygdala that are activated by the pleasure, motivation and emotional response gotten from listening to music.
- Neuroimaging techniques have shown that the difference in the brain activity corresponds to the increase in volume in the brain regions in professional dancers who exhibit more rhythmical movements compared with non-dancers.
- Mirror neurons do not explain the difference in the brain activity of dancers and non-dancers, but it is essential for movement coordination, development and learning.
- Varied rhythmic responses of motion come from an individual's training experience in music and dance, their brain's health condition and the condition of their muscles.
- However, we may be able to get more specific and accurate results in the future with the help of more advanced technology that could monitor brain activity while in motion.
- Questions that arose from this research were:
  - Is the orderly organization of pitch by the brain present in all humans or unique to those able to differentiate pitch?
  - Would the brain regions responsible for movement planning and timing still show activity in people incapable of moving or that have lack of coordination due to a disability if they just listened to music or imagined a dance movement to accompany the music?
  - And finally why some people "have rhythm" more than others? Because being able to respond with proper rhythm can be learned or innate.[6,11]

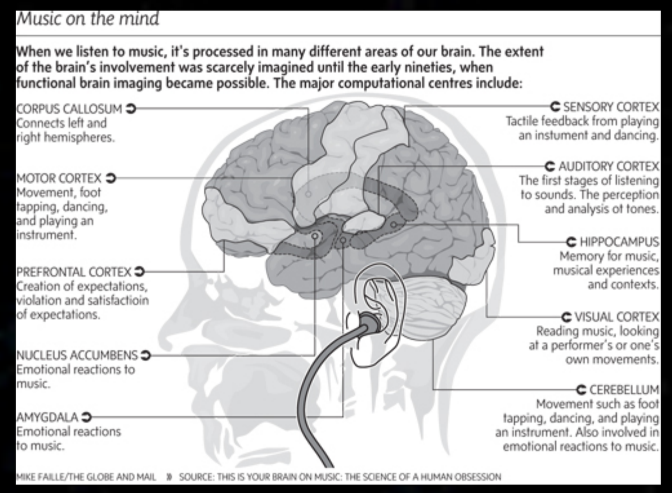

Fig.4 summarizing the major areas of music on the mind. Modified from Cooper, Belle Beth. '8 Surprising Ways Music Affects The Brain'. *Social*, 2013. Web. 21 Feb. 2015. Summarizing Regions of the brain activated by music

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