Tonal Harmony

THE INTERPLAY BETWEEN MUSIC AND TONAL LANGUAGES

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ABSTRACT
This paper presents a summary of current research on the synergies between music and language, especially tonal languages. Since music and language are processed by similar brain structures, research studies have found that individuals with a tonal language background tend to be better at discriminating pitch in music. As well, musically experienced individuals are found to be more proficient at detecting speech-based stimuli. Due to this relationship between music and language, music-based therapies are being created to improve language acquisition and to treat communication deficits associated with developmental disorders.

INTRODUCTION: MUSIC, LANGUAGE, AND THE BRAIN

Music and speech are forms of expression that rely on the ability of the brain to process them. An intrinsically temporal activity, music involves the integration of sensory, motor, and affective systems.[1] Music and language resemble each other because they are both hierarchically arranged. Notes and keys or letters and syllables form the lower level units which integrate to form higher-level units, such as chords and melodies or words and sentences.[2] Moreover, both music and language involve cognitive processes of attention and memory.[3,4,5] Due to these similarities, music is currently being used as a treatment for developmental disorders characterized by poor communication, such as autism spectrum disorders (ASDs), attention deficit hyperactivity disorder (ADHD), aphasia, and dyslexia.[6,7,8]

MUSIC AS A THERAPEUTIC TOOL

Recently, music has been shown to lessen pain and anxiety. In a comprehensive research review of more than 1,000 patients suffering from coronary artery disease, Bradt and Dileo found that listening to music alleviated the anxiety resulting from the disease, as reflected in reduction of heart rate and blood pressure.[10] Later, Bradshaw et al. found that listening to music reduced the intensity of responses to pain stimuli.[11] Prescribing music listening to patients with anxious personality traits was particularly effective. Music is dynamic, complex, and emotionally engaging enough to activate sensory pathways in the brain that compete with pain pathways. In a research review led by Chanda and Levitin, listening to music reduced levels of the stress hormone cortisol.[12] In fact, listening to music post-surgery has been found to reduce sedation.[13] Scientific literature provides ample credence for the wide-ranging therapeutic applications of music.

Researchers have noted that autistic children tend to have enhanced pitch memory and discrimination capabilities as compared to non-autistic children.[14,15] Darrow and Armstrong observed that music-based activities provide non-intimidating experiences that encourage children with ASDs to step out of their comfort zone, explore various musical instruments at their own pace, and develop direct communication with the therapist. [16] Researchers theorized that training in music may help alleviate some of the core autism challenges of attention, non-verbal, and language-based or verbal communication, poor motor performance, and behavioural problems.[17] Based on this observation, music-based therapies have been increasingly used in communicating with children with ASDs.[18] It is estimated that nearly 12% of autism interventions and 45% of alternate treatment strategies in schools are music-based.[18, 19]

COGNITIVE NEUROSCIENCE OF MUSIC AND TONAL LANGUAGES

Yip classified 60 to 70 percent of existing languages as tone-based. Tonal languages revolve around lexical tones instead of words, so the pitch contour of a particular word influences the core meaning of that word.[20] For example: the Thai tonal language consists of five tones: three level tones (low, mid, high) and two contour tones (rising, falling). By contrast, English is not a tonal language because words like 'piano' and 'book' have the same tone regardless of the pitch pattern used for pronunciation.

> **"MUSIC IS THE ONE INCORPOREAL ENTRANCE INTO THE HIGHER WORLD OF KNOWLEDGE WHICH COMPREHENDS MANKIND BUT WHICH MANKIND CANNOT COMPREHEND"**
> **– LUDWIG VAN BEETHOVEN**

An experiment by Stevens, Keller, and Tyler examined the effect of a tonal language background (Thai) compared to a non-tonal language background (Australian English) with regards to discriminating pitch contour in speech and music.[21] Subjects were presented with two-syllable spoken-word stimuli in Thai and English with weak-strong

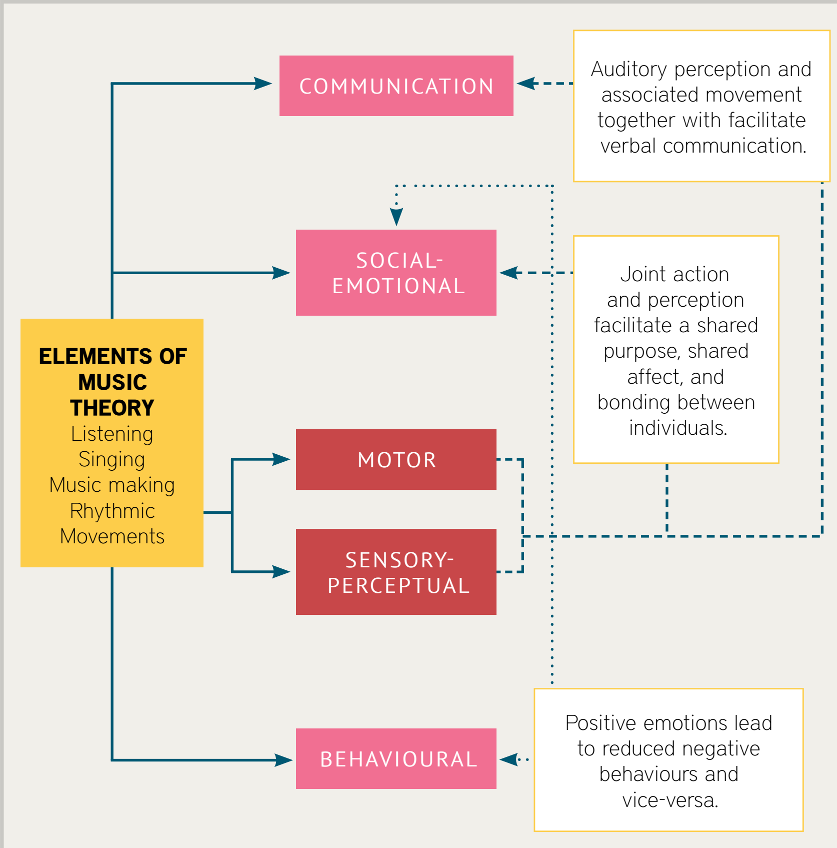

FIGURE 1: Influence of musical experiences on development. Musical experiences may directly or indirectly affect the development of the perceptuo-motor, communication, social-emotional, and behavioural domains of the brain.[9] For example, auditory perception and movement – activities involved with music making – allow for verbal communication, which is lacking in some autistic children.

stress patterns. Each word was announced twice and subjects determined whether the repetition of the word had the same or different intonation. In the next task, subjects listened to pairs of musical intervals and were asked to identify the intervals as same or different. Results showed that tonal language speakers identified pitch changes more quickly and accurately for Thai and English words. Moreover, while tonal and non-tonal language speakers had similar accuracy for the musical tasks, tonal language speakers had significantly faster reaction times to pitch changes.

From a cognitive neuroscience perspective, there are several theories that could explain this enhanced auditory perception in tonal language speakers. Firstly, individuals from different cultures demonstrate different brain function lateralization. In response to pitch stimuli resembling linguistic tones, Mandarin Chinese (and similarly, Thai) speakers demonstrated increased activation in the brain's left hemisphere, which is responsible for language ability.[22] Meanwhile, English speakers showed a greater activation in the brain's right hemisphere, which controls visual processes. The success of Thai speakers, relative to English speakers, in the Stevens, Tyler, and Keller experiment may be attributed to the language-based auditory items presented.

There are likely neural underpinnings for the auditory capabilities of tonal language speakers. Based on functional magnetic resonance imaging results, only tonal language speakers displayed activation of the left frontal operculum near Broca's area, which is important for understanding language.[23] Their brains identified the functional properties of pitch pattern stimuli rather than the auditory properties, thereby resulting in the activation of language-specific mechanisms. Another theory is that neuroplasticity in the brainstems of tonal language speakers contributes to heightened perception of the linguistic elements of speech.[24] Neuroplasticity enables neurons in the brain to remunerate for injury and adjust to environmental changes. One mechanism involved is axonal sprouting, whereby nerve endings are generated to form new pathways.

Music and language have a bi-directional relationship in the sense that musical training has a positive impact on tonal language acquisition. In one study, English-speaking musicians and non-musicians were exposed to Mandarin tones of the syllable "sa".[25] None of the participants had prior experience with Mandarin, yet musicians were almost 25% better at identifying the lexical tones. A second study by Slevc and Miyake found a strong correlation between musical ability and tonal memory as well as tonal memory production.[26] The effect of music on tonal language acquisition can be explained by the fact that compared to non-musicians, musicians exhibit faster and more rigorous auditory brainstem responses to all types of auditory stimuli.[27] As a result, musicians are better at processing musical intervals, communicative sounds, and speech stimuli with pitch contours.

IMPLICATIONS OF THE RESEARCH

The evident and consistent relationship between music and language has numerous applications within the healthcare field. The bi-directionality between music and language can be used to create specific music-based rehabilitation treatments for individuals with speech impairments due to old age or stroke. At the other end of the age spectrum, music-based treatments can help children struggling with language acquisition. In either case, the distinction must be made of the language background – tonal versus non-tonal – so that therapeutic efforts are more targeted.

Moreno et al. randomly assigned eight-year old non-musician children to receive music or painting training.[28] Results showed that the musically trained children responded significantly better to language-based stimuli, as they exhibited superior discrimination of pitch variations in speech. Another application of the bi-directionality between music and language is in the treatment of autistic individuals. A recently developed music-based intervention, an auditory-motor mapping training, consists of three parts: singing, rhythmic motor activity (e.g. drum playing), and imitative repetition.[29] Auditory-motor mapping training strengthened the association between the frontal and temporal lobes of the brain, which are atypical in autistic patients and may be responsible for impaired communication skills. Thus, auditory-motor mapping training can be applied to help autistic patients acquire tonal languages.

FUTURE RESEARCH

Since musical functioning has been shown to ease pain and anxiety, future research is expected to focus on various facets of the relationship between music and language.[30] Researchers also plan to use musical training to enhance neural connections by applying the concepts of neuroplasticity and axonal sprouting.[31] It will be advantageous to conduct longitudinal studies with a large sample size to determine if there are different developmental trajectories for melody, rhythm, and memory with respect to language and, in particular, to tonal languages.

Researchers have noted cultural differences in philosophy of life and living between East Asians and Westerners. Due to these culturally learned behaviours, East Asians tend to have a more interdependent and holistic approach to life.[32,33] In contrast, "Westerners tend to be more individualistic, independent, and analytic."[33] These cultural differences influence musical perception, which, in turn, may determine the effectiveness of music as a therapeutic tool across cultures. However, this hypothesis needs to be systematically tested.

The age of subjects may also impact the efficacy of music-based language therapies. Brain plasticity is highest when subjects are young.[31] As a result, children, teenagers, adults, and seniors could respond differently to music-based treatments.

There is an inherent methodological challenge in conducting studies on the relationship of music and tonal languages. Inconsistencies occur due to lack of a clear definition for tonal language and music in the participant populations of the studies. The participant groups discussed above differ in their level of language and musical skill level. Acquisition of skill in some cases was acquired by exposure to speech within one's family or cultural setting as opposed to formal language education. Therefore, the level of language skill cannot be categorised as systematically as acquisition of musical skill. These factors increase the difficulty of making accurate comparisons or predictions across populations.[31]

The existing research findings support the idea of bi-directionality between music and language, especially tonal languages.[4,30] There is a positive correlation between language ability and music, and this relationship may serve to enhance the efficacy of therapeutic musical interventions for the brain. ■

REVIEWED BY DR. MICHAEL WONG

Dr. Michael Wong (B.Sc., Ph.D.) is a professor at McMaster University in the Faculty of Health Sciences. His research involves applying a combination of physics, neurophysiology, and probability calculus to investigate tactile spatial acuity. The themes of his research include exploring the concept of enhanced tactile perception in the blind, and changes in tactile acuity during development and aging.

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