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Symposium Report: Music & Science: Practice & Convergence—an Organic Symposium

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The Music & Science Symposium in Boston on April 12, 2013 was designated to merge new findings in the fields of music neuroscience, music therapy, music cognition, music technology, and music medicine. Experts in these respective fields presented four talks as well as musical performances. Dr. Psyche Loui reported recent findings in music-related neuropsychological research, followed by Dr. Concetta Tomaino, who focused on music therapy and how it can benefit from the neurosciences. Dr. Lisa Wong discussed the relationship of music and medicine as healing arts. After a musical performance with innovative electronic instruments by Dr. Richard Boulanger and colleagues, Dr. Aniruddh Patel gave a keynote lecture on core topics for future music research, with an emphasis on neurobiology. This report provides a summary of the presentations at the symposium as well as implications for the field of music science.

Keywords: neuroscience, music therapy, cognition, music technology, review

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The Music & Science Symposium, held at the Berklee Performance Center in Boston on April 12, 2013, was aimed at bringing together scientists, music therapists, musicians, educators, and others involved in the study or practice of music to discuss advancements in the respective fields and their implications. About 300 people attended the symposium, which was also transmitted online via live stream. The symposium was organized by Professor Suzanne Hanser, chairperson of the Music Therapy Department of the Berklee College of Music. As Professor Hanser pointed out, "the burgeoning field of cognitive psychoneuroimmunology and the fact that music therapy is an evidence-based practice was the impetus for learning and sharing the latest thinking and research in music and science, notably music cognition, music therapy, music neuroscience, music technology, and music medicine from the world's leaders in these disciplines" (Hanser, personal communication, April 2013). Four key talks were given by Dr. Psyche Loui, Dr. Concetta Tomaino, Dr. Lisa Wong, and Dr. Aniruddh Patel, as well as a musical performance by Dr. Richard Boulanger and colleagues. The audience had the opportunity to post comments and questions on Twitter at #musicscience that were displayed on screen during the symposium. Furthermore, it was possible to communicate with researchers, music therapists, and others around the world who were attending the symposium via live video streaming of the event. The program was accompanied by a musical welcome and farewell by students from the Berklee College of Music. This report provides a summary of the talks and performances at the symposium as well as implications for the field of music science. Additional information on the symposium such as interviews, article reviews, and relevant links can be found online at *http://www.berklee.net/mt/musicscience.html*.

Dr. Psyche Loui - Towards the Convergence of Music, Brain, and Cognition & EEG-Generated Music Performance

Dr. Loui's talk focused on recent findings regarding the production and perception of music. She reported findings on persons with congenital amusia, a neuropsychological condition characterized by the inability to sing in tune and a deficit in pitch discrimination: although amusics could not indicate whether the second of two presented tones was higher or lower than the first, they were able to hum the two tones in the correct direction when asked to repeat them (Loui, Guenther, Mathys, & Schlaug, 2008). This result suggests a production-perception mismatch in congenital amusia. Diffusion tensor imaging showed that the arcuate fasciculus connecting the superior temporal gyrus and the inferior frontal gyrus (also known as Broca's and Wernicke's Area) was significantly reduced in persons with congenital amusia (Loui, Alsop, & Schlaug, 2009), indicating that the reason for a production-perception mismatch might be a reduced connectivity between the associated brain areas. The fact that these areas are also involved in language production and perception inspired a study showing that pitch perception and production in children significantly correlated with their language performance (Loui, Kroog, Zuk, Win-

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ner, & Schlaug, 2011). Another aspect of music that is related to language processing is that people form expectations about which tones or chords will follow each other according to the rules of the musical system. Deviating (highly unexpected) tones or chords lead to specific patterns of event-related potentials (ERP) that can be seen from EEG experiments: the Early Anterior Negativity and the Late Negativity (Loui, Grent't-Jong, Torpey, & Woldorff, 2005). An interesting question is whether we can learn the rules of a new musical system by being exposed to it: Using the Bohlen–Pierce scale, an alternative musical scale with a 3:1 harmonic ratio and 13 instead of the usual 12 tones, it was examined whether people would show the same reactions to deviations of the rules of this new musical system compared with usual Western music. ERP results suggest that responses to deviations in new music indeed are similar in terms of Early Anterior Negativity and Late Negativity (Loui, Wu, Wessel, & Knight, 2009). Another recent study investigated intense aesthetic responses to music: It compared people who reported frequently experiencing chills when listening to music against others who reported rarely or never experiencing chills to music. Using diffusion tensor imaging, it was found that people who often experience chills when listening to music have larger connections between brain regions for hearing and social–emotional processing (Sachs, Ellis, Schlaug, & Loui, 2013). Taken together, results from these music cognition studies have important implications for the design of future training to improve multiple aspects of the human condition: for example, children's language skills and sound perception or production abilities following neurological diseases and disorders.

Dr. Loui concluded her talk with a demonstration of how the neurosciences can also lead to the creation of new music by composing and performing a musical piece in real time with EEG signals recorded from her scalp. The piece was entitled "Organic Symposium," because EEG music represents a form of natural, biological, and constantly evolving music, fitting to the motto of the symposium.

Dr. Concetta Tomaino - Music Therapy and Neuroscience: How Science Helps Explain the Efficacy of Music as Therapy

As Dr. Tomaino pointed out in her talk, music therapy has been practiced for decades with visible success. The emergence of neuroscience, however, now provides possibilities to study the underlying processes that can explain the effects of music therapy and thereby lead to improvements in practice. Impairments of memory, attention, or the sensory system, for instance, can be treated more effectively if it is known how certain aspects of music (such as rhythm, novelty/familiarity) affect these cognitive functions. It has been shown, for example, that familiar music associated with autobiographical memories leads to activation in the medial prefrontal cortex (Janata, 2009), a brain area that is spared in Alzheimer's disease for a longer time than other areas associated with memory. This could explain why playing familiar music to patients with Alzheimer's disease can enhance autobiographical memories (El Haj, Fasotti, & Allain, 2012; El Haj, Postal, & Allain, 2012). Also, unfamiliar lyrics were better recognized by patients with Alzheimer's disease when they had been sung than when they had been spoken to them; a difference that did not occur for control patients (Simmons-Stern, Budson, & Ally, 2010). A possible explanation again could be that brain areas subserving emotional components of music processing, specifically the medial prefrontal cortex, which is engaged during musical improvisation (Limb, 2006), might be preferentially spared in Alzheimer's disease. Other studies suggest that motor timing and rhythmic processing might be linked, leading to a visible improvement of balance and coordination in Parkinson's disease patients when rhythmical music is played to them (for a review, see Thaut & Abiru, 2010). In a recent study, it has also been shown that singing familiar songs as well as finger tapping the rhythms significantly improved language production in patients with nonfluent aphasia (Tomaino, 2012). The question here is which aspects of music processing are connected to the different language functions in the brain. On the basis of these results, the neurosciences have the potential to clarify the biological basis of the therapeutic effects of music on different disorders and thereby give rise to new advancements in the field of music therapy.

Dr. Lisa Wong - Prescription: Music

Bringing together music and medicine as two intimately connected healing arts, Dr. Wong's talk addressed the contribution of the healing arts on the well-being of patients. To her, music and medicine share some common features: They both require, among other things, attention to detail, creativity, and empathy. Engaging in both disciplines also means undergoing three major steps: Getting to know the basics (e.g., learning to read sheet music or how to play an instrument or learning about anatomy, diseases, and ways to treat them), adapting to the world around you (such as playing in an orchestra or starting to work in a hospital), and engaging in the community to make a difference (e.g., by exploring new ways to make music with others or by trying to improve patients' treatment). Dr. Wong further stressed the link between music and medicine by naming prominent persons who excelled in both disciplines, such as Dr. Theodor Billroth (1829–1894), a Viennese surgeon and musician and friend of Johannes Brahms, or Dr. Albert Schweitzer, theologian, musician, and physician (1875–1965). As an example of the fusion of music and medicine, she discussed the model of the Longwood Symphony Orchestra, which is an orchestra consisting to a great part of physicians working in the Longwood Medical Area in Boston, who are raising money for and engaging in many different health care and social organizations. The key questions Dr. Wong asks in this context are: How can physicians heal patients by playing music for them? But also: How can playing music to patients be a healing experience for physicians? Dr. Wong's talk culminated in her performance of Handel's sonata for violin and piano, #3, with Professor Suzanne Hanser on the piano.

Dr. Richard Boulanger - The Future of Creativity

Dr. Boulanger performed two musical pieces together with his colleagues Takahiko Tsuchiya (playing Sensor Violin and iPad), Deepak Gopinath (iPad), Christopher Saunders (MacBook Pro), Christopher Konopka (Arduino-Based Drawing Robots), and Kari Juusela (Cello and Kantele). Dr. Boulanger's instruments were the Radio Baton and a Novation LaunchPad. The aim of Dr. Boulanger's work is to invent and explore new ways of making music, of thinking about sounds. The first piece presented, "Koti" by Kari

Juusela, involved a cello, a kantele, a Novation LaunchPad (triggering cello, kantele, and piano pamples), two iPads (running csSpectral), and a MacBook Pro (processing photos, films, and live video using Jitter). It was inspired by the Finnish national epic, the Kalevala. Fragments of Finnish folk songs were combined in an intriguing way with the novel sounds of the electric instruments, thereby creating a dense musical image that—together with the visualizations—conveyed the spirit of the traditional Finnish mythology. The second piece, "Chasing Shadows" by Richard Boulanger, was played by a Radio Baton (a virtual conducting system), a sensor violin (played and developed by Takahiko Tsuchiya), an iPad (running csSpectral and processing the Radio Baton), a MacBook Pro (doing two camera live video processing using Jitter), and two (Arduino-based) drawing robots (one listening to the performance, the other monitoring BioSensors). "Chasing Shadows" is a three-movement piece consisting of a chamber sonata, concerto, and duet. In the center of the piece was the sensor violin, which is not only controlled by the bow but also by motion, location, and pressure sensors on Takahiko Tsuchiya's wrist. The performance-based picture created by the drawing robots was presented to the audience afterward. Dr. Boulanger stressed that the electronic devices should not be perceived as tools to replay music or to substitute instruments, but as actual instruments that have their own characteristics and thereby create new possibilities of sounds and music making. Developing electronic instruments will not only open up new ways of composing and performing music, however, but will also provide an opportunity for people with physical disabilities to engage in active music making.

Dr. Aniruddh Patel - The Future of Music and Science: A Neurobiological Perspective

Dr. Patel's talk focused on the question of why the human brain reacts so strongly to music. Music has already been shown to activate at least six pathways in the brain: brain stem reflexes, implicit associations with emotional events, emotional contagion from voice-like emotional sounds, visual imagery, episodic memory, and musical expectancy. One of the challenges for future research will be to identify the characteristics of the brain that are responsible for these strong reactions, because a similar reaction was not observed in species closely related to humans, such as apes. Cross-species studies would therefore be an opportunity to study what kind of animals show reactions to or even enjoy music and how they differ from species that do not. It has recently been shown that a sea lion can keep a beat (Cook, Rouse, Wilson, & Reichmuth, 2013); this phenomenon previously had only been observed in parrots (Patel, Iversen, Bregman, & Schulz, 2009) and had been assumed to require vocal mimicry abilities (Schachner, Brady, Pepperberg, & Hauser, 2009). Also, research on cotton-top tamarin monkeys suggests that although they prefer silence over Western music (McDermott & Hauser, 2007), they react to music that is based on tamarin-like sounds (Snowdon & Teie, 2010). Although these results are suggestive of animal preferences for musical or auditory stimuli, they could not address whether animals found music to be intrinsically rewarding. A possibility to address this question lies in neuroscientific methods. In an experiment by Salimpoor et al. (2013) participants heard unfamiliar music while receiving an fMRI scan and had to decide for every song how much money (between 0 and 2 dollars) they would spend to buy the song. The amount of money participants were willing to spend was positively correlated with neural activation in mesolimbic striatal regions, especially the nucleus accumbens, thereby suggesting that pleasurable music triggers reward signals in the brain. Dr. Patel speculated that as fMRI scans have been successfully conducted on dogs, one could potentially adopt the procedure and play high versus low ranked music to them to test whether dogs show comparable reward-related brain activity as humans.

In relation to possibilities for future advancements in music therapy and training, there recently has been a promising attempt to capture individual differences in people's reactions to music: The Absorption in Music Scale (AIMS) developed by Sandstrom and Russo (in press) measures the ability and willingness to let music elicit strong emotional experiences and was shown to correlate with emotional responses to music. The AIMS might therefore be a good predictor of the effectiveness of different forms of music therapy for an individual patient, and may help ensure that a patient receives the most beneficial intervention. Other issues addressed by Dr. Patel that should be considered in future research on brain reactions to music are the reliability of results, effect sizes, comparators (e.g., comparing the effect of music with the effect of storytelling instead of a control group without any "treatment"), and possible neurochemical mechanisms (for instance the roles of dopamine and cortisol pathways). In addition, there is a need for more controlled training studies to analyze the effects of musical training on neural plasticity.

Conclusion

The Music and Science Symposium brought together people from different professions that share a strong interest in music, the effects it has on the human brain, and the implications that can be drawn from scientific findings to apply toward using music for the improvement of people's health and well-being. Recent findings and developments were discussed from the perspective of researchers, physicians, and musicians, with the aim to merge existing findings and technologies from the different disciplines to benefit from an ever-increasing pool of knowledge. It was inspiring to hear about current results and new arising questions, and to see the rapid progress that the field of music-related research has experienced in the last years. The speakers expressed their hope that by enhancing further collaboration, important findings will become more accessible to everyone and thereby enable a better implementation of these results in practice in the form of training and therapy. Informing society about the significant impact that music can have in the treatment of various neurological diseases and disorders might also prevent further budget reductions in musical education. Consistent with the motto of an organic symposium, Professor Hanser concluded the symposium with the appeal to take the presented findings, and also the new questions raised throughout the day, as a starting point for future investigations and collaborations.

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