

NEUROLOGIC MUSIC THERAPY IN COGNITIVE REHABILITATION

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NEUROLOGIC MUSIC THERAPY LAST CAME INTO research and clinical focus via cognitive rehabilitation. New imaging techniques studying higher cognitive functions in the human brain 'in vivo' and theoretical advancements in music and brain function have facilitated this development. There are shared cognitive and perceptual mechanisms and shared neural systems between musical cognition and parallel nonmusical cognitive functions that provide access for music to affect general nonmusical functions, such as memory, attention, and executive function. The emerging clinical literature shows substantial support for these effects in rehabilitative retraining of the injured brain. Key findings relevant for clinical applications of neurologic music therapy to cognitive rehabilitation are presented and discussed below.

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THE ROLE OF MUSIC IN COGNITIVE rehabilitation (CR) has been the last domain to come into full focus in neurologic music therapy. Applications of music to CR were not studied well in the past in comparison to, for example, music's role in motor therapies or speech/language rehabilitation. Several conceptual problems probably accounted for the slow research development. In reviewing the music therapy literature over the past 50 years, very few studies have examined how music can influence cognitive functions in a therapeutic context on a theoretical basis. Music cognition has of course always been a field of very active scholarship, but no conceptual links have been developed as to how cognitive processes in music perception could be transferred to retraining cognition and perception in therapy. The overwhelming reliance on broad—and often psychotherapeutically oriented—concepts of music as a therapeutic tool for models of 'well being' and therapeutic relationship building, as well as an intuitive but mostly undifferentiated emphasis on

emotional components in the therapeutic music experience, contributed to this lack of development.

Another factor that has slowed this research is more technical in nature. There were clear limitations to cognitive brain research from a neuroscience perspective before the advent of noninvasive research tools to study the human brain in vivo. Brain imaging techniques did not develop fully until approximately between 1985 and 1990, and they were slow to become available to musical brain research. Today's wide availability of brain-imaging equipment, together with the considerable refinement in brain-wave measurement techniques via EEG and MEG, has produced a new basis for biomedical research in music cognition and rehabilitation.

Links Between Music and Cognitive Functions

From these efforts a growing body of research has emerged that sheds new light on intriguing links between music and a variety of cognitive functions, including temporal order learning (Hitch, Burgess, Towse, & Culpin 1996), spatiotemporal reasoning (Sarntheim et al., 1997), attention (Drake, Jones, & Baruch, 2000; Large & Jones, 1999), and auditory verbal memory (e.g., Deutsch, 1982; Glassman, 1999; Kilgour, Jakobson, & Cuddy, 2000; Thaut et al., 2005; Chan et al., 1998; Ho et al., 2003).

Efforts have also been put forward to examine models how music can remediate cognitive functions. For example, a large and consistent body of research in musical attention has pointed to the role of rhythm in tuning and modulating attention in music (e.g., Drake et al., 2000; Jones, 1992; Jones, Boltz, & Kidd, 1982; Jones & Ralston, 1991; Klein & Jones, 1996). Rhythmic patterns entrain attention focus by interacting with attention oscillators via coupling mechanisms. Bonnel, Faita, Peretz, and Besson (2001) found evidence for divided attention mechanisms in song between processing of lyrics and processing of music. Very important connections between musical and nonmusical memory formation have been laid out by Deutsch (1982), showing how some of the fundamental organizational processes for memory formation in music—based on the structural principles of phrasing, grouping, and hierarchical abstraction in musical patterns—have their parallels in temporal chunking principles of nonmusical memory processes.

We can now begin to postulate that the mechanisms that drive cognitive processes in music, such as in attention and memory, are shared by equivalent processes in nonmusical cognition. One of the most important shared mechanisms may refer to rhythm as a temporal structuring and patterning process in perception and learning (Conway, Pisoni, & Kronenberger, 2009; Jakobson, Cuddy, & Kilgour 2003; Janata, Tillmann, & Bharucha, 2002).

Shared Mechanisms and Brain Systems

Based on these shared processes we can now formulate hypotheses about how music training can access and modulate cognitive functions in a rehabilitation context. The Rational Scientific Mediating Model (RSMM) was developed to provide a systematic epistemology for translational research in music and rehabilitation (Thaut, 2005). For example, could “musical chunking” be used as a mechanism to enhance verbal learning and rehabilitate verbal memory? Could attention training in music enhance auditory attention control in nonmusical contexts based on principles of attention process training (Sohlberg & Mateer, 1989)? Can music create strong synchronized connectivity between different areas of the brain to help in more efficient rehabilitative relearning and training (Bhattacharya, Petschke, & Pereda, 2001)?

Memory

Research has shown that music can serve as an effective mnemonic device to facilitate verbal learning and recall in healthy persons, patients with memory disorders, and children with learning disabilities (e.g., Claussen & Thaut, 1997; Gfeller, 1983; Maeller, 1996; Wallace, 1994; Wolfe & Hom, 1993). One of the theoretical models for this effect proposes that the highly developed temporal structure in musical stimuli—songs, chants, rhymes—functions as a metrical template that helps to organize and chunk information into more manageable units. “Chunking” is a helpful mechanism not only in declarative learning and recall, but also in motor learning (Verwey, 2001). Indeed ‘chunking’ is probably an innate feature across a broad phylogenetic range of nervous systems (Matzel, Held, & Miller, 1988).

In a recent study of patients with multiple sclerosis, we were able to show that word lists from Rey’s Auditory Verbal Learning Test (RAVLT) were significantly better learned and recalled when presented and rehearsed via song as a rhythmic-melodic template vs. the usual spoken presentation and rehearsal (Thaut et al., 2005). Furthermore, EEG recordings of the study

subjects showed that the musical mnemonics condition induced significantly higher oscillatory synchrony in the lower alpha band rhythms in bilateral prefrontal neural networks underlying memory than the spoken condition. The finding of increased neuronal synchrony in cortical networks in multiple sclerosis is very interesting since the disease is characterized by demyelination processes that interrupt network dynamics of neuronal cell assemblies.

Recent research also has shown that musical memories may survive longer than nonmusical memories and may be functionally available and accessible for persons with neurologic memory disorders such as dementia or Alzheimer’s disease (AD) (Baur, Uttner, Ilmberger, Fesl, & Mai, 2000; Crystal, Grober, & David, 1989; Cuddy & Duffin, 2005; Halpern & O’Connor, 2000; Haslam & Cook, 2002; Samson, Dellacherie, & Platel, 2009; Son, Therrien, & Whall, 2002; Vanstone & Cuddy, 2010; Vanstone, Cuddy, Duffin, & Alexander, 2009). That this function may extend to learning new musical materials was proposed in a case study of a violinist diagnosed with AD and profound anterograde and retrograde memory deficits who not only continued to perform familiar music but learned to play a new, unfamiliar piece (Cowles et al., 2003). Of considerable importance for the use of musical memories in therapy is the evidence that they may help access nonmusical autobiographic recall (Foster & Valentine, 2001; Irish et al., 2006)

Studies also report that accessing musical memories provides a tool for musical memory training to enhance access to nonmusical recall and knowledge (Rainey & Larsen, 2002).

It is well known that emotional context enhances learning and recall (Bower, 1981). It is also well known that positive mood states enhance memory function (Jensen, Lewsi, Tranel, & Adolphs, 2004). Therefore, the access that musical memories provide to triggering nonmusical (e.g., verbal or autobiographical) materials is most likely based on strong associative learning mechanisms that utilize music as a highly salient conditioning stimulus.

In this context, interesting data have come from recent studies that show preserved short term memory functioning in patients with Alzheimer’s disease—where a network of prefrontal-amygdala connections was activated compared to healthy subjects in which prefrontal-hippocampal networks typically were activated (Grady, Furey, Pietrini, Horwitz, & Rapoport, 2001; Rosenbaum, Furey, Horwitz, & Grady, 2004). Since amygdala functions are highly implicated in processing emotional stimuli, emotional context and saliency of memory processing may preserve longer residual memory functions in Alzheimer’s disease. Music-based memory training in

dementia and Alzheimer's disease may therefore facilitate a shift in accessing this amygdala-based neuroanatomical network, again due to the nature of music as a highly salient emotional stimulus.

(In)attention and Neglect

Some evidence for music as an effective training modality exists also in the areas of neglect training. For example, Hommel, Peres, Pollak, and Memin (1990) proposed the beneficial effect of musical stimulation for overcoming visual neglect as a result of right hemispheric lesions due to stroke or traumatic brain injury. Music stimuli were superior to other sensory and cognitive cues, such as instructions and speech or tactile cues. The researchers suggested that the arousal effects of music—specifically on the right brain hemisphere, which is lesioned in visual neglect states—may underlie this positive outcome. In this context Robertson Mattingley, Rorden, and Driver (1998) have shown that unilateral neglect can be dramatically altered by changing the functioning of the brain's arousal system, and have used these findings to develop other arousal-based neglect training techniques, including auditory-based techniques (Robertson, Nico, & Hood, 1995). Frassinetti and colleagues (Frassinetti, Bolognini, & Ladavos, 2002; Frassinetti, Pavani, & Ladavos, 2002) have provided remarkable evidence that auditory stimuli can enhance visual perception in neglect states.

Executive Function and Emotional Adjustment

Attention to the psychosocial functioning of patients as part of their overall executive control has always been a critical aspect of treatment. For example, many patients with traumatic brain injury will suffer from anxiety, depression, sense of loss, and other areas in need of coping. There is evidence that neurologic music therapy can successfully be used to address psychosocial treatment issues (Kleinstaubler & Gurr, 2006; Nayak, Wheeler, Shiflett, & Agostinelli, 2000).

In a recent exploratory study (Thaut et al., 2009), we examined whether specific techniques in neurologic music therapy could improve cognitive retraining in traumatic brain injury rehabilitation. Specifically we

studied neurologic music therapy techniques related to musical attention training, musical executive function training, and musical memory training. Data were measured before and after a single therapy session and compared between the music condition and a standard neuropsychology condition. After a single intervention, memory and attention did not show any significant improvement in either condition. However, executive function was significantly improved. This finding was also further supported by statistics showing significantly improved self-efficacy ratings in executive function by the patients, indicating a stronger sense of self-confidence in their executive function abilities. Furthermore, several areas of psychosocial adjustment improved significantly in neurologic music therapy over the control group in the areas of depression, anxiety, and sensation seeking. Other measures, for example, hostility, positive affect, and global emotional improvement, showed more limited or nonsignificant results. Taken together, the data provide the first more comprehensive view on music in cognitive rehabilitation, albeit on a short term intervention basis. Nevertheless, these data are important in increasing our knowledge of music's beneficial role in cognitive therapy, especially in the area of executive function that had previously not been studied at all.

In conclusion, we can look at emerging data that point to a functional and useful role for music training in cognitive rehabilitation. Based on a new direction that links music cognition and perception research to models of music and learning—and finally, linking music learning to retraining the injured brain—a new model has finally emerged that allows us to study and apply music efficiently as a complex multisensory stimulus to cognitive rehabilitation.

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