

# **Music As Medicine: A Historical Perspective and Review of Select Clinical Applications**

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## **Key words:**

Music therapy, historical perspective, autism spectrum disorders, pain, rehabilitation, complementary and alternative medicine, dementia, stroke, brain injury

## **Abstract**

Music is one of the oldest tools in medicine and has recently received considerable attention, allowing it to be studied with the same methodological rigor as other conventional interventions. In pain management, music provides distraction and cognitive imagery to aide relaxation. It also reduces pain perception by blocking pain impulses to the brain at the spinal cord and releasing endorphins, which simply help us feel good. Therapeutic music helps restore lost abilities, such as memory deficits in dementia, or speech and motor deficits following a brain injury or stroke. One of the fastest growing clinical applications of music therapy is with children with autism spectrum or other developmental disorders, helping improve self-expression, as well as social and shared communication, and perhaps reaching even less measurable goals such as improving self-esteem and quality of life. We know from neuroimaging research that brain circuitry involved in perception and processing of music closely overlaps with those regulating emotions, arousal, pleasure, and cognition. To a great extent, this explains how music can be used as a tool to influence and regulate these fundamental human functions. This paper provides a historical account of music in medicine and reviews select clinical applications.

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## **Introduction**

The history of music as medicine is as old as medicine itself, cutting across time, languages, and cultures. Beyond a source of entertainment, and certainly beyond the performance or active musical experience itself, it has far reaching and long lasting effects of restoring both mind and body. In his Theory of Moral Sentiments (1759), Adam Smith described music as building blocks of innate sympathy and a creative activity of the human mind or body that surpasses learned languages, customs, and beliefs that traditionally separate cultures and their histories, and unifies humanity by helping build connections with others and in our societies <sup>[1]</sup>. This building block is likely rooted in nature's innate biological and physiological rhythms and their role in maintaining the cycles that are vital to sustaining both human and non-human life. It is hardwired and present in infancy, with even newborns demonstrating an ability to discriminate and show interests in song and musical instruments <sup>[2]</sup>. A simple study designed to show the quantifiable effects of music on nature demonstrated that compared to no music at all, in vitro human cancer cells show differential growth rates in the presence of music, growing slower when exposed to more melodic sounds and faster in the presence of hard rock <sup>[3]</sup>.

Despite the recognition of the therapeutic effects of music throughout millennia, the profession of music therapy and its clinical applications are in their infancy. According to the World Federation of Music Therapy (WFMT):

“Music therapy is the professional use of music and its elements as an intervention in medical, educational, and everyday environments with...[those]...who seek to optimize their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and wellbeing. Research, practice, education, and clinical training in music therapy are based on professional standards according to cultural, social, and political contexts” (WFMT, 2011).

Like any other form of therapy, music therapy is an active and creative partnership between a skilled musician/clinician who can facilitate responsive therapy to meet certain goals, whether physiological, emotional, or psychological <sup>[2]</sup>. In the presenting sections below, we summarize the history of music as medicine, provide a comprehensive review of its current clinical applications, and provide a summary of our understanding thus far of the neural underpinnings of the processing and perception of music and its therapeutic benefits. Although this review takes a somewhat reductionistic approach in highlighting the healing benefits of music, it is important to note that beyond such an empirical approach, music can serve as an organizing metaphor for clinical medicine by contributing to human well-being using skill and mutual relational engagement <sup>[4]</sup>.

## **Historical Perspectives**

Since the dawn of time, music has been associated with communication, emotional expression, and healing. Dating back to Biblical times, David was said to have played the harp to rid King Saul of a bad spirit. In fact, the four major traditions of the literary history of medicine in the world parallel the history of music as medicine <sup>[5-7]</sup>. These include the Greco-Roman, Arab, Indian subcontinent, and Chinese traditions, although in many of these, music therapy has

belonged in the realm of philosophical, cultural, and religious spheres <sup>[5]</sup> rather than clinical practice.

In the 6<sup>th</sup> century BC, Pythagoras, considered by some to be the father of music therapy, used music as a vehicle to systematically treat bodily and psychological ailments. Around 400 BC, Hippocrates, father of Greek medicine, was known to play music for his patients while Aristotle described music as a force that purified the emotions <sup>[8]</sup>. This interest in music was sustained later in Europe in the philosophical and musicological literature of Plato, who is credited with the theoretical conceptualization that music therapy works by attuning the soul to the cosmos <sup>[9]</sup>, a concept reiterated by the Turco-Persian psychologist and music theorist al-Farabi (known as Alfarabius in Europe), in his *Meanings of the Intellect* <sup>[10]</sup>. Mkhitar Heratsi, the father of Armenian medicine and author of the *Treatment of Fevers*, published one of the most thorough pieces on fever causing diseases in 1184, as well as the importance of treating the whole of the patient. He highlighted the role of music in healing by prescribing, “as much as possible, let the patient listen to much songs of the singers (troubadours) the sound of the strings and pleasant melodies” <sup>[11, 12]</sup>.

Musical healing was more actively discussed and respected in early Islam, where the use of music as therapy was beyond philosophical in nature. It took on a more practical and secular role, with a presence in hospitals that tended to “insane” patients. The excitement and leadership support of intellectual and scientific enlightenment resulted in the translation of a large volume of Greek works into Arabic and Syriac, resulting in the development of medicine and music as scientific areas subject to systematic investigation with both theoretical and practical applications highlighted <sup>[5]</sup>. But in India, theory was more the norm than practice, often reflecting on the power of music to change nature. Similarly, in Chinese medicine, although music was thought to possess a “quasi-magical transformative power,” it was considered to impact nature, not disease <sup>[9]</sup>.

In the early modern period in Europe, Robert Burton, in his *The Anatomy of Melancholy*, wrote of music as the remedy for despair, with an ability to drive away the devil himself. To a fiddler’s pipe, he attributed the ability to “make a melancholy man merry, and him that was merry much merrier than before, a lover more enamoured, a religious man more devout” <sup>[13]</sup>. Also in Europe, references in French Renaissance poetry included the power of the lyre over nature and Christ’s ability to calm the storm (“serine l’orage”) <sup>[14]</sup>, heal affairs of the heart or “lovesickness” <sup>[15]</sup>, or in reference to the elaborate and ritualistic music and dance used to cure the bite of the tarantula spider in southern Italy, the remnants of which are still present in parts of modern Italy in festivals and other cultural activities <sup>[16, 17]</sup>.

In more contemporary times, music has been used to heal and build during times of destruction, such as the first two genocides of the 20<sup>th</sup> Century. During World War I, Komitas Vartabed (1869-1935), one of the first members of the International Music Society, emphasized the power of healing through music. Despite his virtuoso voice, he lost his sanity and became mute in his last two decades in Paris's Salpêtrière Hospital asylum, after enduring the atrocities committed upon him and his family by the Ottoman Turks during the Armenian Genocide <sup>[18]</sup>. In Theresienstadt, a Nazi concentration camp for middle class Jews in the Czech Republic during World War II, conductor Rafael Schächter formed a chorus within the camp as therapy for the

downtrodden by performing works by Giuseppe Verdi <sup>[19]</sup>.

Though the use of music in medicine has a longstanding history as highlighted above, only recently has its therapeutic utility been systematically collected and researched based on clinical practice <sup>[20]</sup>. Because of this relatively sudden burst in support and interest, the profession of music therapy has never been “safer” than it is now. As chronic and degenerative pathologies have slowly replaced more acute and infective diseases, clinical medicine has integrated the human relationship into the scientific and problem solving model <sup>[21]</sup>. There are a growing number of music therapy training programs in the country, with the Certification Board for Music Therapists (CBMT) functioning as the governing entity that provides certification for qualified care providers. The American Music Therapy Association also has a number of fact-sheets and resources on the applications of music therapy with various educational and clinical settings.

## **CLINICAL APPLICATIONS**

### **Music Therapy with Medical Populations**

Psychological and physical discomforts inherent with the diagnosis and treatment of a life-threatening illness remain challenging for members of the health care team, particularly during hospitalization <sup>[22]</sup>. Further, chronic elevations in cortisol, a marker of physiological and/or psychological stress, can be harmful to the body, including compromising immune responses <sup>[23]</sup>. In this population, music therapy helps modulate and manage pain, discomfort, anxiety, depression, and stress, and enables patients and their families to have better communication and self-expression by encouraging independence and motivation.

#### Pain Management

With regard to the modulation of pain, music creates a distraction that allows patients to focus on something positive and takes attention away from negative stimuli. This creates a cognitive imagery tool to filter information and change perceptions of pain <sup>[24, 25]</sup>, such as through the facilitation of musical alternate engagement (MAD) <sup>[26, 27]</sup>. The gate control theory of pain suggests that distracters such as music block specific pain pathways and disrupt the ability of pain receptors to send signals up to the brain from the spinal cord, thereby diminishing pain perception <sup>[25, 28]</sup>. In addition to reduced pain perception, active music therapy can be helpful in allowing patients to express perceptions with the bi-directional experience of anxiety and pain in ways that allow these symptoms to diminish <sup>[28]</sup>. Music also allows for the release of endorphins in the blood stream while increasing oxytocin levels [old 31, fix this]. Similar to opiates, the former simply makes us feel good <sup>[25]</sup> while the latter results from social bonding, such as those observed in infancy.

In adults, a summary of 42 randomized controlled trials (RDC) of music interventions in perioperative/postoperative settings, half of the studies showed reductions in patients’ perception of pain and anxiety by the use of recorded music <sup>[24]</sup>. Similar findings of lower pain perception were also highlighted in other reviews <sup>[29, 30]</sup>, some of which also indicated that music intervention appeared to reduce use of sedatives and analgesics <sup>[24, 30]</sup>. Some relatively minor but still significant reductions in physiological factors, such as heart rate, blood pressure, respiratory

rate, and blood cortisol levels were also noted, with one study suggesting that the rate of change in these physiological parameters was correlated with musical tempo<sup>[31]</sup>. The musical selections were typically self-selected and described as soothing with a typical listening time of 15-30 minutes. Based on study findings, non-lyrical music that possesses primarily low tones, with mostly string instruments and minimal brass or percussion instruments, and a maximum volume of 60 dB was recommended<sup>[24]</sup>.

In children, a review of 19 RDCs using both active (music therapy with a therapist) and passive (listening to recorded music) interventions, music was found to be an effective means of reducing anxiety and pain in children undergoing medical and dental procedures. This was especially true in subgroups of higher base rates of anxiety and pain, such as very young or ill children<sup>[28]</sup>. Of note, a multifaceted interventional approach that included music therapy was reported to be more effective, supporting the psychological theory of distraction, and resulting in less sedative use and greater compliance in the musical intervention group<sup>[28]</sup>.

### Palliative Care

The effectiveness of music therapy has been reviewed in palliative care settings, where music therapy provides opportunities for self-expression, facilitates supportive interactions with loved ones, and helps maintain some degree of physical and emotional well-being<sup>[25]</sup>. This includes improvements in symptoms of anxiety, depression, pain, and shortness of breath<sup>[32]</sup>. In addition to improvements in the patients' mood, improvements in the quality of life of their family members have also been reported. Unlike painful procedures, pain and suffering addressed in palliative settings are multi-faceted, and include tissue damage, mood changes, spiritual issues, and a range of social and financial considerations<sup>[25]</sup>. Consequently, the role of music as an intervention in this population is far reaching and likely has a great beneficial impact.

### **Music Therapy in Autism Spectrum and Other Developmental Disorders**

Autism Spectrum Disorders (ASD) encompass a group of pervasive developmental disorders of varying severities encompassing primary deficits in social impairment, communication, and repetitive and stereotypical behaviors<sup>[33]</sup>. Music has long been used to bridge gaps in communication and considered a powerful tool to help with self-expression<sup>[34]</sup>. It is, therefore, a uniquely effective complementary and alternative medical treatment for autism spectrum disorders<sup>[35-37]</sup>, and is perhaps one of the fastest growing clinical applications of music therapy to date.

Despite the high interest by educators and parents to use a form of music education or music therapy to facilitate treatment in this population, there are relatively few empirical studies of its effectiveness<sup>[38, 39]</sup>. The few studies available, however, show very encouraging results, so much so that the National Standards Project published by the National Autism Center in 2009 classified music therapy as an emerging evidenced-based approach for facilitating communication<sup>[37]</sup>.

Despite the small sample sizes in two RCTs examining the short-term effects of music therapy in developmental disabilities, significant effects were noted and corroborated by case reports<sup>[39]</sup>. A systematic review of novel and emerging treatments for ASD designated music therapy, along

with the use of melatonin, acetylcholinesterase inhibitors, and naltrexone, to have the highest rating (Grade A), defined as evidence supported by at least two prospective RDCs or one systematic review<sup>[40]</sup>. A review on three RCTs, controlled clinical trials of music therapy, and studies in which music therapy was supplemented to standard “placebo” therapy, improvements in verbal and gestural communicative skills in autistic children were noted, but no effects on behavioral problems were observed, with moderate effect sizes noted for gestural communication (standardized mean difference [SMD] = 0.50) and smaller effects noted for verbal communicative skills (SMD .36)<sup>[41]</sup>. Similarly, in a meta-analysis of nine quantitative studies (reporting on 12 dependent variables) comparing music to non-musical interventions in children/adolescents with autism resulted in an overall large effect ( $d = .77$ )<sup>[42]</sup>. These studies showed that regardless of treatment goals, the age of subjects, type of music used, treatment methodology, or profession of the music provider, music therapy is effective in improving ASD related symptoms.

In a treatment-educational setting, a musically based intervention, including improvisational music therapy, can be designed to engage children, teachers, and staff collaboratively, facilitating positive peer interactions<sup>[43, 44]</sup>, as well as improving joint attention, eye contact, and prosocial behaviors such as turn taking<sup>[45, 46]</sup>. Additionally, songs unique to the child’s therapeutic goals can provide an alternative method for addressing behaviors in a way that leads to significant improvements in behaviors<sup>[47, 48]</sup>. When compared to a toy play session, improvisational music therapy positively impacted social and emotional functioning by improving motivation and interpersonal responsiveness, increasing the experience of joy and emotional synchronicity, and initiating engagement and compliant behaviors<sup>[49]</sup>.

In addition to facilitating deficits observed in autism and related disorders, music has been used as a tool to assess how individuals with a spectrum disorder perceive and process information. In a review of 20 papers evaluating musical intervention, children with spectrum disorders were shown to have differential abilities in processing auditory stimuli and pitch/sound perception, along with a preference for musical auditory information<sup>[37, 50]</sup>. However, their ability to perceive affect in music may be undifferentiated from typically developing peers<sup>[51]</sup>. Additionally, children with a spectrum disorder performed similarly to a control group on a task requiring them to match musical fragments to schematic representations of happy and sad faces<sup>[51, 52]</sup>, highlighting music’s effective role as an intervention with this clinical population.

Beyond spectrum and developmental disorders, music therapy has been explored as a therapeutic tool for general childhood psychopathology. In a meta-analytic review, music therapy showed medium to large effects on outcomes in childhood psychopathology, with effects generally greater for behavioral and developmental disorders relative to emotional disorders, social skills or self-concept<sup>[53]</sup>. Finally, music was shown to improve depression and anxiety in psychiatric patients with a variety of DSM diagnoses<sup>[54]</sup>.

### **Music Therapy in Rehabilitative Settings**

There is evidence that music and language are supported by different neural networks since loss of ability in one domain does not necessarily result in loss in the other<sup>[55]</sup>; however, there is considerable overlap in these skills<sup>[56, 57]</sup>. For example, individuals with Broca’s aphasia can

sing words and phrases even when they lack the ability to speak the same words <sup>[58,59]</sup>, making musically based interventions a promising tool to facilitate recovery from a traumatic neurologic event, such as brain injury or stroke <sup>[60]</sup>. There is, therefore, a growing body of literature and a growing interest in investigating the therapeutic effects of music in the field of rehabilitation medicine <sup>[61]</sup>.

### Stroke Rehabilitation

In a review of current trends in rehabilitative medicine for stroke patients, music therapy has become a promising therapeutic modality following stroke, and considered a conventional therapy by some <sup>[62]</sup>. Rhythmic auditory stimulation is believed to activate motor/premotor cortices, as evidenced by increased activation in fMRI studies, improving gait and arm training after stroke <sup>[62]</sup>. A commonly used therapeutic method is the Melodic Intonation Therapy (MIT) <sup>[63]</sup> and its variants, characterized by exaggerated prosody, utilizing both a melodic and a rhythmic component. MIT has been hypothesized to engage language-capable brain regions in the right hemisphere to compensate for the damaged centers in the left hemisphere that support speech production <sup>[63]</sup>. In a systematic review of 15 studies using this approach primarily with stroke patients, all of the studies showed positive results, although poor methodological and statistical rigor was used <sup>[60]</sup>. Specifically in children, speech pathology rehabilitation combined with music therapy has helped in regaining speech and language abilities following brain injury <sup>[64]</sup>.

### Physical Rehabilitation

The role of music therapy in physical rehabilitation has also been explored. A review of 235 studies suggested that the most commonly cited function of music was to facilitate physical coordination, concluding that music was motivating for repetition and stimulation of movement <sup>[65]</sup>. A more recent review using structured outcome measures compared music therapy with other conventional therapies (e.g., physical and occupational therapy), and found that music therapy improved various aspects of gait rehabilitation, but not over and above other conventional therapies <sup>[66]</sup>, although it was considered more cost effective. Similarly, fine and gross motor improvements relative to conventional therapies were noted, perhaps based on music's stimulating effects on spatiotemporal functioning of the motor cortex networks and more automatic functions including gait and lower limb movement.

### Psychosocial Functioning in Rehabilitation Settings

In addition to facilitating cortical and extremity functions in a rehabilitation setting, music helps patients overcome the emotional and psychological ramifications of dealing with significant loss or limitations due to a neurologic event, helping modulate negative symptoms that may hinder recovery, such as pain, fear/anxiety, and sadness/frustration <sup>[61]</sup>. This also helps pro-recovery characteristics such as improved motivation, attention span, engagement, and long-term memory <sup>[66]</sup>. Consequently, music therapy has been shown to improve participation and social functioning in the rehabilitation setting for stroke patients, thereby positively impacting mood and fostering familiarity, which facilitate rehabilitation efforts <sup>[67,68]</sup>, as well as improving more general quality of life in individuals living with disabilities due to a traumatic neurologic event <sup>[69]</sup>. Specifically in children, musical based therapies allow challenging rehabilitation programs appear more enjoyable and tolerable <sup>[61]</sup>.

## **Music Therapy and the Aging Population**

In the aging population, particularly the group dealing with dementing and related disorders, music therapy is a promising intervention aimed to create a secure and stimulating environment to meet social and emotional needs of patients, and help reduce agitation. A review of 10 RCTs evaluating the efficacy of music therapy in the treatment of behavioral, social, cognitive, and emotional problems in the elders with dementing disorders showed generally moderate effects in reducing behavioral problems, stimulating language skills, and enhancing social/emotional functioning <sup>[70]</sup>. Similarly, a meta-analysis of six RCTs on the use of music-based movement (MbM) therapy in patients with Parkinson's disease showed small but significant and consistent effects in favor of this method as a tool for improving balance and stride length. Gait versus dance related MbM-therapy also improved walking velocity <sup>[71]</sup>.

Studies have shown that music therapy helps improve behavioral and emotional problems in patients with dementing disorders, and minimizes irritability, agitation, aggression, anxiety, and stress, while improving general psychological well-being <sup>[72-74]</sup>. These effects last sometimes weeks after the intervention <sup>[75, 76]</sup> and are deemed cost effective <sup>[77]</sup>. In addition to helping the patient, music therapy has helped relieve the emotional and physical burden experienced by the primary caregiver <sup>[75]</sup>.

## **The Brain on Music, What We Know from Imaging Studies**

Advances in behavioral, electrophysiological, and neuroimaging applications, including fMRI <sup>[78-81]</sup>, PET <sup>[82]</sup>, and EEG <sup>[83, 84]</sup>, have allowed us to pave the way to better understand the link between music and medicine and study it using the same methodological rigor as any other clinical practice in modern medicine <sup>[85]</sup>. This has allowed us to more closely evaluate the structural and functional correlates of the cognitive neuroscience of music to show that brain regions responsible for the same reward/motivation, emotion, and arousal centers of the brain responsible for euphoria inducing experiences, including food, sex, and certain drugs of abuse, are very similar to regions of the brain perceiving and processing musical experiences. Although the science of musical experiences from a cognitive level is still in its infancy and a detailed review of these studies is beyond the scope of this paper, we have summarized a few relevant findings below.

Early studies focused on neural localization of various musical qualities such as pitch, melody, and harmony <sup>[86]</sup>. Later, brain patterns in perception of music in musicians versus non-musicians were explored, with more recent research focused on higher order cognitive processing of different aspects of musical experiences <sup>[86]</sup>. Neuroscience research in the last decade has focused on two brain regions as key in processing musical information: the auditory cortex (which receives sound input) and the somatosensory cortex in the temporal lobe (responsible for representation of fingertips) <sup>[87, 88]</sup>. Other seminal work <sup>[89]</sup> has consistently linked the cerebellum, basal ganglia, supplementary motor areas, and prefrontal and premotor cortices to musical performance. More recent research using novel imaging technology has highlighted the relevance of the mirror neuron system in the shared emotional experience derived from music <sup>[86]</sup>. Music listening alone activates more brain regions than any other known cerebral activity, drawing on structures from the brainstem all the way up to the frontal cortex <sup>[86]</sup>. Clearly, there



are broad neural networks ranging from emotional perception to motor/somatosensory functioning that are key in the various processes involved in musical perception.

## **DISCUSSION**

Music is likely one of the oldest tools in medicine and has recently received considerable attention, allowing it to be studied with the same methodological rigor as other conventional interventions. In pain management, music provides distraction and cognitive imagery to aide relaxation. It also reduces pain perception by blocking pain impulses to the brain at the spinal cord and releasing endorphins, which simply help us feel good. Therapeutic music can also help restore lost abilities, such as memory deficits in dementia, or speech and motor deficits following a brain injury or stroke. One of the fastest growing clinical applications of music therapy is with children with autism spectrum or other developmental disorders, helping improve self-expression, as well as social and shared communication, and perhaps reaching even less measurable goals such as improving self-esteem and quality of life. Table 1 summarizes the therapeutic role, areas of clinical influence, and clinical populations addressed in this review. We know from neuroimaging research that brain circuitry involved in perception and processing of music closely overlaps with those regulating emotions, arousal, pleasure, and cognition. To a great extent, this explains how music can be used as a tool to influence and regulate these fundamental human functions.

Due to very rapid advancements in technology, our access to music and the environments in which we listen to music have changed dramatically. In the last few centuries, we have progressed from listening to pieces of music during live performances, only to hear a given piece once or twice in a lifetime perhaps, to having access to a vast array of music instantaneously <sup>[90]</sup>. As adults, we are said to be exposed to some form of music, though not actively, about 40% of our waking lives <sup>[90]</sup>, with this rate up to 80% in toddler years <sup>[91]</sup>. Although there is a relatively small evidence base for the use of musical interventions to promote health and wellbeing, support for its clinical application is rapidly growing. It is considered a promising and one of the most universal modes of therapy due to its low cost, ease of administration, minimal to no risk of adverse effects, as well as its applicability to a range of clinical populations and age groups. As its effectiveness is measured and studied, attention should be given to identifying measurable therapeutic goals, using adequately powered studies, and methodological rigor (with use of appropriate control groups) to establish quantifiable measures of its efficacy.

With computer and data inundation increasingly isolating subsequent generations, music therapy remains a healing tool, now with a growing evidence base, in fostering social interaction and wellbeing. Music is universal but also highly individualistic and empowering; “When people are touched by music, it often results in real bodily sensations, in ‘real’ and tangible experiences that are way beyond the logic of simply processing information” <sup>[92]</sup>. Although pinpointing the precise healing mechanisms of music remains elusive, we all recognize its powerful influence on ourselves and on others when it undoubtedly occurs.

**Table 1. Summary of identified therapeutic roles and clinical applications of music.**

<b>Therapeutic Role</b>	<b>Areas of Influence</b>	<b>Clinical Population(s)</b>
Modulation of pain and discomfort	Reduce physiological (e.g., cortisol levels) and psychological markers of stress or discomfort; provide cognitive imagery to distract from negative experiences; release of endorphins and oxytocin	Patients undergoing painful and/or invasive procedures; palliative care patients
Modulation of attention	Captivating attention and distracting from other evoked negative experiences (when present)	Patients undergoing painful and/or invasive procedures; autism spectrum and other pervasive developmental disabilities
Modulation of emotion and mood	Regulation of emotion centers in the brain involved in initiation, generation, maintenance, and termination of emotions	Any clinical population (or their caregiver) experiencing anxiety or apprehension; Psychiatric populations
Facilitation of cognition and language (communication)	Facilitate learning/memory and retrieval, alternative forms of communication and self-expression	Dementing disorders, neurologic patients (e.g., stroke or brain injury), pervasive developmental disorders
Facilitation of physical and motor functioning	Facilitating movements involved in walking, speaking, grasping, and gait	Patients in rehabilitation setting (e.g., stroke or brain injury)
Facilitation of social communication	Improve social (including nonverbal) communication, social cognition and self-expression	Autism spectrum disorders and other pervasive developmental disabilities

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