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Music Therapy for the Pediatric Patient Experiencing Agitation During Posttraumatic Amnesia: Constructing a Foundation From Theory

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Abstract

Posttraumatic amnesia can be a clinically difficult phase to manage in the pediatric patient emerging from coma following severe traumatic brain injury (TBI), as agitation is a common presentation during this stage of recovery. Familiar song is offered, as a music therapy intervention, to reduce agitation for the pediatric patient; however, there is a paucity of evidence to support this. The purpose of this article is to combine interrelated knowledge from the fields of pediatric TBI recovery, music therapy, music neuropsychology, and mother–infant musicality to construct a theoretical foundation for the use of familiar song with this population.

Keywords

mother–infant communication, music neuropsychology, music therapy, pediatric, posttraumatic amnesia

The Presence of Agitation During Posttraumatic Amnesia and the Need for Intervention

In developing a theoretical foundation for familiar song as a music therapy intervention to reduce agitation in the pediatric patient during posttraumatic amnesia (PTA), it is first necessary to define PTA as a distinct phase of recovery following traumatic brain injury (TBI). Posttraumatic amnesia is a transient phase of coma emergence and spontaneous neurological recovery that follows severe TBI.[1] Posttraumatic amnesia is characterized by fluctuating levels of consciousness, disorientation, and impaired short-term memory.[1-3] The duration of PTA (including the period of coma) is predictive of injury severity[4]; therefore, severe TBI is correlated with a greater length of PTA.[5]

Agitation is common in the pediatric patient in PTA.[6,7] Agitation may manifest as aggression, continuous movement, self-stimulating behaviors, excessive and repetitive talking, disinhibition, impulsivity, attempts to abscond from the hospital environment, and/or attempts to remove medical devices.[8,9] Agitation present during PTA occurs in a state of reduced consciousness; therefore, the patient does not have the capacity to inhibit these behaviors.[2,9-12] Cognitive improvement in patients in PTA has been found to precede a decrease in agitation.[2,13]

The cause of agitation during PTA remains largely speculative and is likely dependent on the nature and location of the neural trauma.[14-16] Potential pathological substrates of agitation include lesions, compression, changes in cerebral blood flow, or interruption to the balance of neurotransmitters in the frontotemporal regions of the brain. Damage to these neural regions is associated with impulsivity, disinhibition, inattention, and memory impairment.[9,15] Diffuse brain injuries, resulting in damage to the subcortical and brain stem regions that coordinate arousal, attention, and limbic behavioral functions may also result in agitation during PTA.[2,16] An interplay between altered arousal, cognition, and motor control may cause an impaired ability to process stimulation present in the environment, often resulting in overstimulation and an exacerbation of agitation.[17,18]

Pediatric patients experiencing agitation during PTA have an increased potential for injury (to themselves and others), are disruptive to the hospital environment, and require high levels of nursing care. Despite this, there is a paucity of literature detailing clinical management strategies. It has been argued that pharmacological management of agitation is contraindicated as medications may have a sedative effect, exacerbating

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confusion, and cognitive deficits and hence increasing agitation.[9] Therefore, environmental interventions that aim to promote familiarity, comfort, and structure and reduce the potential for overstimulation are encouraged by the specialist medical, nursing, and allied health staff in the pediatric hospital where the first author is employed.[19]

Clinical presentations of patients, including presentation during PTA and recovery trajectory, are impacted by the severity and location of their TBI and premorbid development.[20,21] Therefore, pediatric patients with a TBI are a heterogeneous population. Furthermore, there is a low incidence of severe TBI in children.[22] Hence, it is difficult to design systematic research to measure the effectiveness of interventions for pediatric patients experiencing agitation during PTA. This has likely contributed to the paucity of evidence. Despite this low incidence, PTA is a significant phase in the recovery process following TBI, and therefore, clinical interventions are needed to manage the presentation of agitation.

Trauma and the Developing Brain

It is widely acknowledged in the literature that trauma to the developing brain of a child is distinct to injury in an adult brain, however, theories of recovery following TBI in pediatric patients continue to be debated.[23,24] Advocates of the *plasticity theory* argue that the immature brain is more plastic, meaning it is less rigidly specialized and more malleable to external stimuli. This results in less susceptibility to the impact of neurological damage.[24,25] Contrary to this, proponents of the more recent *early vulnerability theory* emphasize that the young brain is uniquely susceptible to the impact of cerebral trauma.[23]

The early vulnerability theory is the prevailing theoretical culture in the Australian pediatric hospital in which the first author is employed. Clinically, the recovery trajectories of pediatric patients who sustain a severe TBI are aligned with this theory. The premise of this theory is that TBI in a child may disrupt the rapidly developing neuronal networks of the immature brain and further disrupt the future acquisition of skills, leading to compounding difficulties rather than to recovery.[8,23,26-28] Anderson and Yeates[29] emphasized that the growing evidence for a developmentally specific response to TBI means that ''it is not possible to simply translate adult knowledge and theories to the child population.'' Hence, the rapid onset neural trauma of pediatric TBI cannot be compared with the degenerative neural effects of dementia. Therefore, the large body of literature that reports on music therapy to reduce agitation in adults with Alzheimer disease/dementia cannot be used as a framework to develop a theoretical premise for music therapy for pediatric patients experiencing agitation during PTA. This necessitates the generation of a new framework and research of treatment interventions for children who sustain a TBI.

Familiar Music and Agitation

Searches of Medline, Pubmed, CINAHL, PsychINFO, and Cochrane databases[1] revealed only 1 study that empirically explored the use of music as a treatment modality to reduce agitation in patients in PTA. Baker's[30] study found that familiar music had a significant effect in reducing agitation in adult participants (aged 15-66 years) during PTA. Baker's comparison of live, prerecorded familiar music and no music indicated that both presentations of familiar music significantly reduced agitation in adult patients in PTA when compared with the no music condition ($P < .0001$).[30] Baker emphasized that the familiar music selections utilized in the study were suitable to the cognitive abilities of the participants as the music was frequently repetitive, predictable, and simply structured, ensuring minimal cognitive arousal was required when listening to the familiar music.[30] Furthermore, many participants were able to engage with the music through singing along or rhythmically timed body movement and this may have allowed for the appropriate expression of psychomotor components of agitation and an increased level of organization in the patient's otherwise disorganized and nonpurposeful movements.[30-32] Systematic exploration of use of familiar music as an intervention to reduce agitation in children during PTA has not been reported. In a clinical vignette, Magee and colleagues described the use of familiar songs to decrease agitation in a 15-year-old patient in PTA. Familiar songs were sung to the patients to increase attention and alertness, which resulted in an observed decrease in agitation and inappropriate behaviors.[33] Furthermore, Kennelly and Edwards[34] briefly described the use of music therapy to reduce physical agitation and calling out in a child in the ICU. However, this does not include any diagnosis or description of PTA as a distinct phase in recovery from severe TBI.

Music Therapy for Children Who Have Sustained a TBI

The application of music therapy for individuals who have sustained a TBI has continued to expand in the last decade contributing to the field of adult neurorehabilitation particularly in the areas of motor and language rehabilitation.[35] However, the pediatric population remains underrepresented in the current English music therapy literature. The most pertinent precedent for the clinical use of music therapy to reduce agitation in the pediatric patient in PTA comes from studies and clinically based reports exploring the use of music with children during the early coma phase of recovery and later postacute rehabilitation.

Music Therapy for Children in Coma

The use of familiar songs to successfully support predictability, comfort, and orientation in children in coma[34,36] may provide a precedent for the use of familiar music as an intervention to reduce agitation during coma emergence and PTA. The live

singing of familiar songs has been reported in clinical vignettes to stimulate a range of physiological, behavioral, communicative, and emotional responses in children in coma. These responses were interpreted as indicative of an increase in coma arousal and orientation levels.[34,36] Given the length of coma is indicative of injury severity, these arousal responses are positive indicators of recovery potential. Songs familiar to the patients were used to support a sense of predictability, comfort, and orientation through the structured and ordered characteristics of the music.[34,36] Kennelly and Edwards[34] and Rosenfeld and Dun[36] advocated that familiar song may be easier for children in states of reduced consciousness to recognize than improvised music. Familiar precomposed music potentially requires less active cognitive processing than does improvised music.[37] Furthermore, Hurt-Thaut and Johnson[38] described a clinical vignette of a 4-year-old patient admitted to the ICU following a severe TBI. The patient was unresponsive to external stimuli but was observed to be calm, with a decreased heart rate and blood pressure, when presented with singing and gentle music.[38] These applications of familiar music for children in coma are consistent with the stance of providing an environment that promotes familiarity, comfort, and structure to reduce agitation.

Aldridge and colleagues'[39] early hypothesis that music has the potential to offer an alternative form of temporal organization for patients with neurological damage who are lacking orientation remains pertinent to the development of the current theoretical framework. Aldridge and colleagues[39] argued that patients in a coma are in a state of neural disorganization and may have difficulty orientating in an environment of random, loud machine, and human noise. For these patients, music improvised around the rhythmic context of their breathing may provide a focus for orienting and increased awareness.[39] Furthermore, human contact is central in improvised singing and can encourage human interaction in a fundamental form.[39] The fundamental form of human interaction described by Aldridge and colleagues[39] is related to the nonverbal elements of music, including rhythm and melody, that the comatose patient may respond to, despite an apparent lack of response to language-based interactions. Although Aldridge and colleagues described the use of improvised music, human contact is a fundamental aspect of the live presentation of familiar (precomposed) song. This supports the premise that the pediatric patient in PTA responds to the musical elements of the therapeutic interaction, within the predictable structure of familiar song.

Aldridge and colleagues' hypothesis was more recently supported by Magee and Baker[40] who advocated the theoretical principle that music has the potential to enable the adult patient recovering from a TBI to express immediate feeling states and communicative intent when language is lost as a result of TBI. This theoretical principle has not been explored in children; however, it is widely accepted that infants respond to the emotional and fundamentally musical components of early interactions well before they are able to comprehend spoken language.[41] It is therefore possible that music may provide opportunities to express communicative intent in children who have communicative deficits resulting from TBI.

A preference for live music therapy interventions, as opposed to the use of recorded music, has been emphasized for patients in states of reduced consciousness because of the human interaction inherent in the presentation of live music.[34,36,39,42,43] Musical components (eg, rhythm, melody, and harmony) form the fundamentals of human communication and interaction. Therefore, music as an nonverbal, emotionally focused stimulus may have the potential to stimulate a patient's fundamental communicative, emotional, social, and cognitive capacities despite a seemingly nonresponsive presentation.[42,44,45] The musical components of interaction and the value of fundamental interaction are explored below in the section exploring mother–infant musicality.

Music Therapy in the Postacute Rehabilitation of Children Following TBI

One of the principal concepts in developing a theoretical framework supporting the use of familiar song with pediatric patients experiencing agitation during PTA is the utilization of the temporal aspects of music to increase organization and decrease confusion. This principal concept is supported by the literature detailing music therapy interventions for pediatric patients undergoing rehabilitative treatment. Rehabilitation typically commences once a child has emerged from coma and PTA and no longer requires continuous acute medical care.

Highlighting the unique developmental phenomenon that distinguishes the rehabilitation of children from adults, Kennelly and Brien-Elliot[46] outlined that music therapy goals in pediatric neurorehabilitation fall into 4 main areas: (1) motor skills, (2) behavioral/cognitive skills, (3) speech/language/communication skills, and (4) psychosocial care. Both Kennelly and Brien-Elliot[46] and Hurth-Thaut and Johnson[38] emphasized the temporal organization inherent in music and the potential for this to be used with children following TBI to increase the child's organization and attention and decrease confusion to maximize rehabilitative outcomes.

Similarly to the literature supporting music therapy for children in coma, music to stimulate fundamental interpersonal interaction is one of the core elements reported in the pediatric rehabilitation music therapy literature. In his significant contribution to the pediatric neurorehabilitation literature, Gilbertson found that interpersonal relationships were at the core of neurorehabilitation.[47,48] Gilbertson undertook systematic observation and analysis of video-recorded episodes taken from clinical practice in music therapy, with both adults and children in a postacute rehabilitation facility. The participants in his study presented in postcoma low-responsive states. The clinical music therapy sessions were based on Nordoff and Robbin's improvisational, Creative Music Therapy approach. Using therapeutic narrative analysis, 2 primary categories were elicited from the video data: (1) isolated–integrated and (2) idiosyncratic–conventional. These categories were presented as polarities as Gilbertson suggested that one of the roles of a

music therapist is to reverse the isolation an individual with a TBI may experience as a result of enormous physical and psychological barriers. That is, in moving away from isolated, the individual may become integrated in his or her ability to interact and engage with people and his or her surroundings. Further, idiosyncratic behaviors or responses of an individual with a TBI may compound isolation and thus in assisting the patient to move toward conventional, isolation may be reduced. Gilbertson and Aldridge[48] further explained that the essence of these polar categories, or the core category, was relationship. Through the music therapy experience, the participants were able to relate to others in a meaningful way. Music provided a flexible temporal organization that promoted the opportunity for early communication and relationships.[48]

The use of music to increase the social capacity of a child with a non-TBI has also been explored in a case study by Bower and Shoemark.[49] The child had emerged from coma but was unable to commence functional speech rehabilitation as a result of deficits in interpersonal interaction. The use of song singing and instrumental improvisation to engage the child in musical interactions was detailed. Bower and Shoemark highlighted the potential of familiar song to reestablish meaningful interpersonal interaction in a child who initially appeared unresponsive to language.

Mother–Infant Musicality

Human beings are innately musical,[50,51] as evident in the ability to meaningfully process music from birth.[41,52] Relating to others through music is also innate and the foundations of the earliest and most primitive human interactions, those between a mother and infant, are musical.[41,53,54] Hence, the therapeutic interactions described earlier are informed by theories of mother–infant musicality.

Infants are biologically predisposed to attend to melodic contour and rhythmic patterning of sounds and to interpret the musical meaning present in early interactions.[41] Infants respond to the musical elements present in early interactions well before they have developed the ability to process language.[55] The infant's intrinsic ability to respond to the nonverbal, musical elements of early interactions is likely mediated by the brain stem, limbic system, and neocortical regions of the infant's brain.[55] Papousek[56] stated that preverbal communication is a nonconsciously regulated intuitive behavior. For children presenting with agitation and disorganized behaviors during PTA, therapeutic interactions utilizing music may stimulate the subcortical and limbic regions associated with early preverbal interactions promoting meaningful human contact.

In providing a rationale for the use of music as a treatment medium in neurorehabilitation, Magee[40,57] highlighted the musical nature of infant's preverbal interactions and the innate nature of music to emphasize that communicative intent may be expressed through music when a patient's language capabilities are impaired. Trevarthen and Malloch also noted ''music is therapeutic because it attunes to the essential efforts that the mind makes to regulate the body, both in its inner neurochemical, hormonal and metabolic processes and in its purposeful engagements with the objects of the world and with other people.''[54p13] As confirmed in Gilbertson's[48] study, musical interaction has the potential to bring a child, who may be isolated as a result of physical or cognitive deficit, into companionship or interaction with another, and this is a fundamental need of all humans.[54]

Infants have an intrinsic need for companionship with a primary caregiver, usually the mother, and this need for companionship is equal to the need for nutrition and protection.[53,58] Experts in early childhood development have gone so far as to say that infant survival and development are dependant on interaction and preverbal communication with their mother.[54-56,58] Infants interact with their mother to regulate their internal physiological states, and these early interactions are fundamental in the infant's ongoing cognitive, emotional, and psychological health and development.[53,59] Pediatric patients presenting with agitation during PTA have an impaired ability to interact with others. Using music to stimulate fundamental communication, a music therapist may promote opportunities for meaningful interaction. Furthermore, the patient's decreased level of consciousness may result in an inability to regulate his or her internal and external states. Musical interaction between the pediatric patient in PTA and the music therapist may act as a scaffold to increase the patient's level of organization, similar to the physiological regulation achieved through mother-infant interaction.

Neural Processing of Music

For children presenting with agitation during PTA, music may stimulate a global network of cortical and subcortical functions, maximizing opportunity for the music therapist to utilize the inherent temporal structure of music to decrease confusion, disorientation, and agitation. As Thaut[60(p64)] stated, ''music—based on its uniquely ordered structure of sensory patterns in aesthetic forms—initially engages human behavior and brain function meaningfully by arousing, guiding, organizing, focussing and modulating perception, attention and behavior in the affective, cognitive and sensorimotor domains.'' That is, the inherent structure of music can engage, organize, and alter behavior by stimulating a range of global neurological functions.

Current theories of the neural processing of music support the premise that music is a global neural process.[50,61-63] That is, music is processed throughout the primitive and higher cortical regions of the brain. Some capability to process music by the pediatric patients during PTA will likely remain intact because of this global neural processing of music.

As a musical sound reaches the eardrum, it stimulates a series of complex neural events in the brain that result in the perception of the sound as music.[64] The primary auditory circuit in the brain consists of the auditory nerve, brain stem, thalamus, and auditory cortex.[64,65] Historically, it was thought that

music was predominantly processed in the right hemisphere of the brain and language in the left. While some laterality effects do exist, this theory is now considered an oversimplification.[63-65] There is no single music center in the brain.[62] The neural processing of pitch and rhythm appears to result from processes in 2 largely distinct networks.[64] Musical pitch processing predominantly involves the right auditory cortex, often including the more widespread networks of the right temporal neocortex, whereas the processing of the rhythmic and temporal aspects of music recruits a more widespread bilateral neural network.[64] Furthermore, activation of the frontal, temporal, occipital, and parietal lobes and subcortical neural regions may occur depending on the nature of the music activity that an individual is involved in.[62] The brain processes the many, potentially independent, elements of music before integrating them as a coherent whole.[50,62,63]

Music is evaluated on both perceptual and emotional levels and therefore the neural correlates of the emotional processes must also be considered in any description of the neural processing of music.[65] This is illustrated in studies such as Brown and colleagues'[66] positron emission tomography study which found activations in limbic and paralimbic structure in response to the passive listening of pleasant music. Furthermore, Koelsch and colleagues[67] used functional magnetic resonance imaging (fMRI) to determine the neural processing of emotion in response to pleasant and unpleasant music. Activity changes in response to the musical stimuli (both pleasant and unpleasant) were measured in the limbic and paralimbic structures including the amygdala, hippocampus, and temporal poles. The limbic system and paralimbic structures represent the subcortical core for emotional processing.[61,65,68]

The majority of imaging studies exploring the neural processing of music and all of those cited have been undertaken in the adult population, and it has been theorized that much of the neural circuitry develops as a result of ongoing exposure to music.[52] However, a recent fMRI study by Perani and colleagues[52] found the neural architecture involved in the processing of music is present at birth. Furthermore, results also suggested music effects the core emotional centers of the newborn brain, similar to the neural substrates of emotional responses to music seen in adults.[52] It could therefore be expected that the global neural processing of music is present in children.

Importantly, global neural processes are less likely to be impaired as a result of brain trauma.[69] Therefore, music, used as a therapeutic intervention, may ''provide an alternative entry point into a 'broken' brain system to remediate impaired neural processes or neural connections by engaging and linking up brain centers that would otherwise not be engaged or linked with each other.''[70(p372)] The possibility of an ''alternative entry point'' into the brain damaged by trauma is a result of the large distribution of neural areas involved in the processing of music. Furthermore, music is a complex stimulus, involving elements of pitch, rhythm, timbre, tempo, meter, contour, loudness, and spatial location, that activates a global firing of neuronal connections in both the cortical and the subcortical regions of the brain.[62,64]

Music Therapy for the Pediatric Patient Experiencing Agitation During PTA

Familiar song serves as an exemplary experience of predictability for the pediatric patient experiencing agitation during PTA. Familiar song is inherently structured providing an external temporally organized experience to support an increase in organization, orientation, and subsequent decrease in agitation. The live presentation of familiar song within a music therapy intervention also supports the opportunity for fundamental interpersonal interaction. This experience of familiar song can serve as a scaffolding for reemergence into the social world (akin to the newborn infant) unlike other social experiences that may be too complex for the pediatric patient presenting in a state of reduced consciousness. This social reemergence can promote increased organization through interaction within the temporal framework of familiar song. Finally, music is processed globally throughout the brain,[50,64] and because of this, some ability to meaningfully process familiar song in a pediatric patient following TBI is likely to remain intact. This combination of knowledge and theories highlights the unique potential of the therapeutic use of familiar song to reduce agitation in the pediatric patient in PTA.

Summary

The pediatric patient experiencing agitation during PTA presents many challenges for staff and family involved in their care in an acute hospital setting. At present, there is a paucity of evidence supporting clinical management strategies for these patients, despite environment and nonpharmacological intervention/treatments being the preferred methods of management. The use of familiar song as an intervention to support increased organization and a decrease in confusion and agitation in the pediatric patient in PTA has been explored. This article has sought to combine knowledge from interrelated fields to offer a theoretical foundation for this use of familiar song as a preliminary step in the development of evidence.

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