Investigating Music’s Role in Consciousness and Coma Arousal

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**Abstract**

Understanding the inner workings of the mind, consciousness, has been a long sought-after question with few answers. The goal of this paper is to examine how music and consciousness intersect, and how music can be implemented in restoring consciousness under a disordered state such as a coma. Consciousness and its features such as arousal, awareness and vigilance are examined in relation to daily cognitive function. Different cognitive models that account for neural processes in consciousness are also studied. Music and consciousness have overlapping concepts and music has the power to guide conscious experience. Using this information as a foundation, this paper looks at disorders of consciousness and how they arise, and specifically focuses on coma therapy. Currently, music therapy is used in certain aspects of coma recovery such as stimulating arousal and motor therapy. However, I propose that selective music therapy can be used for full coma recovery and restoration of conscious control. This paper suggests a framework for integrating music therapy in multiple aspects of a coma therapy.

Descartes in *Mediations on First Philosophy* posed the idea: cogito, ergo sum (I think, therefore I am). These words sparked a revolution, into foundational understandings still focused on today. Epistemology seeks the answer to questions, such as what we know and how do we know it, and what does it mean to know. Crucially, Descartes also began to investigate the relationship between the mind and body, what we know today as Cartesian dualism. His theory on the separation of mind and body continue to influence our understanding of the human experience. Integrating the ideas of Christian theology, the soul is reflected in the thinking mind. However, Descartes introduced the idea that the body is unthinking matter in a departure from Aristotle thought. This marks a fundamental turning point where the body cannot exist without the mind, or at the very least the mind is a crucial point of being. This established the concept of human beings and what this entails.

These advances in philosophy set the foundation for social and humanistic psychology. The humanistic school of psychology arose as a response to psychoanalysis and behaviorism, which some psychologists saw as limiting. Through humanism, psychologists emphasize looking at an individual as a whole and not stimulus-enabled behavior. Foundationally, the belief is that humans have free will and seek validation of self-concept. Baumeister (1999) explains self-concept as an individual’s belief about themselves, their attributes and who the of ourselves, then we have a concept of who we are. Lewis (1990) suggests that we can divide self-concept into two components: the existential self and the categorical self. When we realize that we as individuals exist separately and independent of others, changing over time, we have the knowledge of the existential self. Once we realize we are a separate being, we then work towards the realization that we are part of the world. Similar to an object, we have our own properties and attributes. We begin to form an image of ourselves, internally and externally describing ourselves. Understanding this helps us understand consciousness.

**Defining Consciousness**

Consciousness can loosely be defined as our experience of the self and the world around us. It is our unique thoughts, memories, feelings, sensations and environments that mentally form our subjective experience, an experience we are aware of. Understanding consciousness begins with defining consciousness. It is our capability of perceiving and processing environmental stimuli we encounter. The Stanford Encyclopedia of Philosophy described the problem of consciousness in three parts: what, how, and why questions of consciousness. The descriptive what line of inquiry asks what consciousness is, its features and through which methods can we empirically study it. The explanatory how questions ask how consciousness is imbued in the mind, accounting for other nonconscious processes as well. Lastly, the functional why questions consciousness’ utility and how it affects our overall function. From a first-person perspective, an individual can describe their conscious experiences, but not sufficiently as methodological inquiry.

In order to create thorough models of consciousness, the different features of consciousness need to be ontologically defined. Qualia are defined as individual instances of this subjective, conscious experience (Dennett, 1998). Rather than focus on belief or verbal description about an experience, qualia deal with the perceived and qualitative characters of sensation. Dennett (1998) categorizes four properties of qualia: ineffable, intrinsic, private, and apprehensible. Qualia cannot be communicated without personal experience and are independent of other experiences, unique to an individual, and a consciously known experience. Rather than an analysis of an experience, this feature focuses on the whole feeling of an instance. Qualia lies in contrast to the phenomenal structure of consciousness. Phenomenal structure also refers to the qualitative feel of experiences; however, the accessibility of this experience remains in question. Carruthers (2000) argues that phenomenal consciousness results from sensory experiences but excludes intentionality and cognition. This form of consciousness is out of our direct control of action and reasoning. Vice versa, access consciousness is a representational form of consciousness. This includes thoughts, conscious will, and beliefs. Access consciousness is reportable as it is available for immediate use in determining our behavior (Block, 1995).

When we consider the issue of how we have consciousness, subjectivity can also be considered a distinct representation. Nagel (1974) uses bats as an example to elucidate how we acquire knowledge from conscious experience. The argument is that we may know objective facts about brain and behavior in bats, but we will never know what it is like to be a bat. As humans, we will never have the subjective experience of a bat. Objectively, it is possible to learn everything about bat cognition and behavior in bats, but not directly experiencing it. Conscious experience comes from a first-hand, subjective experience of an event. It is unique to each individual’s brain and body. We cannot know another person’s subjective experience, while our knowledge of the world is dependent on our own subjective experience.

**Examining Consciousness**

Chalmers (1995) discusses the hard and easy problem of consciousness. This can be viewed as an extension of Cartesian dualism. Chalmers suggests that consciousness has qualities to it that cannot be reduced, suggesting a theoretical gap between the mind and phenomenal structures. He extends this line of reasoning by stating that consciousness arises from physical processes. The easy problems of consciousness are determining the relationship between physical systems and basic functions like vision and hearing. This can be answered by identifying the neural mechanisms behind a function, such as using fMRI to study brain activation. These phenomena can be answered through reductive logic. The same explanations do not apply for consciousness. Determining why we have phenomenal experiences is the hard problem. Consciousness cannot be functionally analyzed or easily categorized, creating an ontological problem.

Despite these challenges, there has been movement towards defining states of consciousness. The global workspace theory seeks to resolve the issues of conscious and unconscious experiences coexisting. Akin to working memory, the global workspace selectively attends to consciousness, dependent on unconscious processes that the mind does not directly have access to (Baars, 1998). The contents of the workspace correspond to inner speech and visual imagery that we are conscious of, guided by inaccessible cognitive processes that act as input. Consciousness differs from cognitive processes such as attention. There are functional and anatomical distinctions between the two. Attention can be considered the target-selection process. Meanwhile, consciousness can be considered as reportable events we can verbally describe or access. Baars (1998) describes consciousness as phenomenal experience, while attention selects potential conscious content unconsciously. As an example, it is the difference between looking and seeing or hearing and listening. At the surface level, these functions sound similar and appear to connote the same meaning. However, the difference comes from the way

Wu (2018) defines awareness as directly knowing and perceive an event happening, such as an action we decide to take or how we feel emotionally. Put simply, awareness can be considered knowledge of something that exists externally or internally. This includes emotions, memories, and sensory patterns. It is also important to note that awareness exists in different degrees in different individuals. Awareness is dependent on an individual’s sensory perception, knowledge and cognitive functions. Awareness can be considered a necessary condition of consciousness, but involuntary actions or thoughts can occur without awareness of it. These are considered unconscious processes that work in conjunction with conscious processes. Consciousness is a higher state of awareness.

Physiological concepts of consciousness have also been identified. Vigilance is a state of consciousness, dependent on the level of wakefulness and alertness. This cognitive process is maintained by the reticular formation in the brainstem and thalamus (Tassi & Muzet, 2001), Disorders of vigilance can affect conscious responses to stimuli and accuracy of cognitive abilities. Arousal is another important concept of consciousness that will be visited throughout this paper. This mechanism is key regulator in consciousness, attention, and alertness. Similar to vigilance, arousal relies on reticular activation which mediates the nervous and endocrine system in stimulating sensory perception and responsiveness. Neural systems partner with neurotransmitter in activating cortical function and alertness.

Once researchers understood the importance of neural activity in consciousness, theories of consciousness began to be examined. Higher-order theories (HOT) are an important conceptual foundation of consciousness. HOT seeks to explain the difference between conscious and unconscious mental states. Mental states are seen as a hierarchy, where phenomenally conscious states are a higher-order representation formed off of unconscious states of perception and feeling (Rosenthal, 1986). Using the idea of primary representations and higher-order representations, neural correlates of consciousness (NCCs) began to be examined. Early research focused on visual perception from the visual cortex and found that the V1 region played an important role in connecting primary visual sensations with complex cognitive functions unrelated to vision such as memory and decision-making (Metzinger, 2000). Additionally, somatosensory stimulation has found that consciously perceived stimuli and unconsciously perceived stimuli activate different regions of the brain such as the frontal and parietal lobe versus the primary somatosensory regions (Palva, 2005). Furthering our understanding of consciousness will require continued NCCs identification.

**Music and Consciousness**

Integrating the themes discussed in this course, there is great intellectual and academic potential in examining the underlying concepts of musicking and consciousness. In short, there are strong conceptual similarities between these two ideas. Small (1998) depicts musicking as a way for an individual to experience the world and their relationships formed within it. Crucial to this topic of discussion, Small engages with the theories of Cartesian dualism. Small rejects this formulation of dualism, suggesting that the body plays an important role in conjunction with the mind’s behavior. Rather than the body and mind being two separate entities, Small suggests that knowledge comes from actively partaking in the world through experience. This is a circular process where the body’s activity shapes the mind and the mind’s activity guides the body. Both are necessary in musicking. Current theories on consciousness also offer similar understandings of body and mind. Consciousness, like musicking, focuses on subjective experience of the self and perceptions of the external world. Consciousness also helps form self-concept and evaluation of relationships with others. The current consensus suggests that the body engages with sensory and external stimuli that the mind translates into sensory experiences, both conscious and unconscious. The conscious experiences we have access to help define ourselves and our place in the world, just as musicking helps define interactivity and existence in our environment.

Not only are musicking and consciousness similar processes, but music also has the power to shape conscious experience. Studying the relationships between music and various cognitive functions show that music plays an important role in attenuating cognition. For example, attending to music helps us attend to language (Jancke, 2012). In this review paper, the authors examined studies that found significant interactions between musical practice and language functions, such as the ability to process unvoiced stimuli in phonetic perception. Additionally, Strait and Kraus (2011) found that musicians have perceptual advantages in neural attention and encoding of speech. These studies have broad implications for music in language learning and recovery. Musical training has the potential to heighten sensory perception of speech, and this can be translated into facilitating speech perception and learning for those who have neurological deficits in areas necessary for language.

Further relating to the topic of discussion, music is embodied in consciousness. One way to visualize consciousness is building blocks. There are foundational blocks necessary to consciousness, like sensory input, basic neurological functions such as visual and somatosensory processing and awareness. However, consciousness can be built up block by block to form a larger tower. External experiences and interactions with the world such as gaining new motor skills or adding to long-term memory fulfill this function. These growing experiences heighten our subjective experience and understanding of the outside world. Music is a sensorily and perceptually complex activity that contributes to conscious experience. Music guides mental imagery and emotional neural activation, alongside physical experiences that enhance consciousness. Clarke and Clarke (2011) write that music does not only offer insight into consciousness, but actively shapes mental states. Since music integrates cultural, social, emotional and motor features, it offers significant opportunity to guide consciousness. Subjective experiences of music and memory are one such function. Each individual listen to music and forms emotional and visual imagery connections that embed into long-term memory. As we listen to music, neural activation can arouse the body as a response, inducing a physiological response. As we revisit and continue to engage with music throughout our lives, our conscious experience builds on these factors.

Connecting with Baars (1998) theories of phenomenal and access consciousness, music can also facilitate access consciousness. Specifically, induction techniques and guided music therapy can be implemented (Bonny, 1975). In this study, Guided Imagery and Music (GIM) was utilized in psychiatric therapy as well as the general population. As a non-verbal medium of self-exploration, the researchers found that music invoked multi-sensory activity and responses. The subjects in this study were able to access and engage with different conscious states, including memory and emotional experiences. These induction techniques pioneered by Bonny allowed patients to attend to images, thoughts, feelings and memories that may have been unconsciously stored as they became consciously active. Doing so allowed patients to engage with sources of trauma through music in a cognitively stimulating and healing way.

**Research Question**

The research question of this paper seeks to determine how music therapy can be used to address an altered state of consciousness, coma, and be utilized in such a way that consciousness can be regained or restored. Altered states of consciousness occurs when there is a disorder of consciousness, either due to neurological deficits or trauma or changes in wakefulness. In these mental states, the mind is often aware of the self and its surroundings, but not at its normal level of function. The contents of consciousness and levels of wakefulness can be used to classify altered mental states (Laureys et al., 2009). Wakefulness deals with the concept of vigilance, where connections between neuronal firing and neurotransmitter release through the brainstem and thalamus shift the brain between sleep and wakefulness. This is a recurring process where we become conscious and are primed to cognitively and behaviorally respond to external stimuli. When we are not in a state of wakefulness, we are no longer conscious, and the brain has a chance to recuperate from processing external inputs. Wakefulness is impaired under neurologically traumatic conditions such as vegetative states and brain death. Contents of consciousness refers to integrity of consciousness, as measured by cognitive ability. Healthy cognitive function leads to a proper integrity of consciousness. When there is disruption to contents of consciousness, an individual is usually conscious to different degrees, but perception and response to stimuli is altered. Examples include hallucinations, exiting REM sleep cycles, and the influence of narcotics or alcohol. This leads to states where perception is decreased and affects conscious behavior. Laureys et al. (2009) provide a scale comparing different classifications of wakefulness to conscious content ratios for disorders of consciousness.

Coma is one such example of a consciousness disorder. Giacino et al. (2014) identify two categories of consciousness when disordered. There can be normal vigilance, but a lack of significant and actionable responses to stimuli. Conversely, alertness and vigilance can be impaired while contents of consciousness are accurately functioning. Comas are specifically considered to be a disorder of vigilance under the overarching lens of disrupted consciousness. When an individual is in a coma, they are completely unconscious and cannot react to stimuli. The Glasgow Coma Scale (GSC) is used to assess consciousness in three categories on a scale of 15 points (Teasdale & Jennett, 1974). These categories include eye-opening responses to factors such as touch and speech, verbal responses and clarity, and motor responses and reflexes. The GCS is used to generally assess consciousness. Comas in particular are classified in two general categories. In a deep coma, there are no reflexive responses to pain or other stimuli. There is a possibility that some automatic processes such as breathing may remain. Superficial comes are usually ranked with a higher GCS score. With this form of coma, there is the pain-inducing sensation will elicit a motor response, and potential verbal responses.

By understanding the concepts of arousal and alertness factor in relation to comas, we can begin to study how coma recovery occurs. In general, recovery from comas is a gradual process. Patients gain awareness slowly, may be alert for a short period of time a day, then transition towards longer periods of wakefulness (Teasdale & Jennett, 1974). Severity of scores assessed in the first 24 hours of a coma determine the likelihood of successful recovery. The higher the score, the more likely a full recovery. Post-coma, patients often require intensive therapy to regain physical and cognitive skills that have been disrupted from the normal cycles of consciousness. Basic cognitive skills such as speech and motor movements may need to be relearnt. In the case of deep comas, it is plausible that a complete recovery may not occur, and patients may only be able to move to the lower end of the GSC. It is possible that patients may return to a vegetative state where autonomic functions controlled by the brainstem such as breathing and digestion are fully recovered, but they will not regain full consciousness and respond to external stimuli on any level.

Music therapy has recently become a field of interest in coma arousal and recovery. The most successful treatments in music therapy have been in superficial coma recovery. Tamplin (2000) found that familiar presentation of musical stimuli leads to heightened awareness and memory arousal. Musical memories are cross encoded across multiple regions of the brain, compared to simpler verbal or visual long-term memories. Music activates auditory, motor and emotional cortexes. This results in a sensorily-complex encoding process working with the hippocampus. Patients sensorily respond on basic levels to music, and there is a notable physiological state of arousal due to these cross-activations. Active music therapy can also be implemented to help induce conscious control of motor behaviors in coma patients (Lendraitienė, 2016). Through music therapy, fine and gross motor skills can be facilitated through motor control as well as body awareness. Techniques such as rhythmic entrainment and music-guided motor therapy improves fluidity and precision of movements as well. These factors in motor control enhance patients’ conscious control over their body. Lastly, using these techniques of music therapy, it is possible to increase awareness in coma patients (Magee, 2005). As patients slowly awaken from comas, music is a useful tool in speeding up the process of wakefulness. It helps patients acknowledge their surroundings and internal state of mind when compared to awakening with no music. This indicates that music therapy can be potentially a useful tool in restoring consciousness and improving recovery outcomes.

**Experimental Framework**

I propose two experiments that will study music therapy and comas that can result in new treatments for coma recovery. The first experiment will focus on both superficial comas and deep comas. I hypothesize that using verbal and emotional memory of music can fully restore consciousness, or partially restore consciousness in deep comas. In the current body of research, music is generally used as an aide alongside familiar voices and touch in coma recovery. I propose that using music in a systematic way aligning with normal patterns of wakefulness and consciousness can lead to a full recovery of consciousness. Playing music that is familiar and carries emotional resonance to patients results in quicker recovery. Additionally, music that is leads to higher physiological arousal – upbeat, rhythmically-nuanced, and auditorily complex – may lead to a higher likelihood of recovery. Current treatments have not factored in the way music shapes consciousness. Categorically studying how culturally, socially and sensorily integrative music can be used in coma arousal and response-induction can lead to more effective treatment. As time periods for consciousness improvements are crucial to full recovery, it will be useful to determine how music that evokes memories and emotional responses quickens the timeline for improvements in consciousness.

The second experiment will focus solely on superficial comas. This study will examine how musical therapy can be implemented as a way to induce conscious behavior and specific cognitive skills. Once coma patients are the higher end of the GCS score, the focus turns to regaining cognitive functions and control that have been lost due to the decrease in brain state. The gap in the literature comes from the range of functions studied with music therapy. Motor skills have been shown to improve when music therapy is given. However, other cognitive functions such as decision-making, language and thinking skills like math and reading have not been studied. I predict that using guided music therapy, these cognitive functions recover and strengthen more quickly than without. Using a similar set of music to the first paradigm, it may be possible to induce cross-neural activations that increase neuroplasticity to strengthen these basic cognitive functions. Can techniques such as induction and guided imagery that access different levels of consciousness be cross-modally connected to cognitive recovery? Music has been shown to shape multiple dimensions of consciousness, and it will be notable to see if music therapy enhances cognitive recovery and conscious control the same way it does for motor function.

In both experiments, coma patients will be assessed on their GCS scores pre- and post-treatment. A treatment can be considered successful if the score ranges above 9, indicating moderately decreased consciousness. A highly successful treatment will result in score above 13, where consciousness has returned to a mildly decreased state. For deep coma patients, success will be measured on a different scale. Generally, deep coma patients have extremely low scores where there is severely decreased consciousness. If a deep coma patient is able to move towards the lower end of moderately decreased consciousness or out of a vegetative state, then that can be considered a successful treatment. With the second experiment, therapy outcomes can be determined by comparing to control groups where music is not implemented. Cognitive assessments and skills tests can be used to compare the two groups. The goal of these propositions is to come up with actionable recommendations that can be used alongside traditional coma arousal techniques and therapy.

**Further Exploration**

Different disorders of consciousness and their relationships to music can also be examined as a future research question. Determining how different cognitive functions can be restored or rehabilitated through music therapy will also be a useful point of study. As an example, music therapy has been shown to be a useful tool in both anterograde and retrograde amnesia. Verbal memory skills have been shown to improve through music therapy (Baur et al., 2000). When exposed to music therapy, amnesic patients are able to improve their ability to describe past memories that may have been lost and learning from new events. Additionally, familiarity of music helps in agitating conscious behaviors in various disordered states of consciousness (Baker, 2001). This suggests strong linkage between cognitive functions such as decision-making and reasoning and the sensory encoding and processing in music. As a future point of study, there is potential in studying how consciousness intertwines with the different neural processes of behavior through music. Overall, this line of study will not only help us understand the human mind and behavior, but also guide treatment and recovery for maximal outcomes when consciousness is damaged.

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