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Music and the Unconscious Mind: A Proposed Study Examining The Autonomic Nervous System in Response to Basic Musical Rhythms

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Music and the Unconscious Mind: The Autonomic Nervous System in Response to Basic Musical Rhythms

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Rhythm is an integral component of human culture, notably in language and music. It is one of the most basic elements that make up music, which has become an influential force in peoples' day-to-day lives across cultures. Music is known to impact various autonomic functions such as blood pressure and heart rate, which have a correlative relationship with emotions and stress levels. Focusing on internal autonomic processes influenced by rhythm, such as heart rate, may give insight to how the mind unconsciously interacts with music, and what mental processes this might affect. This paper proposes a study in which individuals listen to a rhythmic pattern played on a djembe drum at either a slow tempo or fast tempo. During rhythm playback, individuals' heart rates are proposed to be measured using a pulse oximeter. Expected results are discussed in terms of how they relate to ideas offered in entrainment theory as well as timing systems theory, both of which suggest internal rhythmic processes are influenced by or respond to external rhythmic stimuli. Additionally, expected results focus on applications in clinical and therapeutic settings, where low heart rates, and stress levels may be required or optimal.

Rhythm is an integral component of human culture, notably in language and music (Konoike et al., 2012). Rhythm is one of the most basic elements that make up music, which has become an influential force in peoples' day-to-day lives across cultures. Music has a large effect on both physical and mental aspects of the human experience. It is the brain that is responsible for perceiving, organizing, and holding various sensory inputs that make up a rhythm, as well as initiating an appropriate response (Konoike et al., 2012).

Music is made up from a variety of complicated components that harmoniously coincide together. When studying the effects music has on the brain, each individual component of the music is observed separately, in order to best identify its implications. Two components, rhythm and beat, are very closely related, and the difference between the two should be noted in order to understand the influences they have separately and combined on the physical and mental aspects of the human experience.

Rhythm is referred to as a pattern of time intervals in a sequence (Grahn, 2012). The rhythmic pattern is marked by the onset of an auditory stimulus such as a tone, click, or other sound. The time between these onsets defines the length of the intervals in the pattern (Grahn, 2012), thus creating a rhythm. Beat is also a commonly focused on component of music, usually studied alongside rhythm. When listening to musical rhythms, a sense of beat is sometimes experienced (McAuley, & Semple, 1999), which can be referred to as the pulse. The beat or pulse is described as a series of steady recurring psychological events that respond to a musical rhythm (Grahn, 2012).

A great deal of focus in psychological research regarding music has involved indicating the areas of the brain that respond to beat and rhythm, which work simultaneously together in a musical composition. The majority of studies have observed how each brain structure plays a

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role in the conscious perception and processing of music, particularly beat and rhythm. A past study conducted by Grahn and Brett (2007) investigating beat perception, found that the basal ganglia and supplementary motor areas (SMAs) consolidate beat perception. The cerebellum, superior temporal gyrus (STG), and the ventrolateral prefrontal cortex (PFC)/anterior insula, all bilaterally (on both sides of the brain), were also found to consolidate beat perception (Grahn & Brett, 2007). Two further functional magnetic resonance imaging (fMRI) studies confirmed the role of the basal ganglia in beat perception, by finding that activity increased when beat was induced in a rhythm (Grahn, 2012).

Brain imaging studies have also highlighted brain regions associated with the perception of rhythms, without the accompaniment of a beat (Konoike et al., 2012). Neuroimaging experiments have found substantial overlaps in brain activity regarding the perception of rhythms with the perception of beats in the SMA, cerebellum, and basal ganglia. Brain activity levels have also been found in the premotor cortex for rhythm perception only (Grahn, 2012).

In order to have the perception of a rhythm, the auditory stimulus must be processed in the brain. This includes the encoding, retrieval, and maintenance of rhythmic information. Electroencephalography (EEG) and magnetoencephalography (MEG) are especially useful in rhythm processing studies, which have been a more recent focus in the field. These techniques have better temporal resolution than fMRIs, which have been used in the past, and can better distinguish neural components (Grahn, 2012). Auditory rhythm processing studies have consistently observed activation in the cerebellum (Konoike et al., 2012). Other brain areas involved in these processes include the inferior parietal lobe, inferior frontal gyrus, and the SMA (Konoike et al., 2012).

Although the majority of studies have used brain imaging and recording techniques, many other methodologies have been explored including behavioural and emotional work in humans and animals, and psychophysiological approaches (Grahn, 2012). For studies focusing on the emotional aspect of music and rhythms, the wellbeing, activity, mood test (WAM test), and the Spillberger test that test levels of internal and situational anxiety have been used (Kazymov, Mamedov, Alieva, & Chobanova, 2014). On the other hand, psychophysiological techniques focus on the autonomic nervous system and its role in the emotional response to music. Three main techniques are used in psychophysiological research to measure activity in the autonomic nervous system. These techniques are focused around the cardiovascular system and are measurements of heart rate, arterial blood pressure, and blood volume. A study conducted by Kazymov et al. (2014), which used a combination of emotional and psychophysiological techniques, found that when exposed to fast musical compositions, youths with neurotic conditions experienced emotional-autonomic arousal. The autonomic arousal was reflected as an increase in heart rate (Kazymov et al., 2014).

The findings of psychological studies using all of the previously stated techniques have brought the development of select theories pertaining to the brain's response to rhythms and music. Many studies using neurological techniques find their results are comparable to timing systems theory. This is a theory that suggests that a distinguishing factor between commonly activated neural structures responding to rhythm may be their roles in either automatic timing (continuous unconscious measurement of rhythm) or cognitively controlled timing (conscious measurement of distinct rhythms) (Grahn, & Brett, 2007). The data collected in the study conducted by Grahn and Brett (2007), may suggest that rhythm perception is associated more with the automatic timing system, meaning that the process of rhythm perception is executed in the unconscious mind.

Another proposed theory is entrainment theory. This describes the process of the synchronization of internal rhythmic processes in the body and brain, to beats found in external stimuli such as an auditory rhythm (Grahn, 2012). The entrainment concept has inspired other theories regarding the effects of rhythm in the brain, one of which includes the neural resonance approach. This theory suggests internal rhythmic processes in the brain result from the interaction of excitatory and inhibitory neural groups. This neural activity is periodically increasing and decreasing, creating a natural, steady pattern, which mimics external rhythmic stimuli (Grahn, 2012).

Music is known to impact various autonomic functions such as blood pressure and heart rate (Kazymov et al., 2014). For example, the study conducted by Kazymov et al. (2014) found that music specially selected by participants had an effect on individual measures of blood pressure and autonomic regulation. Both systolic and diastolic blood pressure decreased with exposure to the selected fragments with the addition of normalized cardiovascular functions (Kazymov et al., 2014). It has been suggested that unconscious autonomic processes such as those involving cardiovascular functions, are influenced by external rhythms and can mimic them (Grahn, 2012). There has been an abundance of studies focusing on the perception of musical rhythms and the brain areas related to this process, however, there has been a lack of focus on the unconscious effects rhythm has on humans. The current study will attempt to link concepts discussed in the neural resonance approach to the autonomic nervous system, and investigate the effects musical rhythms have on heart rate. A connection between these variables may give insight to how the mind unconsciously interacts with music, and what mental processes this might affect.

If the brain’s internal rhythmic processes are presented with a musical rhythm, then it will reflect its response in the autonomic nervous system by changing the heart rate according to the particular rhythm. For example, if presented with a fast rhythm, the heart rate will increase.

Method

Participants

Participants will include 70 volunteer undergraduate students (35 females, and 35 males), in a Psychology 1000 course at Western University. The participants will be free of any hearing or heart deficits. Mean age will be 18 years (range: 17-25 years). Participants will receive a course credit for their participation.

Materials

A pulse oximeter (O’Donnell, Creamer, Elliott, & Bryant, 2007) will be used to measure the heart rate of participants. The pulse oximeter consists of a monitor containing the batteries and display screen, and a probe that measures the heart rate (World Health Organization, 2011). The probe is designed to use on the finger, toe, or earlobe. This study will use the probe on the finger. A pre-recorded 4/4 musical rhythmic pattern created for this study (see Appendix) played on a djembe drum will be presented via a computer, and heard through Bose over-ear noise cancelling headphones. Participants will listen to either a slow tempo (50bpm) or a fast tempo (180bpm) version of the rhythmic pattern that will be pre-set to play for 90 seconds.

Procedure

Participants will be randomly assigned to either the slow rhythm condition or the fast rhythm condition (35 participants in each group). All participants will be connected to the pulse oximeter by attaching the probe to the left index finger. Before beginning the trial, each participant's pre-manipulation resting heart rate will be recorded. Both groups will be instructed to sit comfortably in the chair provided, and listen to the musical rhythm through the Bose over-ear noise cancelling headphones with their eyes closed, focusing on the rhythm. The slow rhythm group will listen to a recording of a 4/4 musical rhythm played on a djembe drum with a largo tempo of 50bpm for 90 seconds. The fast rhythm group will listen to a recording of a 4/4 musical rhythm played on a djembe drum with a presto tempo of 180bpm for 90 seconds. Heart rate measures using the pulse oximeter will be taken and recorded at the 60-second mark of the rhythm playback for both groups. After the 90 seconds of rhythm playback, participants will be disconnected from the pulse oximeter, debriefed, and dismissed from the study.

Expected Results

This study will examine the brain's response to musical rhythms expressed in the autonomic nervous system. It is expected that when presented with a slow rhythm, the heart rate will decrease, and if presented with a fast rhythm, the heart rate will increase. Heart rate averages for both groups will be compared to the calculated average resting heart rate of all participants (M = 78bpm). Consistent with the prediction, it is expected that those who listened to the slow rhythm (50bpm) will have a decrease in heart rate (M = 54bpm) while those who listened to the fast rhythm (180bpm) will have an increase in heart rate (M = 102bpm). The difference between the effects of the two tempos will be quite noticeable in that the fast tempo will produce a much higher heart rate, and the slow tempo a much lower heart rate in comparison (see Figure 1).

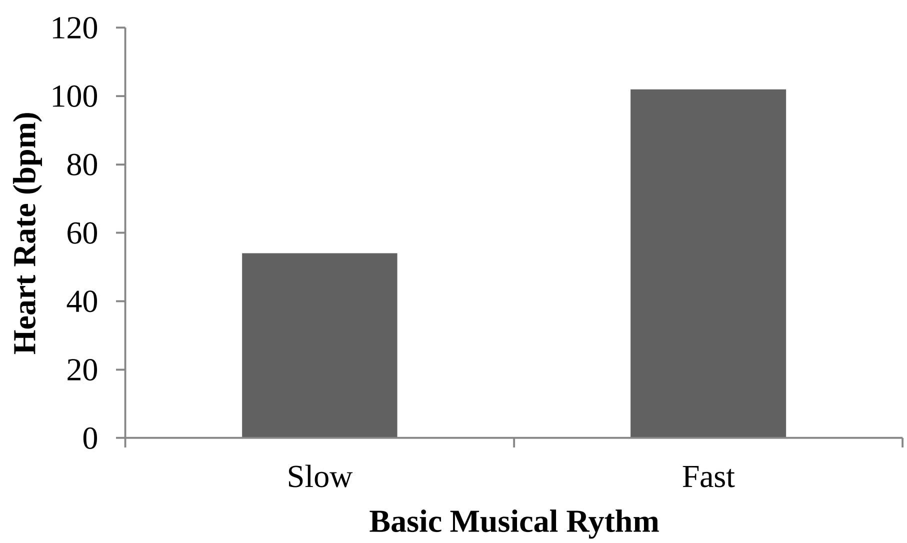

Figure 1. Mean heart rate associated with basic musical rhythm tempo.

The findings of this study will have shown that there is a connection between rhythm and the mental processes controlling heart rate. This would follow patterns discussed in the neural resonance approach; an internal process in the brain responding to, and mimicking patterns of an external stimulus, as well as findings from the study conducted by Grahn and Brett (2007), suggesting that rhythm perception is associated with an automatic timing system, as compared to a conscious one. These findings would begin to fill in the gap of research regarding music and the brain, as pertaining to unconscious, autonomic processes.

The neural resonance approach was derived from entrainment theory, which has been an important foundation to more complex and detailed concepts. The theory suggests that internal rhythmic processes in the body and brain, which are unconscious and autonomic, are able to synchronize to beats found in external stimuli (Grahn, 2012). External stimuli can be in the form of various types of beats and rhythms, music being a predominant source. The musical rhythms in this study will have influenced the heart rate of participants, an internal rhythmic process. These musical rhythms will affect heart rate in such a way that a fast rhythm increases heart rate, and a slow rhythm decreases heart rate. Even though heart rate averages found in this study will not be linear to the tempo of the rhythm (for example, the fast rhythm of 180bpm will not produce a heart rate of 180bpm) the rhythm will cause the heart rate to increase, likely in the direction of the tempo. The findings of this study will follow the pattern proposed by the entrainment theory in that heart rate, as an internal rhythmic process, will begin to promote synchronization when exposed to an external rhythmic stimulus.

The neural resonance approach itself, would be an avenue for future research. This applies ideas used in entrainment theory specifically to brain wave patterns, suggesting that neural activity will mimic external rhythmic stimuli (Grahn, 2012). This study will have been shown to follow patterns of entrainment theory, which may also be the case for the neural resonance approach in regards to brain wave patterns. Neural activity may not identically mimic external rhythmic stimuli, but may mimic it in a similar pattern, comparable to the way heart rate will begin to synchronize to the rhythm tempo. It is the brain that controls all other internal rhythmic processes; therefore it would be probable to assume that it would follow the same pattern. Future studies could measure neural activity as compared to basic musical rhythms in order to determine if brain waves show the same effect.

In previous studies it has been suggested that external rhythmic stimuli are associated with an automatic timing system, a component of timing systems theory. Timing systems theory proposes that two timing systems respond to rhythm: the automatic system and the cognitively controlled system (Grahn & Brett, 2007). This study would also concur in stating that the automatic timing system processes external rhythmic stimuli. The heart rate of participants, an unconscious and autonomic process, will be influenced by the tempo of the presented musical rhythm. This would additionally be an unconscious and autonomic response. It could be inferred that the rhythm will be unconsciously measured, using the automatic timing system.

Further research in other components of the autonomic nervous system and internal processes, such as blood pressure, blood volume, skin conductance and internal body temperature may be explored to see if they follow the same pattern as seen with heart rate. Studying these aspects of unconscious processes give an overall picture of how rhythm plays a role in, or has the potential to affect, various functions.

Rhythm is a basic component within music, which is very influential in human culture. Other components of musical structure may be tested in the same way, to see if they produce similar responses. These components could include dynamics, melody, key, and pitch. More complicated musical compositions, combining all of the individual elements that make up music, may also be studied. Examining a musical composition as a whole is more relatable to what humans experience in their daily lives, and can provide insight to the effects music has on the unconscious processes of the brain.

This study will suggest that slow rhythmic patterns decrease heart rate. This knowledge may be applied to settings where a low heart rate is optimal or required, for example in a doctor’s office, or in various kinds of therapy. Slow rhythms could be used as a technique to decrease elevated heart rates, or keep them at a low level. This theory may be an opportunity for future studies to test if this method is effective.

The possible avenues of future research pose several limitations to the proposed study. First, the participants selected for this study’s sample will represent a young, healthy population. This sample may not be representative of those found in settings where findings from this study may be applied, such as clinical or therapeutic environments. However, this study is primarily intended to examine heart rate as influenced by tempo in healthy subjects, as a gateway to further research. Second, related to this, the study’s setting also stands as a limitation. Trials will be conducted in a controlled lab setting, as opposed to conditions similar to clinical or therapeutic settings, where it is imperative to keep heart rate at a low level. A lab setting, on the other hand, may not provoke the same levels of stress found in these environments, which could have a different response in heat rate. Lastly, this study only examines one autonomic function, and is unable to generalize to other internal rhythmic and autonomic processes. Heart rate will follow patterns proposed by entrainment theory and timing systems theory, but it is unclear if additional components of the autonomic nervous system will follow these patterns as well. It is highly encouraged that alternative populations are considered as well as various study settings that reflect the nature of stressful environments. It is also encouraged that additional internal autonomic processes such as blood pressure, blood volume, skin conductance and internal body temperature are explored.

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Appendix