Individualized Music Intervention as a Treatment for Nightmares

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Nightmare disorder is a parasomnia that affects approximately 4% of adults[1] and is defined by repeated awakenings of terrifying dreams that cause significant distress or impairment in important areas of functioning[2]. Despite being relatively common, nightmares are rarely studied or discussed in academic circles and there has been very little research done to understand and characterize them. While there are no FDA-approved treatments specifically made to address nightmares, current treatments for nightmare disorder include therapies such as imagery rehearsal therapy (IRT) and medications like prazosin. In this proposal, I will argue that nightmares are an important part of cognitive and emotional processing and need not be eliminated nor suppressed. Instead, I propose that auditory interventions in the form of music be used to lessen the intensity of nightmares and superimpose them with positively-associated stimuli. In this way, nightmares can be redirected rather than interrupted, allowing individuals to ride through rather than escape from their dream.

While we can not say for sure what the exact purpose of dreams is, many theories are centered around our memories and the ways in which we incorporate them into our dream narratives. A study conducted on the memory sources of dreams found that 80% of dream reports had an incorporated memory[3] and in fact many scientists believe that dreams serve a key role in memory consolidation. While different dreams can be centered around the same theme or memory, the dream content will vary depending on the stage of sleep in which the dream occurs. In general, REM dreams tend to be more bizarre and emotionally centered whereas NREM dreams are more thought-like and less personally involving[4]. For this reason, the sleep memory consolidation theory holds better when discussing dreams that occur in NREM than REM. A recent study conducted on veterans with diagnosed PTSD found that nightmares in NREM were more likely to be direct replays of traumatic memories whereas those that occurred in REM sleep included traumatic-related, yet distorted content[5].

In fact, REM dreams are rarely, if ever, direct replays of the original memory and are often true distortions in which the memory is superimposed into a new contextual reality. This leads to the question: why are the original memories not affected by this recontextualization? If every time we recount a memory we distort it, then it would stand to reason that the narrative treatment of memories in dreams would cause dream content to seep into our waking recollection and yet, our brain is exceptional at distinguishing between dream content and experienced reality. This experiential difference between dreams in NREM and REM sleep stages suggests that perhaps these dreams serve different purposes, with dreams in NREM indeed seeming to serve as a way to consolidate and cement recent memories. So then, what is the purpose of the bizarre narratives we so often encounter in REM sleep?

Many theories are centered around the idea that the dream world provides us with a “safe space” in which we can simulate potentially dangerous scenarios so that we are better able to handle them in waking life. Specifically, the fear extinction hypothesis [6] suggests that dreams are a way for us to reassociate previous fearful memories with new contexts, which then help us better confront fearful scenarios in waking life. Interestingly, REM dreams have been shown to have a higher likelihood of containing aggressive social interactions while NREM social interactions tend to be more friendly[7]. In healthy people, increased feelings of fear in dreams has been shown to decrease fear response during wake[6], which serves as evidence for the simulation theory of dreams. Additionally, it has been shown that dreaming about a task can improve performance on that task in waking life[3], further proving we are able to learn from our dreamt experiences. Dreams are a tool by which we explore different scenarios. We

have little to no control or volition in the experienced scenarios and even in lucid dreams which are oftentimes associated with a greater sense of narrative control, we see themes and feelings associated with nightmares[8]. Bad dreams occur when there is a growing source of distress that builds anxiety in the dreamer. They turn to nightmares when the anxiety snowballs to the point of wake. Waking up is our body's natural defense against nightmares.

Currently, there is just one non-pharmacological product on the market that is aimed at reducing nightmares in those with PTSD and nightmare disorder. NightWare is a company that uses modified Apple Watch sensor data to determine when a person is in a state of agitation. It then sends vibrations through the watch to "interrupt nightmares without waking the patient".[9] In a 30-day trial of 70 participants, sleep quality improved for both the control group and the active group using NightWare, with improvement being greater in the active group[10,18]. While no long-term studies have been conducted, the device is intended to be used every night indefinitely and in conjunction with additional therapies and/or medications. It is likely that since the device abruptly interrupts the dream, the patient is never able to form the positive reassociations necessitated by the fear extinction process.

Additionally, there is interesting work being done that uses individualized music as an intervention for managing agitation in patients with Alzheimers and dementia[11]. They used surveys taken by either the patient or their family to create curated, or individualized, music that was integrated into their lives and based on personal preferences. The experiment was based on the mid-range theory of individualized music intervention for agitation (IMIA) which hypothesizes that music can be a way to shift attention to interpretable stimuli in people who have a decreased ability to interpret environmental stimuli and that by using individualized music they are more likely to elicit memories associated with positive feelings[12]. Additional studies have shown that music-assisted relaxation both throughout the day and at bedtime can improve sleep quality in people with various conditions[13].

While music-assisted relaxation is proven to be a beneficial intervention to disrupted sleep, it is most effective when paired with individualized music. The issue with individualized music is that it is difficult, imprecise, and time-consuming to build an individualized acoustic portfolio, particularly in situations where the patient is unable to communicate their preferences. Another issue with applying the mid-range theory to sleeping participants is that the distortion of memory sources, particularly in REM sleep can make even positively-associated memories scary. We know that people are open to sensory cues including sounds while sleeping and studies have even shown that two-way communication during sleep is possible[14]. The idea of using an acoustic intervention is centered around the bidirectional relationship between the body and mind which holds true in the context of nightmares. In the top down direction, emotional states like high stress are correlated with an increased likelihood of experiencing a nightmare[15,17] and looking from the bottom up we see physiological changes like an upset stomach after a large meal also showing an increased rate of reported nightmares[16].

For this reason, it is necessary to develop an automated platform for generating new acoustic content that has no direct memory associations (novel sounds), but that is still based on the patient's personal profile. In order to confirm the need for and begin to develop this platform, I propose a series of three experiments designed to collect information on the physiological response to auditory cues.

Each experiment will involve measuring agitation markers and responding to heightened signals by emitting a series of novel auditory sequences. The music will be an experimental collection of sounds including a combination of instrumental and nature sounds. These will vary in tempo, pitch, and frequency in order to categorize how these elements influence physiological response. In cases in which the onset of music was correlated with a reduction in agitative markers, the song that was played will be

added to that person's database in which an algorithm then analyzes the song's characteristics to build an individualized profile of calming songs. The idea is to use songs that do not have any established memory connections to build a more physiologically-based acoustic profile.

The experiments:

1. Hypothesis: We can simulate a decrease in heart rate by matching the tempo of an audible beat to a person's heart beat and slowing it down to desired rate over a period of time
    a. Experiment: Measure a person's heart rate over a prolonged period of time. When an elevated heart rate is detected, a beat should be played at a predetermined tone that matches the tempo of the person's heart rate. Over a varying period of time (5s-60s), the tempo of the beat should be gradually decreased to match the individual's resting heart rate. The individual's heart rate should be monitored throughout and in the period of time immediately following the beat. This experiment should be conducted both in the waking state and in the sleeping state, with heart rate baselines being determined independently based on state to be tested.A control group should be tested in which a beat is played at a resting tempo and one at an elevated tempo. Dream reports should be collected every night and sleep quality index should be measured for every trial in the sleeping state.
2. Hypothesis: Short-term use of musical intervention during nightmares will show an improvement in sleep quality
    a. Experiment: Use a combination of available ambulatory biometric data (heart rate, skin conductivity, movement, EEG, etc) and dream reports to establish a baseline for sleep in which nightmares are not reported. When agitation is detected based on a deviation from the baseline metrics, music is played and physiological response recorded. Upon wake, participants are asked to fill out a dream report and a sleep quality index survey.
3. Hypothesis: Long-term use of musical intervention during nightmares will decrease nightmare frequency even when the device is not worn
    a. Experiment: Following the conclusion of experiment 2, participants are sent home and over the course of the following months, they are surveyed on the prevalence and frequency of nightmares. During these follow-up months, participants do not have access to the music intervention system.

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