Acetaminophen Blunts Emotional Responses to Music

Lindsay Warrenburg[1] and Baldwin Way[2]

[1] *School of Music, Ohio State University, USA*
[2] *Department of Psychology, Ohio State University, USA*

[1]warrenburg.3@osu.edu, [2]way.37@osu.edu

Abstract

The capacity of listeners to perceive or experience emotions in response to music depends on many factors including dispositional traits, empathy, and musical enculturation. Emotional responses are also known to be mediated by pharmacological factors, including both legal and illegal drugs. Existing research has established that acetaminophen, a common over-the-counter pain medication, blunts emotional responses (e.g., Durso, Luttrell, & Way, 2015). The current study extends this research by examining possible effects of acetaminophen on both perceived and felt responses to emotionally-charged sound stimuli. Additionally, it tests whether acetaminophen effects are specific for particular emotions (e.g. sadness, fear) or whether acetaminophen blunts emotional responses in general. The experiment employs a randomized, double-blind, parallel-group, placebo-controlled design. Participants are randomly assigned to ingest acetaminophen or a placebo. Then, they are asked to complete two experimental blocks regarding musical and non-musical sounds. The first block asks participants to judge the extent to which a sound *conveys* a certain affect (on a Likert scale). The second block aims to examine a listener's *emotional responses* to sound stimuli. The study is currently in progress; here, preliminary results are reported for 19 participants of a planned 200 cohort. In light of the fact that some 50 million Americans take acetaminophen each week, if the final results prove consistent with existing research on the emotional blunting of acetaminophen, this suggests that future studies in music and emotion might consider controlling for the pharmacological state of participants.

Introduction

Acetaminophen (paracetamol) is the active ingredient in several popular over-the-counter analgesic medications. It is estimated that over 20% of all adults in the United States consume acetaminophen at least once a week (Kaufman et *al*., 2002). Although it is typically used to reduce physical pain, acetaminophen has also been shown to reduce social pain and empathy for others (Durso, Luttrell, & Way, 2015; Mischkowski, Crocker, & Way, 2016). One of the possible reasons for these emotional effects is that there are speculated common neurochemical pathways for physical and social pain (Panksepp, 1998). If acetaminophen affects these shared neural pathways, an intended reduction in pain for the physical domain could inadvertently cause a reduction in the social domain. Consistent with this theory, recent research has shown that acetaminophen reduces neural activity in two cortical areas responsible for social pain: the anterior cingulate cortex (ACC) and the agranular insular area (AI) (DeWall et *al*., 2010).

Since acetaminophen is taken by approximately 50 million Americans every week (Kaufman et *al*., 2002), the possibility that it reduces social pain and empathy has wide-reaching implications. It is possible that people who regularly take acetaminophen are unintentionally living in a world that is less emotionally charged and is more isolated than for people who do not take the drug. In other words, those who take acetaminophen could be experiencing blunted emotional responses to affectively-charged events compared to their normal state. A recent study (Durso, Luttrell, & Way, 2015) is consistent with this theory. In their study, participants who ingested acetaminophen made attenuated emotional judgments of pleasant and unpleasant pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), compared to those who took a placebo. Of particular importance for the present study is that participants in the acetaminophen condition experienced blunted reactions to both *perceived* and *induced* emotion in response to the pictures. That is, participants on the drug not only rated pleasant and unpleasant stimuli as *displaying* less emotion than did those who received a placebo, but they also *experienced* less emotion in response to pleasant and unpleasant pictures, compared to those in the placebo group.

In the current study, we aim to extend the findings of Durso et al. (2015) by replicating their methodology using sound stimuli instead of visual stimuli. Specifically, we aim to test whether the emotional blunting effects of acetaminophen extend to the auditory and musical domains.

In auditory research, three broad categories of sound can be distinguished: (1) natural sounds, (2) speech, and (3) music. All three categories are used in this study.

(1) *Natural Sounds*: These sounds include the sounds of natural and common manufactured objects, such as a bubbling brook or a door slamming, as well as non-speech vocalizations, such as the sounds of sneezing, coughing, crying, and screaming.

(2) *Speech*: In the case of speech, affect can be communicated via prosodic features and by semantic content. Speech prosody includes features such as precision of articulation, microstructural irregularity, and the contour of the spoken utterances. Semantic content can be roughly defined as the understood meaning of words spoken in a sentence.

(3) *Music*: Although music contains its own syntax, grammar, and formal structures, it is also known to emulate speech characteristics (Juslin & Laukka, 2003). For example, sad music contains many features of sad speech. Sad speech exhibits a quieter-than-normal voice, a slower speaking rate, low pitch, a monotone voice, mumbling, and a dark timbre (Kraepelin, 1921). Sad-music characteristics parallel these sad-speech characteristics: sad music is quieter, slower, lower in pitch, has smaller pitch movements, is legato (smooth-sounding), and uses darker timbres (Huron, 2008; Schutz, Huron, Keeton, & Loewer, 2008; Turner & Huron, 2008; Post & Huron, 2009; Yim, Huron, & Chordia, MS). In the current

study, we use all three categories of sound: natural sounds, speech, and music.

Many empirical studies have examined how people respond to semantic and prosodic elements of speech. Speech studies have included how people respond to emotionally-charged speech (e.g. Mitchell et *al.*, 2003), how language and prosody affects recognition of emotion in speech (e.g. Ververidis & Kotropoulos, 2006), how meaning can be created in language (e.g. Ricoeur, 2003), and how basic demographics affect emotional speech perception (e.g. Paulmann et *al.,* 2008; Schirmer et *al.,* 2004). By contrast, there has been comparatively little empirical research examining why emotional reactions to music vary across situations and people. In the music and emotion literature, studies tend to be divided into two categories. First, researchers study the kinds of emotions that listeners believe the music is displaying. This is often referred to in the literature as the study of *perceived emotion* – the study of how listeners recognize emotions in music. This type of research is often focused on the structural aspects of the music itself. Musical works that are thought to display fear, for example, have been examined in terms of its compositional features, such as the use of wide leaps, the creation of scream-like sounds, and instruments that are used in unusual ways (e.g. prepared piano). This area of research has given rise to a wealth of knowledge about compositional practice, performance decisions, and how music can help amplify emotional effects in movies and other soundtracks.

Second, music and emotion researchers have been interested in what kinds of emotion music is able to induce in its listeners. *Induced* or *experienced emotion* studies examine how listeners can feel an emotional response to (typically) instrumental music. Researchers want to know, for example, if people actually experience sadness when listening to sad music, and if so, why they enjoy the experience of being in a negatively-valenced state. Experts on musically-induced emotions use different methodological techniques than do experts on perceived emotion. Studies of music-induced emotions employ fMRI, EEG, and prosodic analysis of musical excerpts. The driving theories often rely on evolutionary psychology, cognitive psychology, and even comparative psychology.

In the current study, the effect of acetaminophen on emotional responses to sound will consider both *perceived* and *experienced* emotion.

Hypotheses

H1: Compared to those in the placebo condition, participants who ingest acetaminophen will *perceive* positive sounds as less positively valenced and negative sounds as less negatively valenced.

H2: Compared to those in the placebo condition, participants in the acetaminophen condition will *experience* less valenced emotion when listening to positive and negative sounds.

H3. The blunting effects of acetaminophen will differ among emotion categories. That is, some perceived and induced emotions will be blunted more than other emotions.

Methods

As noted, the goal of the study is to test the effect of acetaminophen on perceived and experienced emotion in response to emotionally-charged auditory stimuli. The experiment follows the design used by Durso et *al.* (2015) and employs a randomized, double-blind, parallel-group, placebo-controlled design.

Pharmacological Procedure

Participants signed up for the experiment online. An email was sent to the participants detailing the risk factors associated with acetaminophen. They were also instructed to avoid eating any food for three hours prior to the experiment. Participants arrived at the lab and were told that they would be given a pill containing either 1000 mg of acetaminophen or a placebo. Participants were randomly assigned to the drug or placebo condition. At the time of the study, participants and the experimenters were blind to the drug condition. After consuming the pill, participants were asked to wait 50 minutes for the drug to take effect (Durso et *al*., 2015). During this waiting period, participants completed questionnaires described below. After the study was over, participants were asked to guess whether they had been given the drug or the placebo. They were then told they should avoid consuming acetaminophen and drinking alcohol for the next 15 hours.

Stimuli and Experimental Conditions

The experiment consisted of two blocks of trial, where the first block was aimed at testing hypotheses 1 and 3 and the second block was aimed at testing hypotheses 2 and 3. The order of these blocks was counter-balanced across participants, and the sound examples were randomized within each condition. For each block, participants listened to selected musical passages (described below), speech samples from the Crowd-Sourced Emotional Multimodal Actors Dataset (CREMA-D) (Cao et *al*., 2014), and natural sound stimuli taken from the International Affective Digital Sounds (IADS-2) (Bradley & Lang, 2007). Participants listened to the stimuli via headphones. Prior to the two blocks–while waiting for the drug to take effect–participants provided a blood sample to measure inflammation and were asked to complete measures of current affect (Positive and Negative Affectivity Scale (PANAS); Watson, Clark, & Tellegen, 1988), musical sophistication (Ollen Musical Sophistication Index (OMSI); Ollen, 2006), musical preferences (Short Test of Musical Preferences-Revised (STOMP-R); Rentfow, Goldberg, & Levitin, 2011), personality (Big 5 Personality Questionnaire; John & Srivastava, 1999), empathy (Interpersonal Reactivity Index (IRI); Davis, 1980), absorption in music (Absorption in Music Scale (AIMS); Sandstrom & Russo, 2011), and basic demographic questions.

Block 1: Perceived Emotion

The goal of the first block was to examine perceived emotion in sound stimuli. Namely, participants were asked to judge the extent to which a sound conveyed a certain emotion. The sound stimuli consisted of emotionally-charged musical excerpts, speech excerpts, and non-musical sounds.

Natural Stimuli. The natural stimuli were drawn from the International Affective Digitized Sounds library (IADS-2; Bradley & Lang, 2007). This set of stimuli consists of 167 sound stimuli that have been coded for valence, arousal, and dominance, and have been normalized in sound properties such as loudness and duration (all samples are 6 seconds in length). Sounds include non-speech vocalizations (e.g., coughing, laughing), non-human sounds (e.g., alarm clock, breaking glass), and musical excerpts (e.g., choir singing, bagpipes, whistling). No musical excerpts from the IADS library were used. The sounds in the other two categories were sorted by the rated valence (which ranged from 1.57-7.78) in the Bradley & Lang (2007) study. It was established *a priori* that audio files with valence scores less than 3.5 would be considered "low valence," audio files with valence scores between 3.5 and 5.5 would be considered "neutral valence," and audio files with valence scores higher than 5.5 would be considered "high valence." Once the audio files were sorted by valence, the sound clips were sorted into five sub-categories based on how the participants of the Bradley & Lang (2007) rated arousal levels: 1) Low-Valence, High-Arousal (LVHA); 2) Low-Valence, Low-Arousal (LVLA); 3) Neutral-Valence, Middle-Arousal (NVMA); 4) High-Valence, High-Arousal (HVHA); and 5) High-Valence, Low-Arousal (HVLA).

Speech stimuli. Speech samples were taken from the CREMA-D (Crowd-sourced Emotional Multimodal Actors Dataset; Cao, et *al.*, 2014). This dataset consists of audio (spoken), visual (video), and multimodal (audio-visual) performances by 91 professional actors (ages 5-74). The actors were instructed to portray twelve "neutral" sentences with six emotions: *anger, disgust, fear, neutral, happy,* and *sad.* The sentences used in the database were the following: (1) Don't forget a jacket. (2) It's eleven o'clock. (3) I'm on my way to the meeting. (4) I think I have a doctor's appointment. (5) I think I've seen this before. (6) I would like a new alarm clock. (7) I wonder what this is about. (8) Maybe tomorrow it will be cold. (9) The airplane is almost full. (10) That is exactly what happened. (11) The surface is slick. (12) We'll stop in a couple of minutes.

For the purposes of this study, 12 sentence performances were chosen as the stimuli. Only four of the six emotional categories of speech were used, selected to represent a continuum of both arousal and valence scores: namely, fear (low valence, high arousal), happy (high valence, high arousal), sad (low valence, low arousal), and neutral (neutral valence, medium arousal). The sentences with the highest CREMA-D agreement scores for each emotion category resulted in the final stimuli list of 12 stimuli (3 'fear', 3 'happiness', 3 'sad', and 3 'neutral' performances).

Musical stimuli. The musical stimuli were drawn from excerpts of film soundtracks (curated by Eerola & Vuoskoski, 2011). The selected excerpts have been empirically shown to be unfamiliar to Western-enculturated participants of a similar age to those participating in the current experiment, and so minimizes confounds with possible episodic memories. Each excerpt is between 10 and 15 seconds in duration and represents one of five discrete emotions: *fear, anger, sadness, tenderness,* and *happiness.* Participants in Eerola & Vuoskoski's (2011) study showed high agreement in choosing the categorical emotion for each of these excerpts. Four of these categories were chosen in order to represent the four arousal-valence quadrants of the Russell et *al*. (1989) affect grid: fear (low valence, high arousal), happiness (high valence, high arousal), sadness (low valence, low arousal), and tenderness (high valence, low arousal). In this study, three excerpts were chosen per categorical emotion (3 'fear', 3 'sadness', and 3 'happiness' passages). However, six tenderness passages were used because there were no high valence, low arousal speech samples.

Experimental Procedure. Participants were reminded about the difference between perceived and felt emotion and then were asked three questions. The first two of these three questions aim to probe the perceived valence of the sound; the third question aims to identify the perceived emotional arousal of the sound. Perceived valence was separated into two unipolar scales because previous research has shown that positivity and negativity are separable in emotion experiences (Larsen & McGraw, 2011). The first question was, "*To what extent does this audio file sound positive?*" (11-point Likert scale from 0 'not at all positive' to +10 'extremely positive'); the second question was, "*To what extent does this audio file sound negative?*" (11-point Likert scale from 0 'not at all negative to +10 'extremely negative'; the third question was, "*To what extent does this audio file sound energetic/arousing?*" (11-point Likert scale from 0 'this sound represents no energy/arousal' to +10 'this sound represents an extreme amount of energy/arousal').

Next, participants were asked to "*Identify which emotion(s) the audio file represents by checking the appropriate emotion(s) from the following list. You may select as few or as many as you like.*" Once participants finished selecting the emotion terms, the list of terms they chose reappeared in isolation on the screen. They were then given the following instructions: "*Given this list of emotion terms you chose, which one(s), if any, strongly apply?*" By asking participants to choose emotion terms that strongly apply, a three-level response gradient is available for analysis (i.e. does not apply, applies, strongly applies).

The questions about emotion categories are exploratory questions, whose aim is two-fold: first, to identify possible affective confusions that might arise due to the effect of the acetaminophen; second, to test whether acetaminophen effects are different for separate emotions (hypothesis 3).

The emotion choices listed in the fourth question were inspired by the music cognition literature and the speech literature (both perceived and induced emotion). First, emotions were listed that were the intended emotion of the musical and speech stimuli (Cao et *al.*, 2014; Eerola & Vuoskoski, 2011): *angry, disgusted, fearful, happy, sad, tender*. The term *grieved* was added, as grief is thought to be related—but distinct—from musical sadness (Huron, 2015; Warrenburg & Léveillé Gauvin, 2017). The emotion terms *bored* and *relaxed* were added in order to investigate whether sad or tender sounds could be confused with boring or relaxing sounds (Huron, Kinney, & Precoda, 2006). Finally, the term *surprised* was used, as music and speech are known to be surprising when they do not conform to our enculturated expectations (Huron, 2006). Although these emotions span the four quadrants of a typical circumplex model, there is a bias towards high arousal-negative valence emotions. The terms *excited* and *invigorated* were therefore added to balance the number of terms in each quadrant (King & Meiselman, 2010). The final list of 14 emotions was the following: *angry, bored, disgusted, excited, fearful, grieved, happy, invigorated,* *relaxed, sad, surprised, tender, neutral/no emotion, other emotion(s).*

Finally, participants were asked to indicate their degree of familiarity with the music files using a three-point scale (0 = not familiar, 1 = somewhat familiar, 2 = very familiar). After completing the first block, participants were given a short break.

Block 2: Induced Emotion

The purpose of the second block was to examine the *induced* emotion from 18 sound stimuli, with a focus on music-induced emotions. Specifically, we measured the magnitude of listeners' emotional responses to the audio stimuli. The musical and natural sound stimuli in this block were different from the musical stimuli in the first block. The natural sounds were included because it was thought that they might induce stronger emotions than the musical samples (e.g., a person is likely more likely to respond to an audio file of domestic abuse than to musical passages). The speech samples were not included in this block, as the files were intended to examine perceived emotion, rather than to arouse emotion in listeners (Cao et *al.*, 2014; Keutmann et *al.,* 2015).

Stimuli. The primary aim of the second block was to examine whether acetaminophen can reduce music-induced emotions. Music is known to be able to induce strong emotion in listeners. Choosing passages of music that will reliably induce a specific emotion in listeners, however, is difficult. In the first instance, it is difficult to identify passages that might be considered to evoke a single affect. Even works that are typically thought to be affectively homogenous can represent and evoke more than one emotion. For example, Samuel Barber's *Adagio for Strings* is widely considered to be a quintessentially "sad" work. When listening to this piece, however, one can hear clear shifts in the affective mood. One may call some passages *sad*, *melancholic*, and *despondent*, but describe other passages as *grief-like* or *full of despair* (Huron & Warrenburg, 2017). The audience may experience alternating emotions of *sadness*, *despair*, and *compassion* throughout the work.

A second consideration relates to musical preferences. If a listener dislikes a particular musical style, the dominant emotional experience may simply be one of *boredom*. Both of these potential confounds can be minimized through the use of shorter musical passages. It is easier to find a shorter passage of music that is affectively homogenous or that will evoke a single affect than it is to find a longer passage that accomplishes the same thing. Fortunately, previous studies have tested many passages of music and identified various passages that are effective in displaying and inducing certain emotions in listeners (e.g., Eerola & Vuoskoski, 2011).

A further problem confounding research on music-induced emotion is high between-listener variability in induced affect. Differences in emotional responses to music can be due to many factors, including episodic memory, musical preferences, current mood, trait empathy, familiarity, and age. There is no guarantee that a participant will even react emotionally to a given musical passage.

A final caveat is that music is thought to commonly induce mixed-emotions in listeners (Juslin, 2013a; Juslin, 2013b). For example, when listening to nominally sad music, many people may experience a mixture of positive and negative valence. Listeners may label these affective states differently, although there is some consensus that people may claim to feel sadness and tenderness, sadness and compassion, or sadness and beauty (Peltola & Eerola, 2016; Tarrufi & Koelsch, 2014). Music has also been known to induce nostalgia, which is characterized by a bittersweet emotion (Barrett et *al.*, 2010). The experience of mixed emotions (presumably) consists of various numbers of emotion categories. These categories may differ from person to person. An additional source of variation is that each component emotion may be experienced at different intensities. This gives rise to a large number of possibilities of emotion combinations.

Although listeners are relatively quick to identify the displayed or represented emotion in an auditory stimulus, it takes somewhat longer for an emotion to be induced in a listener. A meta-analysis of music and emotion research conducted by Eerola and Vuoskoski (2013) estimates that stimulus durations of 30-60 seconds may be necessary in order to induce an emotion in a listener. At the same time, longer musical passages are more likely to exhibit subtle or substantial shifts in affective content. Consequently, we made use of one-minute musical clips as stimuli in our induced-emotion block. Specifically, we employed a subset of stimuli used by Eerola and Vuoskoski (2013) representing scary, happy, sad, and tender feelings. These four emotion categories parallel the four emotion categories in the perceived emotion block. In addition to the music stimuli, participants listened to 10 natural stimuli, independent from the ones used in the first block. These stimuli were chosen in the same way as in the perceived emotion block.

Experimental Procedure. The participants heard the sounds in a random order. After listening to each stimulus, participants were asked the following two questions: (1) "*To what extent does this audio file make you feel a positive emotional reaction?*" using an 11-point Likert scale (from 0 'I feel little or no positive emotion' to 10 'I feel an extreme amount of positive emotion'); (2) "*To what extent does this audio file make you feel a negative emotional reaction?*" using an 11-point Likert scale (from 0 'I feel little or no negative emotion' to 10 'I feel an extreme amount of negative emotion'). Participants were also asked to identify which emotion(s) they felt by checking the appropriate emotion(s) from a list of emotions. The emotion choices included all of the 14 terms from the first block (*angry, bored, disgusted, excited, fearful, grieved, happy, invigorated, relaxed, sad, surprised, tender, neutral/no emotion, other emotion(s)*). Also included were emotions that are commonly induced by music (Zentner, Grandjean, & Scherer, 2008): *wonder, transcendent, nostalgic, peaceful, power, joyful, tension*. The term *anxious* was also added. One additional term was used in order to directly investigate the amount of empathy (or compassion) a person might feel towards the sounds (Greitemeyer, 2009): *sympathetic.* This resulted in a final list of 24 items: *angry, anxious, bored, disgusted, excited, fearful, grieved, happy, invigorated, joyful, nostalgic, peaceful, power, relaxed, sad, soft-hearted, surprised, sympathetic, tender, transcendent, tension, wonder, neutral/no emotion, other emotion(s).*

Similarly to Block 1, after participants checked which emotions they felt from the list of 24-terms, they were presented with a list of the terms they checked. From this list, they were asked to respond to the question "*From this list of* *emotions that you chose, which one(s), if any, strongly apply?"* Finally, participants were asked to indicate their degree of familiarity with the musical passages on a three-point scale (0 = not familiar, 1 = somewhat familiar, 2 = very familiar).

Preliminary Results and Conclusion

The study in currently in progress. Nineteen participants have completed the task (10 placebo condition, 9 drug condition). No statistical tests regarding a difference between the two drug conditions have been carried out, as a power analysis indicates that approximately 200 participants would be needed in order to establish a reliable effect.

For the initial 19 participants, descriptive statistics of the stimuli have been conducted by using t-tests. In the perceived emotion task, the stimuli correspond to their hypothetical quadrants on the Russell et *al*. (1989) Affect Grid. That is, stimuli that were *a priori* considered to be low-valence, high-arousal (including fearful music and speech) were rated as equally negative, but more arousing than stimuli considered to be low-valence, low-arousal (including sad music and speech) (LVHA mean negativity = 6.91, LVLA mean negativity = 6.13, $p > 0.05$; LVHA mean arousal = 5.91; LVLA mean arousal = 3.63, $p < 0.05$). Stimuli considered to be high-valence, high-arousal (including happy speech and music) were rated as significantly more positive and arousing than stimuli considered to be high-valence, low-arousal (including tender music) (HVHA mean positivity = 7.06, HVLA mean positivity = 5.59, $p < 0.05$; HVHA mean arousal = 6.72, HVLA mean arousal = 4.05, $p < 0.05$).

For the initial 19 participants, in the induced emotion task, there was no difference in the experienced negativity of the low-valence, high-arousal stimuli and the low-valence, low-arousal stimuli (LVHA mean negativity = 5.69, LVLA mean negativity 5.04, $p > 0.05$). There was a difference in the experienced positivity of the high-valence, high-arousal stimuli and the high-valence, low-arousal stimuli, with the high-arousing stimuli contributing to greater experienced positivity (HVHA mean positivity = 6.59, HVLA mean positivity = 5.22, $p < 0.05$). Complete results for the planned cohort of approximately 200 participants are pending.

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