Acetaminophen Blunts Emotional Responses to Music and Speech

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Abstract

Music is known to be able to effectively represent many types of emotions, such as sadness, aggression, and peacefulness (e.g., Juslin & Sloboda, 2008). Music is also known to be able to induce emotions in its listeners, such as happiness and tension (e.g., Zentner, Scherer, & Grandjean, 2008). The capacity of listeners to *perceive* emotion in music, and for music to *induce* emotions in listeners depends on many factors, including listener dispositional traits and listener mood. The current study examines a potential pharmacological factor, namely, the effect of acetaminophen on *perceived* and *induced* music-related emotions. We report an experiment that employs a randomized, double-blind, parallel-group, placebo-controlled design. Participants ingested either acetaminophen or a placebo, and subsequently listened to emotionally-charged speech and music stimuli. The results are consistent with the hypothesis that, compared to those in the placebo-condition, listeners who ingested acetaminophen reported lessXX perceived and lessXX felt emotion in response to music. This is one of the first music perception studies that experimentally manipulates a biological system. The results are also consistent with the idea that music perception may be influenced by a biochemical processXX. Implications suggest that people who have taken acetaminophen could have reduced emotional responses to various forms of communication, like music and speechXX. Note that emotion-related experiments may expect reduced power if participants have consumed acetaminophen.

*Keywords*: perceived emotion, evoked emotion, acetaminophen, music, listening

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**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 natural sounds include the sounds of natural objects, such as a bubbling brook or a door slamming, as well as non-speech vocalizations, such as the sounds of sneezing, 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. Researchers are often inspired by hypotheses arising from developmental psychology, compositional practice, and music theory.

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.

**Aims and Hypotheses**

A pertinent consideration in the areas of both *perceived* and *induced* *emotion* is whether emotional responses to sounds can be systematically altered through the use of a pharmaceutical agent. The present research addresses this issue directly by testing the impact of acetaminophen on both *perceived* and *induced* responses to emotionally-charged sound stimuli. The implications of the acetaminophen effects differ for perceived and induced emotion. If acetaminophen blunts emotional judgments of sound stimuli in a laboratory condition, it raises the question of whether people are less likely to *perceive* emotion in auditory communication in everyday life. For example, people may be less able to discern sarcasm, where the prosodic and semantic elements of speech may indicate different emotions (e.g. imagine someone saying “I’m so happy about that!” in an angry tone of voice). If acetaminophen blunts the emotions people *experience* in response to auditory stimuli, however, it could be that acetaminophen reduces empathy not only in situations of pain – as in Mischkowski et *al.* (2016) – but also in situations of various emotional states, such as despair, excitement, and fear.

Our aims are threefold. The first aim of the current study regards how listeners detect emotions in speech, music, and natural sounds. Certain emotions are commonly expressed in music and speech, such as happiness, sadness, anger, fear, and tenderness (Juslin & Laukka, 2004). In speech, both semantic content and prosodic features help listeners reliably recognize distinct affective states. Features such as voice intensity variability, rising/falling F0 contour, and microstructural (ir)regularity are often cited as features that help in emotion recognition (Juslin & Laukka, 2003). The recognition of emotion in music can be attributed to similar factors, including the structure of the music itself and the musical context (Juslin, 2000; Schubert, 2004; Sloboda & Lehmann, 2001). Mode (i.e. major or minor), tempo, dynamics, articulation, rhythmic smoothness, and interval size are some of the features commonly identified as helping to convey certain emotions in music (Hannon & Trehub, 2005; Hevner, 1935; Juslin & Sloboda, 2010; Scherer & Oshinsky, 1977; Watson, 1942; Wedin, 1972). Through combinations of these (and other) features, music is able to express a variety of emotions of different intensities.

If acetaminophen blunts emotion perception, it is also possible that the ability to discriminate between emotions may also be reduced. The (potentially) reduced ability to discriminate among emotions could lead to some degree of confusion about which emotion a sound is expressing. In particular, low arousal emotions, such as sadness and boredom, could be confused with each other. In support of this idea, prior research has shown that there are similar prosodic elements in sadness, boredom, and sleepiness (Huron, Kinney, & Precoda, 2006). Given the shared acoustic features among these affects, acetaminophen could (say) lead to confusion between nominally sad sounds and nominally sleepy or bored sounds.

The current study utilizes speech and musical excerpts that have previously been shown to express or represent various emotions. Given the expectation that acetaminophen blunts perception of emotion, we may identify the first hypothesis as follows:

**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.

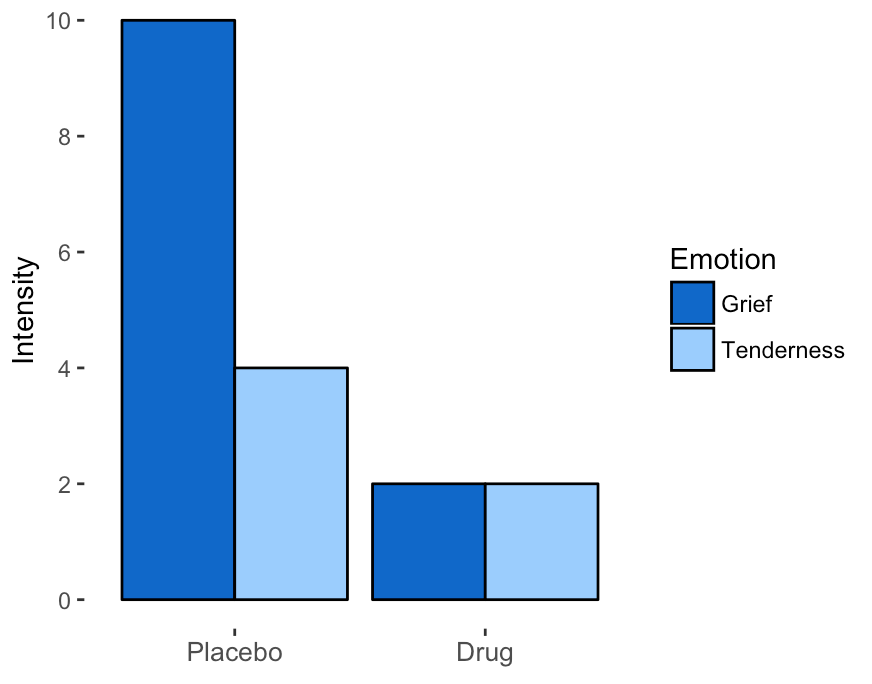
The second aim of this study is to examine the effect of acetaminophen on emotions induced by emotionally-charged sounds. Although speech and natural sounds are able to evoke emotional responses, this paper pays particular attention to music-induced emotional experiences. Music has the capacity to induce strong emotional responses in listeners, such as frisson (pleasurable chills or goosebumps), laughter, crying, and awe (breath-holding) (Blood & Zatorre, 2001; Huron, 2006; Zatorre & Salimpoor, 2013). Many theories have been proposed for how music is able to accomplish this; popular ideas include mirror-neuron pathways (Molnar-Szakacs & Overy, 2006; Buccino et al., 2005), learned associations (Seashore, 1932; Huron, 2006), and ethological signals and cues (Huron, 2012). The most popular model of music-induced emotions is summarized in the Geneva Emotional Music Scale (GEMS; Zentner, Scherer, & Grandjean, 2008). In this paper, researchers claim that music tends to induce feelings of sublimity (wonder, transcendence, tenderness, nostalgia, peacefulness), feelings of vitality (power, joyful activation), and feelings of unease (tension, sadness). Importantly, however, the *induced* emotion does not necessarily match the *displayed* emotion in the musical passage. As an example of this, consider a passage representing grief. Gliding (often descending) pitches, high sounds, and loud sounds can effectively represent a sort of “psychic crying” in music (Huron, 2015). However, listeners do not necessarily experience grief when listening to these passages. Instead, it is hypothesized that these listeners will instead experience feelings of compassion, a positively-valenced emotion (Warrenburg & Huron, 2017). This difference between *perceived* and *induced* emotion is a key methodological distinction of the current paper.

Specifically, we predict that acetaminophen will have a general blunting effect on listeners’ emotional reactions to music, regardless of the valence of the music. Because of the large variability of music-induced emotion among listeners, however, there are experimental limitations inherent in the study of induced emotions. Therefore, the examination of music-induced emotions is, by nature, more exploratory than is the examination of perceived emotion in music. The second hypothesis is as follows:

**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.

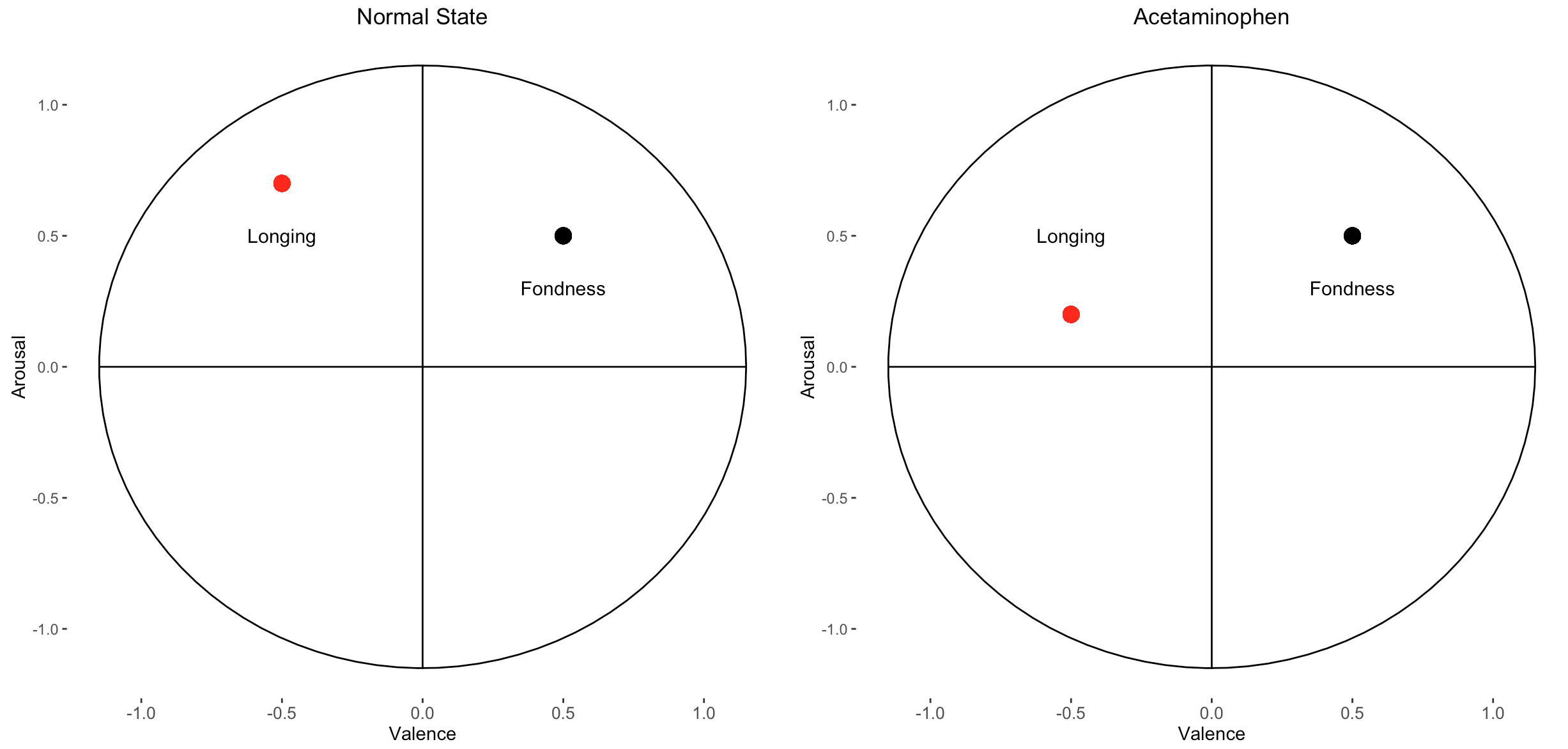
Finally, our third aim is to test whether acetaminophen will have differential effects on the examined emotions. No research has yet examined whether acetaminophen effects are specific for particular valences or whether the drug blunts emotional responses in general. Russell’s (1980) widely-used circumplex model maps emotion terms in a circle around four quadrants of space: high valence, high arousal (e.g. joy, invigoration); high valence, low arousal (e.g. tenderness, relaxation); low valence, high arousal (e.g. grief, anger); and low valence, low arousal (e.g. sadness, boredom).

Of interest in this study is the idea that acetaminophen may affect one emotion component more than another emotion component. One possibility is that that acetaminophen may be more likely to influence *high arousal* emotions than *low arousal* emotions. If this is the case, higher-intensity emotions, such as grief or fear, may be blunted proportionally more than lower-intensity emotions, such as tenderness or sadness (see Figure 1XX).



**Figure 1XX.** Possible differential effects of acetaminophen on a high-intensity emotion (grief) and a low-intensity emotion (tenderness).

Another possibility is that acetaminophen may affect *negatively-valenced* emotions more than *positively-valenced* emotions (or vice versa). Namely, an emotion like sadness may be blunted more than an emotion like happiness. This raises interesting implications for the experience of mixed emotions under the influence of acetaminophen. For the sake of illustration, imagine a person experiences *nostalgia* while listening to music. What the person labels as *nostalgia* may, in fact, consist of two separate emotion components (e.g. *longing* and *fondness*). In person’s normal state condition (i.e. without acetaminophen), the intensity of *longing* may be greater than the intensity of *fondness*, leading to an overall negative nostalgic experience, as detailed in Figure 2XX (left side). If acetaminophen affects negatively-valenced emotions more than positively-valenced emotions, however, it is possible that after consuming the drug, the intensity of *fondness* will be greater than the intensity of *longing.* This would lead to an overall positively-valenced nostalgic experience in the drug condition, as detailed in Figure 2XX (right side).



**Figure 2XX.** Possible experience of the mixed emotion *nostalgia* under a person’s normal state (left) and with acetaminophen (right).

The current study aims to test whether acetaminophen will have differential effects on the examined emotions. Since there has been no prior research on this topic, no specific predictions will be made regarding which emotions would be blunted more than others. Rather, we simply predict that the effects of acetaminophen will differ among the emotions studied. This is a relatively easy task in the case of *perceived* emotions, as the experimenters (theoretically) know from prior research which emotions are displayed in the audio files. Since listeners can *experience* different emotions to the same sounds, however, there is not a clear way to determine, *a priori*, which emotions should be induced by the sound files. In the induced-emotion case, the comparison among emotion categories is therefore dependent upon the group of participants. In summary, differential acetaminophen effects can be tested among emotion categories in both *perceived* and *induced* emotion cases, but the latter leads to a more exploratory analysis. This leads to our final hypothesis:

**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.

**Materials and 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.

**Participants**

150XXXX participants from the Ohio State University School of Music and Department of Psychology took part in the experiment. The median age was XXXX (SD = XXXX, range from XXXX to XXXX). Of these participants, XXXX (XXXX%) were female. Participants exhibited a wide range of musical training, with a range of XXXX years of formal music theory training (mean = XXXX). Participants have reported a range of XXXX years of formal instrumental or vocal training (mean = XXXX). The Institutional Review Board at the Ohio State University approved all experimental procedures.

**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. Both the placebo and the acetaminophen were powders dissolved in a liquid solution and were prepared by Pharmacy Specialists Compounding Pharmacy (Altamonte Springs, Florida; <http://www.makerx.com/>). The drug solution contained 1000 mg acetaminophen dissolved in Ora-Plus suspension liquid at a 100 mg/ml ratio. The liquid was flavored with Ora-Sweet Syrup. The placebo condition contained Avicel Microcrystalline power dissolved in the Ora-Plus suspension liquid at a 100 mg/ml ratio, and was also sweetened with Ora-Sweet Syrup.

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 (Anderson, 2008; Møller et al., 2000; Randles et al., 2013; Durso et al., 2015; Singla et al., 2012). 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 were administered a physiological measure of inflammationXX and were asked to complete measures of current affect, musical sophistication, musical preferences, personality, empathy, absorption in music, and basic demographic questions.

***Inflammation***. Inflammation was measured by XXXX.

***Current Affect.*** The measure of current affect employed the Positive and Negative Affectivity Scale (PANAS, Watson, Clark, & Tellegen, 1988). The PANAS is a widely-used questionnaire that asks participants to rate 10 positive words and 10 negative words on a 1-5 scale (*1—very slightly or not at all, 5—extremely*). These items are averaged to create indices of positive affect (alpha = XX) and negative affect (alpha = XX). Appendix 1AXX lists all of the questions.

***Musical Sophistication.*** Musical sophistication was measured using the Ollen Musical Sophistication Index (OMSI, Ollen, 2006). The Ollen Sophistication Index is a 10-item survey that assesses the musical expertise, comprehension, and ability of an individual. It contains items such as “*How much college-level coursework in music have you completed?*”, “*To the best of your memory, how many live concerts (of any style, with free or paid admission) have you attended as an audience member in the past 12 months?*”, and “*For how many years have you engaged in regular, daily practice of a musical instrument or singing?*”. Appendix 1BXX lists all 10 questions.

***Musical Preferences***. Musical preferences were measured using the Short Test of Music Preferences-Revised (STOMP-R; Rentfrow, Goldberg, & Levitin, 2011). This is a 23-item questionnaire that measures a person’s musical preferences for 23 musical genres on a 7-point Likert scale (anchors*: 1—dislike strongly, 7—like strongly*). A person’s responses to the musical genres (e.g. *blues*, *classical*) are grouped into five dimensions: 1) Mellow, 2) Unpretentious, 3) Sophisticated, 4) Intense, and 5) Contemporary. These five dimensions summarize each person’s musical preferences profile. Appendix 1CXX lists the complete questionnaire.

***Empathy***. The Interpersonal Reactivity Index (IRI; Davis, 1980) was used to measure trait empathy. The IRI consists of 28 questions, each of which falls into one of four dimensions: perspective taking (PT), empathic concern (EC), personal distress (PD), and fantasy (FS). Each question is anchored by a 5-point Likert scale (*A—does not describe me well; E—describes me very well*). Sample items include “*I daydream and fantasize, with some regularity, about things that might happen to me*”; “*When I see someone being taken advantage of, I feel kind of protective towards them*”. Appendix 1DXX lists all 28 questions and the dimensions to which each question corresponds.

***Personality.*** The inventory of personality traits employed the Big 5 Personality Questionnaire (John & Srivastava, 1999). This is a widely-used 44-item scale that purports to measure a person’s personality. A person is given a score on five dimensions: 1) Extraversion vs. Introversion, 2) Agreeableness vs. Antagonism, 3) Conscientiousness vs. Lack of Direction, 4) Neuroticism vs. Emotional Stability, and 5) Openness vs. Closedness to Experience. Each of these factors is further separated into six distinct personality facets. Each item is anchored on a 5-point Likert scale (*1—disagree strongly, 5—agree strongly*). A sample item is: “*I see myself as someone who is talkative.*” The complete inventory is listed in Appendix 1EXX.

***Musical Absorption.***A person’s tendency to become absorbed in music was measured using the Absorption in Music Scale (AIMS; Sandstrom & Russo, 2011). This is a 34-question survey that asks participants to rate their experiences while listening to music. Specifically, it measures a person’s ability and willingness to respond emotionally to music. Each question is anchored on a 5-point Likert scale (*1—strongly disagree, 5—strongly agree*). Sample items include the following: “*When listening to music, I often imagine the musicians playing the songs*”*;* *At times when listening to music,* “*I feel more connected with other people*”; *“I sometimes feel that I understand the songwriters/composers’ intentions completely*.” The complete questionnaire is provided in Appendix 1FXX.

***Demographics.*** Participants were asked to list their age, preferred gender identity, preferred ethnicity designation, and which medications they were currently taking.

*Instructions to Participants*

In order to avoid possible confusion between perceived and induced emotions, instructions began by pointing out the critical differences. Then, participants were given specific instructions for each of the two blocks. Participants were given specific definitions regarding perceived and induced emotions. The statements given to the participants were the following:

In this study, you will listen to sounds and be asked questions about how those sounds are connected to emotions. You will two distinct blocks of questions, each lasting about twenty minutes. Each block will focus on a different kind of emotion. One block of questions asks you about **perceived emotion**. For this block, you should think about what emotions the sound is *representing*. In other words, you should focus on the emotional characteristics that the sound itself displays. For example, an audio file may sound like it is sad or sound like it is angry. You should *not* take into account how you are feeling in order to answer these questions. For example, it is possible that you might hear some sound that sounds happy, but the sound might actually make you feel angry. For this block we want you to describe the sound rather than what you feel. So you’d say the sound sounds happy.

A separate block of questions will ask you about **experienced emotion**. For this block, you should only consider *how you feel* when you listen to the sound. A sound may make you feel happy or make you feel afraid. The sound may not make you feel any emotion – this is okay. If this happens, you should answer “no emotion” to the question. For these questions, you should not think about the characteristics of the sound itself, but rather how you are feeling in response to the sound.

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.

*Stimulus Selection*

The sound stimuli selected were categorized into three groups: natural stimuli, speech samples, and musical stimuli.

**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).

The natural sounds in each category (i.e. human and non-human sounds) were then sorted by the rated valence (which ranged from 1.57-7.78) in the Bradley & Lang (2007) study. It was determined *a priori* that an audio file with a valence score less than 3.5 would be considered “low valence,” an audio file with a valence score between 3.5 and 5.5 would be considered “neutral valence,” and an audio file with a valence score 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 (see Table 1XX): 1) Low-Valence, High-Arousal (LV-HA); 2) Low-Valence, Low-Arousal (LV-LA); 3) Neutral-Valence, Middle-Arousal (NV-MA); 4) High-Valence, High-Arousal (HV-HA); and 5) High-Valence, Low-Arousal (HV-LA).

**Table 1.** List of natural sounds stimuli categories. Abbreviations: LV-HA = low valence, high arousal; LV-LA = low valence, low arousal; NV-MA = neutral valence, middle arousal; HV-HA = high valence, high arousal; HV-LA = high valence, low arousal.

Human Example Non-human Example

Sounds (valence, arousal) Sounds (valence, arousal)

LV-HA Scream LV-HA Car wreck

(2.05, 8.16) (2.04, 7.99)

LV-LA Couple sobbing LV-LA Busy signal   
(3.27, 5.79) (2.65, 5.68)

NV-MA Walking NV-MA Wind

(4.83, 4.97) (4.32, 5.4)

HV-HA Sports crowd HV-HA Slot machine  
(7.17, 7.07) (7.32, 6.56)

HV-LA Kids HV-LA Brook

(6.84, 4.46) (6.62, 3.36)

For the low-valence items, the files with the highest eight arousal ratings became the LV-HA items. The low-valence files with the lowest eight arousal ratings became the LV-LA items. For the high-valence items, the files with the highest eight arousal ratings became the HV-HA items. The high-valence files with the lowest eight arousal ratings became the HV-LA items. The NV-MA were the neutral-valence sound files with the middle eight arousal ratings. FourX stimuli were chosen for each of these categories, leading to 5X human sounds natural stimuli and 5X non-human sounds natural stimuli (for a total of 2X ‘LV-HA’, 2X ‘LV-LA’, 2X ‘NV-MA’, 2X ‘HV-HA’, and24X ‘HV-LA’ clips ).

**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.* For each emotion condition, the actors were also asked to perform the sentences at three intensities (high, medium, and low). The final dataset consists of 7,442 sentence performances for each modal condition (22,326 files in total). 2,443 independent raters listed the perceived categorical emotion label(s) and perceived intensity value(s) for each performed sentence. [*NOTE: the paper says the recognition of fear and disgust tended to rely on audio-visual clues, rather than from cues from each modality*]. The researchers then calculated the accuracy and intensity of the expressions for each sentence. 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, 12XX sentence performances were chosen as the stimuli. The performances were chosen as follows. First, sentences were eliminated when the actor’s intended emotion (anger, disgust, fear, neutral, happy, sad) did not match the raters’ perceived emotion. This resulted in a reduced list of 3099 performances where the intended emotion matched the perceived emotion (770 ‘anger’ sentences, 343 ‘disgust’ sentences, 407 ‘fear’ sentences, 330 ‘happiness’ sentences, 209 ‘sad’ sentences, and 1040 ‘neutral’ sentences). For each emotion, the sentence performances were then ordered by the amount of agreement of the raters in the Cao *et al.* (2014) and study. Four of these emotional categories of speech were chosen, in order to represent a continuum of both arousal and valence scores: 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 agreement scores for each emotion category resulted in the final stimuli list of 12X stimuli (3X ‘fear’, 3X ‘happiness’, 3X ‘sad’, and 3X ‘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 experimentXX, 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 Thayer’s (1989X) 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, threeX excerpts were chosen per categorical emotion (3X ‘fear’, 3X ‘sadness’, and 3X ‘happiness’ passages). SixX tenderness passages because there were no high valence, low arousal speech samples and we wished to maintain the same number of stimuli per emotion category. The complete list of 15X musical stimuli is shown in Appendix 2AXX.

*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 a various number 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.

With these difficulties in mind, additional musical stimuli were chosen in the following way. We aimed to use experimenter-chosen musical passages that were curated to evoke a singular emotion in listeners. The results of a meta-analysis of music and emotion indicate that around 30-60 seconds may be sufficient to induce emotion in listeners (Eerola & Vuoskoski, 2013). It was therefore determined that the short 15-20 second clips curated by Eerola & Vuoskoski (2011) were not sufficient for this task. As such, it was decided that participants would listen to 8X one-minute passages of experimenter-selected music. These clips came from a previous study that showed these clips were effective in inducing emotion in listeners (Eerola & Vuoskoski, 2011). Notably, these stimuli were chosen to evoke *scary, happy, sad,* and *tender* feelings in listeners. These four emotion categories parallel the four emotion categories in the perceived emotion block.

In addition to the music stimuli, participants listened to 10X 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. The complete list of stimuli used in the induced emotion condition can be found in Appendix 2BX.

*Experimental Procedure*

Participants were once again reminded about the difference between perceived and felt emotion. They were then given the following instructions:

This block is about **experienced emotion.** You will listen to some passages of music and some other sounds. During this time, we ask that you to try to become absorbed in the music/sounds as much as you can. We would like you to pay attention to the audio files and to monitor how you feel when you listen to them. You may feel one or more emotions as you listen, or you might not feel any emotion. That is okay. We are just interested in how you feel as you listen to the audio files *right now*. Try not to think about how the music/sounds may have made you feel in the past, but rather focus on your experience as you listen to the music/sounds today. It is important that you listen to the entire audio file. Do you have any questions?

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).

**Results**

*Statistical Analysis*

We predicted that, compared to the placebo condition, the acetaminophen condition will result in blunted emotional responses to music listening. These findings would be consistent with the hypothesis that acetaminophen reduced responses to affective stimuli.

**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.**

H1 – Plan: Compare acetaminophen group mean with placebo group mean using an independent groups t-test (1-tailed) for:

1. positive valence
2. negative valence
3. arousal

**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.**

H2 – Plan:

1. compare acetaminophen group mean with placebo group mean using an independent groups t-test (1-tailed) for felt emotion
2. use a conditional process model (simple moderation or/and simple mediation models) to connect:
   1. *Independent Variable:* condition (acetaminophen/placebo)
   2. *Moderator/Mediator:* emotion category (e.g. fear, sad, tender, happy)
   3. *Dependent Variable:* felt emotion ratings

**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.**

H3 – Plan:

1. Numerical Statistics: compare acetaminophen group mean with placebo group mean for the *target emotion* (i.e. compare *sadness* for a song that was intended to be sad)
   1. To do this, we will use a three point scale.   
      0 = this emotion does not apply to this sound  
      1 = this emotion applies to this sound  
      2 = this emotion strongly applies to this sound
   2. we can use a simple weighting calculation to determine how much each emotion applies to a sound. For example, if 25 people answer 0, 75 people answer 1, and 100 people answer 2, we could use the following equation: (0\*25)+(1\*75)+(2\*100) = 275.
   3. we can then compare the total score between the acetaminophen group and the placebo group. For example, for a sad song, the acetaminophen group may rate sadness as a total of 275 (for rated sadness) and the placebo group may rate sadness as a total of 350. We could conduct an independent groups t-test (2-tailed) for 275 vs 350.
2. Descriptive Statistics: we could graph all the total scores for a target emotion (e.g. sad). In other words, we could see how many people rate a sad song as: sad, bored, tired, grief, tender, happy. This would give us an idea about any type of mixed emotion or emotional confusion among low-arousal emotions. (see graphs if this is not clear).

Is there a difference between music/non-music? What about different emotional categories (they should theoretically be the same)

*Regarding H1:* Music, of course, is not the only sound stimulus that can convey emotions. Speech and natural sounds can also communicate emotions. Sounds such as screams, doors slamming, and babies laughing all convey different affects. If acetaminophen reduces emotional judgments about music, it is also likely that it will reduce emotional judgments about other sounds. It is possible that the purported blunting due to acetaminophen consumption may be stronger in either the music condition or in the natural sounds condition. A post-hoc test examined the difference in blunting in the music conditions and in the natural sound conditions.

*Regarding H2:* Similarly, we could expect a difference in how participants experienced emotional blunting in the natural sounds and music conditions. Accordingly, a second post-hoc test examined these differences.

Recall that participants were able to choose which emotion was used. Discrete emotion labels were used to initially categorize the data (10X sad, 10X happy, 10X scared). The participant definitions were used to further refine the emotion categories (ex/ the 10X sad emotion labels became 7X melancholy emotions and 3X grief emotions).

Notice that 75%X of the participants picked a positive emotion, while only 25% of the participants picked a negative emotion. We can measure the effect of acetaminophen (vs placebo) in the ‘positive emotion’ group and in the ‘negative emotion’ group. However, we cannot statistically analyze how the acetaminophen effects differ between these two groups. The results among discrete emotion categories are necessarily more exploratory.

**NOTE: How will we score matches to the emotions? Eg, if someone selected a sad piece but then rated it nostalgia, is that a match or not? What about peaceful vs tender? What if there is incomplete overlap?**

*Inflammation*. One of the effects of acetaminophen is to reduce inflammation. It is thought that inflammation may affect the amount of positive emotions experienced (REFERENCE). Therefore, the ingestion of acetaminophen may (broadly) impact the amount of positive emotion associated (?) with positive stimuli.

*Music and Empathy*. A consistent trend in research on music listening and empathy is for emotions to be correlated primarily with one of the four IRI subscales: the IRI-FS subscale. The IRI-FS subscale assesses a person’s tendency to “transpose themselves imaginatively into the feelings/actions of fictitious characters in books/movies/plays” (Davis, 1980). For example, some of the items on the FS-subscale are “*I really get involved with the feelings of the characters in a novel; When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me*.” It makes sense that this component of an empathy scale resonates the most with music listening. Music provides a context outside of day-to-day life where listeners can perceive and experience emotions. The fact that we can separate real-life contexts and music-listening (aesthetic) scenarios is of paramount importance for distinguishing traditional, “psychological” empathy and “musical” empathy.

Vuoskoski and Eerola (2011b) conjecture that the IRI-FS is related to emotional contagion, a known method of emotion induction in music listening. Namely, the music’s emotions are able to trigger similar emotions in the listeners. Research by these authors has also shown that trait empathy, especially the FS subscale, is associated with self-rated experienced emotions from sad and tender music. This shows that people with a higher baseline ability to transport themselves into the feelings of a ‘musical other’ (the FS-score) are more susceptible to feel compassion and concern, and therefore are more affected by sad and tender music. The FS scale is also correlated with self-reported intensity of emotions in response to sad and tender music, as well as with liking for sad and tender music (Vuoskoski et al., 2011).

A hypothesis proposed by Schubert (1996) provides another possible reason for why musical empathy may pertain primarily to the FS scale. Schubert hypothesized that when a person is in an aesthetic context, a cognitive mechanism prevents the person from experiencing displeasure. He uses this explanation to describe how a person can emotionally respond to (sad) music without feeling any displeasure. Other researchers believe this cognitive process may be related to other limbic system processes, such as musical absorption – the willingness to be immersed in sensory stimuli without distraction (Garrido & Schubert, 2011; Saver & Rabin, 1997). In fact, musical absorption was associated with the IRI-FS subscale (Sandstrom & Russo, 2013).

The fact that both trait empathy and musical absorption correlate strongly with the IRI-FS subscale, but less strongly with the other IRI subscales provides an interesting hypothesis. Here, we predict that people high in trait empathy (IRI total and FS-subscale) are likely to have more extreme ratings of valence and arousal, in response to auditory stimuli, than are people who score less-high in trait empathy. Furthermore, we predict that those who score higher in trait empathy are more likely to have greater blunting effects due to acetaminophen consumption.

*Music and Big 5:* Previous research has shown that people who score higher on the Openness scale are more likely to enjoy sad music (Reference).

**Conclusion and Discussion**

The current study employs one of the first experimental manipulations of a biological system that subsequently measures the perception and emotional reactivity to music. The results are consistent with the fact that ingesting a pharmaceutical agent alters a person’s psychological responses to musicXX. Therefore, it is possible that part of music perception is rooted in a biological process. Previous work on this… [PATEL’S WORK].

Recent research (Kraus, 2017) has examined how people communicate emotion and recognize emotional cues in social interactions. Kraus found that voice-only communication enhances empathic accuracy compared to vision-only and vision-and-voice communication. He additionally found that the increased emotional-accuracy in speech conditions was due to linguistic and paralinguistic vocal cues. Kraus theorizes that people attend more to speech cues than to facial expressions because of the tendency to mask emotions in the face. The current study addresses the possibility that acetaminophen can blunt sensitivity to these emotional cues in sounds. It has implications for how people socially interact and the empathy they experience during social interactions. [EXPAND THIS – SAY MORE. ESPECIALLY IF IN ABSTRACT.]

In previous music research, the perception and induced feeling of *sadness*, compared to other emotions, has a special place. Many researchers have wondered why people enjoy listening to sad music. Three contradictory facts exist regarding sad music. 1) Sad music makes you sad. 2) People enjoy listening to sad music. 3) People do not enjoy being sad. Because of this apparent contradiction, many philosophical debates and empirical research have studied the “sadness paradox.” When conducting a study on music-induced/music-represented sadness, it is common for researchers to adopt a paradigm that features many musical emotion types, such as joy, fear, sadness, and aggression. In many of these paradigms, however, a problem occurs. Although “sadness, aggression, and fear” are all negatively-valenced emotions, of the entire list, only “sadness” is a low-arousal emotion. The “special case” of sadness, especially people’s ability to discriminate sadness from other musical emotions, may not actually be unique to the emotion of sadness. It could be that people are attending to features of low arousal, such as slow rhythms and small pitch intervals, rather than the emotion of sadness. If other low-arousal emotions, such as sleepiness or contentment, were (more often) included in music emotion research, it could be that sadness does not turn out to be that special, after all.

By using musical excerpts that represent fear, anger, sadness, tenderness, and happiness, we can begin to untangle whether arousal contributes to many musical emotion effects. [THIS IS ONLY FOR PERCEIVED EMOTIONS – SAY THAT]. Fear, anger, and happiness are likely high-arousal emotions, while sadness and tenderness are likely low-arousal emotions. In this study, we examine whether acetaminophen has a different blunting effect on high- and low-arousal emotions, as well as on high- and low-valence emotions. Therefore, we can begin to clarify whether the pharmaceutical effects are specific for particular valences and whether it blunts high-arousal emotions more than low-arousal emotions.

Both blocks tested the difference between nominally “sad” and nominally “grief-like” music.

Induced emotion: we care about a difference in emotion (due to acetaminophen). it doesn’t matter where the emotion comes from.

What does the overlap of speech, natural sounds, and music accomplish?

Limitations: The sounds in the IADS-2 were originally intended to be “emotionally-evocative” and therefore are appropriate to use in this block (Bradley & Lang, 2007, p.1). However, the original purpose of the CREMA-D was to examine how listeners *perceive* emotions in the speech clips (Cao et *al.*, 2014). It is not clear, therefore, whether the speech passages in the CREMA-D are able to induce emotion at all. The speech passages were still included in the block, but the results must take into account that the audio files were used differently than the purpose of the original manuscript.

Speech in both IADS and CREMA-D:

IADS: “Let go of me!” – emotional speech in an emotional situation, full of semantic meaning. Prosody, background sounds, semantic content.

CREMA-D: “It’s 11:00!” – emotional speech in an acted, non-emotional situation, with no emotional semantic meaning. Meaning in the CREMA comes from prosody/infection, but there is no background sounds and no semantic/situational content.

advertisement – companies use music to help convey emotional content. impact of acetaminophen on watching ads/in ad focus groups?

**Implications and future directions**

Goals:

1. Musical reactions/reactivity can be systematically controlled by a pharmaceutical agent?

2. The blunting effects of acetaminophen are different for different emotions?

3. Extends the findings of blunted ratings of valenced picture-stimuli to the musical and auditory domains.

**OUTTAKES**

*Cognitive Control*

For each of the 54XX clips, participants were also asked to respond to the question “*What is the durationXX of this sound?*” using an 11-point scale (0: 1-2 seconds, 1: 3-4 seconds, 10: 19-20 seconds). The purpose of this question was to examine participants’ judgments of the sounds in a non-emotional context. The effects of acetaminophen have been shown to be specific to emotional judgments (Durso, Luttrell, & Way, 2015). Namely, the acetaminophen should not affect other types of judgments, such as the durationX of the sound. The question acts as a control because the structure of the question is similar to the measures of perceived and induced emotion. With this control measure, it is possible to test whether acetaminophen reduces stimuli judgments in general, or whether the blunting is restricted to emotional judgments.

*Participant Selected Music*

Second, we aimed to use participant-selected musical passages. Previous work has shown that participant-selected music was more effective in inducing an intended emotion than experimenter-selected music (Carter et *al.*, 1995). In a pre-experiment questionnaire, participants were asked to think of two 1-minute selections of music that reliably induce strong emotional reaction(s) in them. The two minutes of music could come from a single work or from multiple works. Two 1-minute passages of music were selected in order to mirror the two 1-minute passages of experimenter-selected musical passages.

In these participant-selected passages, it was determined *a priori* that the experimenters should not assign a music-induced emotion for each participant. The reasoning behind this is that people are not equally likely to experience a particular emotion from music listening. For example, suppose that we assigned two participants to the music-induced emotion of *sadness*. One participant might love sad music and would easily be able to pick musical works that make them feel extremely sad. The other participant might not like sad music. Because the participant may be less familiar with music that causes them to feel sad, he or she could have difficulty finding any music that makes them sad. The music that this participant picks, then, might only make them feel slightly sad. These two experiences of *music-induced sadness* cannot be easily compared, since the arousal, intensity, and valence of the *sad* affect is different for each participant. In fact, this scenario is common, as 50% of the population does not like nominally sad music and about 10% of the population says that sad music is their least favorite music (REFERENCE).

Instead of assigning participants to a discrete emotion, participants were asked to choose music that would make them feel strong emotion(s). By asking participants to choose the music-induced emotion that would make them feel the strongest affect, the intensity and arousal of the participants’ emotions may be as large as could be obtained in an experimental study. Additionally, people who choose an emotion like *music-induced sadness* would be familiar with music that makes them feel this way and would be better able to make good choices with their selected musical passages.

Of course, each participant may operationalize an emotion construct in a different way. In order to examine this possibility, participants were asked to define the emotion they chose, as well as to list what experiences they have while listening to that music. The experimenters may then be able to compare operationalizations across participants, which could be used later in the data analysis. Nonetheless, the induced emotion data analysis is necessarily exploratory in nature. Each participant was given the following instructions to pick their emotionally-inducing music:

We are interested in how music makes you *feel* certain emotions. Before coming to the experiment on [DATE], we would like you to think of music that makes you feel a strong emotion. We would like you to choose **two one-minute passages of music** that make you feel *a strong emotion.* For example, the music could make you feel a positive emotion (e.g. happy, compassionate, peaceful) or a negative emotion (e.g. sad, angry, fearful, surprised). It does not matter which emotion you pick, but the two minutes of music should make you feel **the same emotion**.

The two minutes of music can come from one musical piece or from multiple pieces. Please list the name(s), composer(s), and duration marking(s) (min:sec) of the music that evokes a *strong* emotion in you. Send an email to [EXPERIMENTER] by [DATE] with (1) your two musical choices (each one-minute in length) and (2) the emotion you feel when listening to this music. Additionally, please describe (3) how you would define this emotion, (4) what types of things you experience when listening to music that makes you feel this way, and (5) why you chose these musical passages.

Two additional one-minute musical passages were also given to the participants. These passages were intended to be a control condition. A list of all of the participant-selected musical passages and emotion categories was collected for those in the acetaminophen group and for those in the placebo group. Each participant was given a randomly-selected passage from the list of emotion-inducing music provided by participants in the opposite group (placebo or acetaminophen group). Namely, a participant in the acetaminophen condition was randomly matched with a one-minute passage of music selected by a participant in the placebo group (and vice versa). This other-selected music serves as a control passage because it was considered emotionally arousing to at least one listener. Because of people’s different musical tastes and familiarity, however, the control passage is less likely to induce a strong emotional response in another listener.

*Experiences with Frisson*

Some listeners experience strong emotional reactions to music. These experiences have been chronicled in the music cognition literature (Gabrielsson, 2011; Huron, 2006). David Huron has written about these sublime musical experiences. In his Supressed-Fear Theory (Huron, 2006; Huron & Margulis, 2010), he claims that sublime experiences come from the activation and subsequent suppression of the amygdalae. His theory posits that subcortical pathways are activated in response to certain sounds. Sounds that are loud, have many sound sources, contain crescendos or close proximity, contain infrasound, scream-like, low in pitch, and surprising induce fear in listeners (Angliss, 2003; Fletcher & Munson, 1933; Huron, 1992; Huron, 2006; Huron, Kinney, & Precoda, 2006; Maren, 2007; Marks, 1987; Matthews, 1979). A person’s cognitive assessment of the situation – ‘this is just music, I don’t need to be afraid – suppresses this fear response. Because of the contrasting valence between these two pathways, listeners experience the music as phenomenologically pleasurable.

Physiologically, listeners experience one or more phenomenon in response to sublime music. They can cry, hold their breath, feel ‘choked up’, or experience goosebumps. The experience of goosebumps or having chills running up and down the spine is referred to as the frisson response. Frisson has been documented and studied by Goldstein (1980), Sloboda (1991), Panksepp (1995) and others. People who are more susceptible to frisson are those who are more susceptible to System 1 fear. Namely, frisson is more common in females than in males (Panksepp, 1995), and in those who are less thrill-seeking (Grewe, Nagel, Kopiez, & Altenmüller, 2007).

Frisson experiences tend to be reliable – a person will experience frisson to the same passage of music on multiple occasions. Huron (2006) posits that this is because fear resists habituation. However, one passage of music may not elicit frisson across listeners. Namely, people often experience frisson in response to different musical passages.

In line with this research, another a priori hypothesis was made. Recall that Hypothesis 2a predicts that emotional responses to stimuli will be diminished in the acetaminophen condition, compared to the placebo condition. Hypothesis 2b states, therefore, that a person’s frisson response should be diminished in the acetaminophen condition, compared to the control condition.

Not all listeners experience frisson. A simple pre-experiment survey was conducted asking participants if they have ever experienced “goosebumps, chills, or shivers” in response to music listening. Furthermore, the survey asked participants to list the musical work, composer, and moment in the work (minute:second) that they tend to experience frisson. Those who indicated that they reliably had a frisson response to the same passage of music were selected to participate in an extra task.

The group of frisson-experiencers (n = XX) were asked to listen to two passages of music. One was the self-selected passage of music that caused them to experience frisson. The other passage was a control. The control passage was randomly selected as one of the passages the other participants self-identified as contributing to their frisson experiences. A frisson-inducing passage of music does not usually generalize to a frisson-inducing experience in another listener. Therefore, the controls are works that have been shown to elicit frisson in some listeners, but not in other listeners. The self-selected of frisson-inducing passages is listed in Table 4XX.

Listeners listened to the self-selected frisson passage and the other-selected frisson passage in a random order. They were asked the following questions.

1.

2. They were also asked to describe their emotions and physiological response(s) to the passages in a short paragraph.

They were also asked to indicate their familiarity (0 = not familiar, 1 = somewhat familiar, 2 = very familiar) of the musical passages.

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Appendices

Appendix 1A: The Positive and Negative Affectivity Scale Questionnaire (PANAS; Watson, Clark, & Tellegan, 1988)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment OR indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)

Very Slightly or Not at All A Little Moderately Quite a Bit Extremely

1 2 3 4 5

\_\_\_\_\_\_\_ 1. Interested \_\_\_\_\_\_\_ 11. Irritable

\_\_\_\_\_\_\_ 2. Distressed \_\_\_\_\_\_\_ 12. Alert

\_\_\_\_\_\_\_ 3. Excited \_\_\_\_\_\_\_ 13. Ashamed

\_\_\_\_\_\_\_ 4. Upset \_\_\_\_\_\_\_ 14. Inspired

\_\_\_\_\_\_\_ 5. Strong \_\_\_\_\_\_\_ 15. Nervous

\_\_\_\_\_\_\_ 6. Guilty \_\_\_\_\_\_\_ 16. Determined

\_\_\_\_\_\_\_ 7. Scared \_\_\_\_\_\_\_ 17. Attentive

\_\_\_\_\_\_\_ 8. Hostile \_\_\_\_\_\_\_ 18. Jittery

\_\_\_\_\_\_\_ 9. Enthusiastic \_\_\_\_\_\_\_ 19. Active

\_\_\_\_\_\_\_ 10. Proud \_\_\_\_\_\_\_ 20. Afraid

Appendix 1B: The Ollen Sophistication Index Questionnaire (Ollen, 2006)

1. How old are you today?

\_\_\_\_\_ age in years

2. At what age did you begin sustained musical activity? “Sustained musical activity” might include regular music lessons or daily musical practice that lasted for at least three consecutive years. If you have never been musically active for a sustained time period, answer with zero.

\_\_\_\_\_ age at start of sustained musical activity

3. How many years of private music lessons have you received? If you have received lessons on more than one instrument, including voice, give the number of years for the one instrument/voice you've studied longest. If you have never received private lessons, answer with zero.

\_\_\_\_\_ years of private lessons

4. For how many years have you engaged in regular, daily practice of a musical instrument or singing? “Daily” can be defined as 5 to 7 days per week. A “year” can be defined as 10 to 12 months. If you have never practiced regularly, or have practiced regularly for fewer than 10 months, answer with zero.

\_\_\_\_\_ years of regular practice

5. Which category comes nearest to the amount of time you currently spend practicing an instrument (or voice)? Count individual practice time only; not group rehearsals.

c I rarely or never practice singing or playing an instrument

c About 1 hour per month

c About 1 hour per week

c About 15 minutes per day

c About 1 hour per day

c More than 2 hours per day

6. Have you ever enrolled in any music courses offered at college (or university)?

c No ˙ (Skip to #8)

c Yes

7. (If Yes) How much college-level coursework in music have you completed? If more than one category applies, select your most recently completed level.

c None c 1 or 2 NON-major courses (e.g., music appreciation, playing or singing in an ensemble)

c 3 or more courses for NON-majors

c An introductory or preparatory music program for Bachelor’s level work

c 1 year of full-time coursework in a Bachelor of Music degree program (or equivalent)

c 2 years of full-time coursework in a Bachelor of Music degree program (or equivalent)

c 3 or more years of full-time coursework in a Bachelor of Music degree program (or equivalent)

c Completion of a Bachelor of Music degree program (or equivalent)

c One or more graduate-level music courses or degrees

8. Which option best describes your experience at composing music?

c Have never composed any music

c Have composed bits and pieces, but have never completed a piece of music

c Have composed one or more complete pieces, but none have been performed

c Have composed pieces as assignments or projects for one or more music classes; one or more of my pieces have been performed and/or recorded within the context of my educational environment

c Have composed pieces that have been performed for a local audience

c Have composed pieces that have been performed for a regional or national audience (e.g., nationally known performer or ensemble, major concert venue, broadly distributed recording)

9. To the best of your memory, how many live concerts (of any style, with free or paid admission) have you attended as an audience member in the past 12 months? Please do not include regular religious services in your count, but you may include special musical productions or events.

c None

c 1 - 4

c 5 - 8

c 9 - 12

c 13 or more

10. Which title best describes you?

c Nonmusician

c Music-loving nonmusician

c Amateur musician

c Serious amateur musician

c Semiprofessional musician

c Professional musician

Appendix 1C: The Short Test of Music Preferences-Revised (STOMP-R; Rentfrow, Goldberg, & Levitin, 2011)

Please indicate your basic preference for each of the following genres using the scale provided.

1----------------2-----------------3-----------------4---------------5---------------6-----------------7

Dislike Dislike Dislike a Neither like Like a Like Like

Strongly Moderately Little nor dislike Little Moderately Strongly

1. \_\_\_\_\_ Alternative 13. \_\_\_\_\_ New Age
2. \_\_\_\_\_ Bluegrass 14. \_\_\_\_\_ Oldies
3. \_\_\_\_\_ Blues 15. \_\_\_\_\_ Opera
4. \_\_\_\_\_ Classical 16. \_\_\_\_\_ Pop
5. \_\_\_\_\_ Country 17. \_\_\_\_\_ Punk
6. \_\_\_\_\_ Dance/Electronica 18. \_\_\_\_\_ Rap/hip-hop
7. \_\_\_\_\_ Folk 19. \_\_\_\_\_ Reggae
8. \_\_\_\_\_ Funk 20. \_\_\_\_\_ Religious
9. \_\_\_\_\_ Gospel 21. \_\_\_\_\_ Rock
10. \_\_\_\_\_ Heavy Metal 22. \_\_\_\_\_ Soul/R&B
11. \_\_\_\_\_ World 23. \_\_\_\_\_ Soundtracks/theme song
12. \_\_\_\_\_ Jazz

Appendix 1D: Interpersonal Reactivity Index (IRI; Davis, 1980)

The following statements inquire about your thoughts and feelings in a variety of

situations. For each item, indicate how well it describes you by choosing the appropriate

letter on the scale at the top of the page: A, B, C, D, or E. When you have decided on your

answer, fill in the letter next to the item number. READ EACH ITEM CAREFULLY

BEFORE RESPONDING. Answer as honestly as you can. Thank you.

ANSWER SCALE:

A B C D E

DOES NOT DESCRIBES

DESCRIBE ME VERY

ME WELL WELL

1. I daydream and fantasize, with some regularity, about things that might happen to me. (FS)

2. I often have tender, concerned feelings for people less fortunate than me. (EC)

3. I sometimes find it difficult to see things from the "other guy's" point of view. (PT) (-)

4. Sometimes I don't feel very sorry for other people when they are having problems. (EC) (-)

5. I really get involved with the feelings of the characters in a novel. (FS)

6. In emergency situations, I feel apprehensive and ill-at-ease. (PD)

7. I am usually objective when I watch a movie or play, and I don't often get completely

caught up in it. (FS) (-)

8. I try to look at everybody's side of a disagreement before I make a decision. (PT)

9. When I see someone being taken advantage of, I feel kind of protective towards them. (EC)

10. I sometimes feel helpless when I am in the middle of a very emotional situation. (PD)

11. I sometimes try to understand my friends better by imagining how things look from

their perspective. (PT)

12. Becoming extremely involved in a good book or movie is somewhat rare for me. (FS) (-)

13. When I see someone get hurt, I tend to remain calm. (PD) (-)

14. Other people's misfortunes do not usually disturb me a great deal. (EC) (-)

15. If I'm sure I'm right about something, I don't waste much time listening to other

people's arguments. (PT) (-)

16. After seeing a play or movie, I have felt as though I were one of the characters. (FS)

17. Being in a tense emotional situation scares me. (PD)

18. When I see someone being treated unfairly, I sometimes don't feel very much pity for

them. (EC) (-)

19. I am usually pretty effective in dealing with emergencies. (PD) (-)

20. I am often quite touched by things that I see happen. (EC)

21. I believe that there are two sides to every question and try to look at them both. (PT)

22. I would describe myself as a pretty soft-hearted person. (EC)

23. When I watch a good movie, I can very easily put myself in the place of a leading

character. (FS)

24. I tend to lose control during emergencies. (PD)

25. When I'm upset at someone, I usually try to "put myself in his shoes" for a while. (PT)

26. When I am reading an interesting story or novel, I imagine how I would feel if the

events in the story were happening to me. (FS)

27. When I see someone who badly needs help in an emergency, I go to pieces. (PD)

28. Before criticizing somebody, I try to imagine how I would feel if I were in their place. (PT)

Appendix 1E: The Big Five Inventory (BFI; John & Srivastava, 1999)

Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who likes to spend time with others? Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement.

Disagree Disagree Neither agree Agree Agree

strongly a little nor disagree a little strongly

1 2 3 4 5

I see Myself as Someone Who…

\_\_\_\_1. Is talkative \_\_\_\_23. Tends to be lazy

\_\_\_\_2. Tends to find fault with others \_\_\_\_24. Is emotionally stable, not easily upset

\_\_\_\_3. Does a thorough job \_\_\_\_25. Is inventive

\_\_\_\_4. Is depressed, blue \_\_\_\_26. Has an assertive personality

\_\_\_\_5. Is original, comes up with new ideas \_\_\_\_27. Can be cold and aloof

\_\_\_\_6. Is reserved \_\_\_\_28. Perseveres until the task is finished

\_\_\_\_7. Is helpful and unselfish with others \_\_\_\_29. Can be moody

\_\_\_\_8. Can be somewhat careless \_\_\_\_30. Values artistic, aesthetic experiences

\_\_\_\_9. Is relaxed, handles stress well \_\_\_\_31. Is sometimes shy, inhibited

\_\_\_\_10. Is curious about many different \_\_\_\_32. Is considerate and kind to almost everyone

things

\_\_\_\_11. Is full of energy \_\_\_\_33. Does things efficiently

\_\_\_\_12. Starts quarrels with others \_\_\_\_34. Remains calm in tense situations

\_\_\_\_13. Is a reliable worker \_\_\_\_35. Prefers work that is routine

\_\_\_\_14. Can be tense \_\_\_\_36. Is outgoing, sociable

\_\_\_\_15. Is ingenious, a deep thinker \_\_\_\_37. Is sometimes rude to others

\_\_\_\_16. Generates a lot of enthusiasm \_\_\_\_38. Makes plans and follows through with

them

\_\_\_\_17. Has a forgiving nature \_\_\_\_39. Gets nervous easily

\_\_\_\_18. Tends to be disorganized \_\_\_\_40. Likes to reflect, play with ideas

\_\_\_\_19. Worries a lot \_\_\_\_41. Has few artistic interests

\_\_\_\_20. Has an active imagination \_\_\_\_42. Likes to cooperate with others

\_\_\_\_21. Tends to be quiet \_\_\_\_43. Is easily distracted

\_\_\_\_22. Is generally trusting \_\_\_\_44. Is sophisticated in art, music, or

literature

Appendix 1F: Absorption in Music Scale (AIMS; Sandstrom & Russo, 2013)

Strongly Somewhat Neutral (Neither Somewhat Strongly

Disagree Disagree Agree nor Disagree) Agree Agree

1 2 3 4 5

1. I will sometimes move my hand as if I were ‘conducting’ music
2. When listening to music, I sometimes temporarily forget where I am
3. I sometimes feel like I am ‘one’ with the music
4. When I listen to music I can get so caught up in it that I don’t notice anything
5. When I feel that nobody understands me, I often turn on some music
6. I will stop everything that I’m doing in order to listen to a special song/piece of music that is playing
7. I can imagine a song/piece of music so vividly that it holds my attention as if I were hearing it live
8. When I hear good music I tend to lose my train of thought and forget what I was thinking about
9. Sometimes when listening to music I feel as if my mind can understand the whole world
10. I sometimes feel that I understand the songwriter/composer’s intentions completely
11. I can change almost any sound into music by the way I listen to it
12. I have stopped walking to listen to music that I came across on my path
13. While listening to music, I may become so involved that I may forget about myself and my surroundings
14. If I want to feel creative, I will turn on some music
15. It is sometimes possible for me to be completely immersed in music and to feel as if my whole state of consciousness has been temporarily altered
16. I know what people mean when they talk about mind-altering musical experiences
17. At times when listening to music, I feel more connected with other people
18. I find that different sounds have different colors (e.g. red, blue)
19. I spend as much time as I can every day listening to music
20. Sometimes music makes me feel and experience things as I did when I was a child
21. Sometimes I almost feel as if a song was written especially for/about me
22. I sometimes make my movements/actions (opening doors, pushing buttons, stepping of curbs) coincide with the music
23. I like to find patterns in everyday sounds
24. When listening to music I can lose all sense of time
25. Before I do an activity (e.g., exercise, study), I usually carefully consider what music to play along with it
26. The sound of a speaking voice can be so fascinating to me that I can just go on listening to it
27. Music sometimes helps me ‘step outside’ my usual self and experience an entirely different state of being
28. When listening to music, I often imagine the musicians playing the songs
29. When listening to great music I sometimes feel as if I am being lifted into the air
30. When I am listening to music, I can tune out everything else
31. I sometimes see vivid images in my head when I listen to music
32. I sometimes close my eyes so I can focus on the music I am listening to
33. There are times when I will do nothing except listen to music
34. I sometimes feel like I’m part of something bigger than myself when I listen to music

Appendix 2A: List of musical and non-musical stimuli used in Block 1 (perceived emotion). All musical sounds are taken from Vuoskoski & Eerola (2011). All natural sounds are taken from the IADS-2 (Bradley & Lang, 2007). All speech sounds are taken from the CREMA-D (Cao et *al.*, 2014).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Number** | **Name of Sound** | **Class of Sound** | **Expected Emotion or Dimensionality** | **Time  (min:sec)** | **Database Number** |
| 1 | JFK,  Track 8 | Music | Fear | 01:26-01:40 | 012 |
| 2 | The Alien Trilogy,  Track 5 | Music | Fear | 00:26-00:41 | 014 |
| 3 | Hannibal,  Track 1 | Music | Fear | 00:40-00:54 | 015 |
| 4 | The Rainmaker,  Track 3 | Music | Happy | 02:55-03:13 | 021 |
| 5 | Shallow Grave,  Track 6 | Music | Happy | 02:02-02:17 | 023 |
| 6 | Man of Galilee CD1, Track 2 | Music | Happy | 03:02-03:18 | 024 |
| 7 | Running Scared, Track 15 | Music | Sad | 02:06-02:27 | 032 |
| 8 | The Portrait of a Lady,  Track 9 | Music | Sad | 00:00-00:22 | 033 |
| 9 | Man of Galilee CD1, Track 8 | Music | Sad | 01:20-01:37 | 035 |
| 10 | Pride & Prejudice,  Track 1 | Music | Tender | 00:10-00:26 | 042 |
| 11 | Dances with Wolves,  Track 4 | Music | Tender | 01:31-01:48 | 043 |
| 12 | Pride & Prejudice,  Track 12 | Music | Tender | 00:01-00:15 | 044 |
| 13 | Oliver Twist, Track 8 | Music | Tender | 00:14-00:30 | 045 |
| 14 | Oliver Twist, Track 8 | Music | Tender | 00:15-01:32 | 047 |
| 15 | Oliver Twist, Track 2 | Music | Tender | 00:00-00:29 | 050 |
| 1 | Scream | Natural Sounds | Low Valence, High Arousal |  | 275 |
| 2 | Car Wreck | Natural Sounds | Low Valence, High Arousal |  | 424 |
| 3 | Couple Sobbing | Natural Sounds | Low Valence, Low Arousal |  | 295 |
| 4 | Busy Signal | Natural Sounds | Low Valence, Low Arousal |  | 703 |
| 5 | Walking | Natural Sounds | Neutral Valence, Middle Arousal |  | 722 |
| 6 | Fan | Natural Sounds | Neutral Valence, Middle Arousal |  | 701 |
| 7 | Kids 1 | Natural Sounds | High Valence, Low Arousal |  | 112 |
| 8 | Brook | Natural Sounds | High Valence, Low Arousal |  | 172 |
| 9 | Sports Crowd | Natural Sounds | High Valence, High Arousal |  | 352 |
| 10 | Slot Machine 2 | Natural Sounds | High Valence, High Arousal |  | 717 |
| 1 | “It’s eleven o’clock” | Speech | Fear |  | 1064\_IEO\_FEA\_HI |
| 2 | “The surface is slick” | Speech | Fear |  | 1036\_TSI\_FEA\_XX |
| 3 | “We’ll stop in a couple of minutes” | Speech | Fear |  | 1036\_WSI\_FEA\_XX |
| 4 | “It’s eleven o’clock” | Speech | Happy |  | 1038\_IEO\_HAP\_HI |
| 5 | “I think I’ve seen this before” | Speech | Happy |  | 1049\_ITS\_HAP\_XX |
| 6 | “That is exactly what happened” | Speech | Happy |  | 1064\_TIE\_HAP\_XX |
| 7 | “It’s eleven o’clock” | Speech | Sad |  | 1029\_IEO\_SAD\_HI |
| 8 | “We’ll stop in a couple of minutes” | Speech | Sad |  | 1028\_WSI\_SAD\_XX |
| 9 | “The airplane is almost full” | Speech | Sad |  | 1007\_TAI\_SAD\_XX |
| 10 | “I’m on my way to a meeting” | Speech | Neutral |  | 1074\_IOM\_NEU\_XX |
| 11 | “I would like a new alarm clock” | Speech | Neutral |  | 1083\_IWL\_NEU\_XX |
| 12 | “The airplane is almost full” | Speech | Neutral |  | 1029\_TAI\_NEU\_XX |

Appendix 2B: List of musical stimuli used in Block 2 (induced emotion). These works are participant-chosen.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Number** | **Name of Sound/Musical Passage** | **Class of Sound** | **Class** | **Listed Emotion or Dimensionality** | **Time (min:sec)** | **Database Number** |
| 1 | Batman Returns,  Track 15 | Music | Scary |  | 00:00-00:46 | F2 |
| 2 | The Alien Trilogy,  Track 11 | Music | Scary |  | 02:04-02:58 | F4 |
| 3 | Dances with Wolves,  Track 10 | Music | Happy |  | 00:00-00:46 | H2 |
| 4 | Pride & Prejudice, Track 4 | Music | Happy |  | 00:10-01:06 | H4 |
| 5 | Running Scared, Track 15 | Music | Sad |  | 01:45-02:40 | S3 |
| 6 | Pride & Prejudice, Track 13 | Music | Sad |  | 00:40-01:30 | S4 |
| 7 | The Portrait of a Lady, Track 3 | Music | Tender |  | 00:23-01:08 | T1 |
| 8 | Shine, Track 10 | Music | Tender |  | 01:01-02:00 | T2 |
| 1 | Female Scream 3 | Natural Sounds | Low Valence, High Arousal |  |  | 277 |
| 2 | Buzzer | Natural Sounds | Low Valence, High Arousal |  |  | 712 |
| 3 | Man Sobbing | Natural Sounds | Low Valence, Low Arousal |  |  | 293 |
| 4 | Engine Failure | Natural Sounds | Low Valence, Low Arousal |  |  | 502 |
| 5 | Hiccup | Natural Sounds | Neutral Valence, Middle Arousal |  |  | 245 |
| 6 | Wind | Natural Sounds | Neutral Valence, Middle Arousal |  |  | 500 |
| 7 | Giggling | Natural Sounds | High Valence, Low Arousal |  |  | 230 |
| 8 | Seagull | Natural Sounds | High Valence, Low Arousal |  |  | 150 |
| 9 | Baseball | Natural Sounds | High Valence, High Arousal |  |  | 353 |
| 10 | Horse Race | Natural Sounds | High Valence, High Arousal |  |  | 363 |