

The PUMS Database: A Corpus of Previously-Used Musical Stimuli in 306 Studies of Music and Emotion

LINDSAY WARRENBURG[1]
Ohio State University, United States of America

ABSTRACT: A corpus of Previously-Used Musical Stimuli (PUMS) is presented. The PUMS database is an online, publicly-available database where researchers can find a list of 22,417 musical stimuli that have been previously used in the literature on how music can convey or evoke emotions in listeners. A total of 306 studies on music and emotion are included in the database. Each musical stimulus used in these studies was coded according to various criteria: its designated emotion and how it was operationalized, its length, whether it is an excerpt from a longer work, and its style or genre. In the PUMS corpus, there is also information regarding the familiarity of the original participants with each musical sample, as well as information regarding whether each passage was used in a study about perceived or induced emotion. The name of the passage, composer, track number, and specific measure numbers or track location were noted when they were identified in the original paper. The database offers insight into how music has been used in psychological studies over a period of 90 years and provides a resource for scholars wishing to use music in future behavioral or psychophysical research. The PUMS database can be accessed online at <https://osf.io/p4ta9>.

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THERE are innumerable accounts of music's ability to express and evoke emotions in listeners. Philosophers dating back to Aristotle have noted that music can induce feelings of sadness and pleasure (e.g., Levinson, 2014). Today, people throughout the world still use music as a means to engage with emotion, which can be seen through the myriad of Spotify playlists with titles like "sad songs," "happy tunes," and "calm vibes." People may listen to music as a means of escape, to experience transcendence, to produce pleasure, to regulate their own emotions, and to provide diversion (Saarikallio & Erkkilä, 2007; Schäfer et al., 2013). In scientific studies of emotion, music is often used as a medium to convey certain affective states (Eerola, 2011), to evoke feelings in listeners (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009), or to both represent and induce emotion (Hunter, Schellenberg, & Schimmack, 2010).

Despite the prevalence of music in everyday life and in behavioral and psychophysical research on emotion, there has been a lack of systematic analysis of which musical passages have been associated with specific emotions. Although there are several review papers that discuss musical stimuli (Eerola & Vuoskoski, 2013; Gabrielsson & Lindström, 2010; Garrido, 2014; Juslin & Laukka, 2003; Schubert, 2013; Västfjäll, 2002), these articles tend to concentrate on *how* stimuli (broadly) might affect emotion or mood, rather than summarizing characteristics of the stimuli themselves. Furthermore, although some music and emotion stimulus sets have been shared openly in the past (e.g., Eerola & Vuoskoski, 2011; Gosselin et al., 2005), there is no comprehensive database that identifies which musical stimuli have been used in previous emotion-related studies. Rather, researchers have often summarized stimuli characteristics without providing references to the stimuli themselves. This article describes the creation of an online and publicly available database of Previously-Used Musical Stimuli (PUMS), which summarizes the types of musical passages that have been used in studies of emotional expression and evocation from 1928 through 2018. The PUMS database also provides a resource for researchers designing new emotion-related studies.

A number of methodological questions are likely to arise for any researcher interested in conducting emotion-related research. In particular, various questions include how to find the most suitable musical stimuli, how long the passage should be, whether an excerpt is suitable for the study or whether the full



musical work is needed, whether participants should be unfamiliar or familiar with the musical samples, and which style (or genre) of music is most appropriate. Researchers may also be interested in whether these characteristics of emotional music passages differ in studies about perceived emotion or experienced emotion. The PUMS database addresses these and other methodological considerations. Perhaps most importantly, the PUMS corpus clearly identifies the names, composers, performers, and specific measure numbers for thousands of musical passages used in emotion-related studies so that future researchers can (1) listen to the musical stimuli that other researchers have used, (2) replicate hundreds of studies with the exact musical passages, and (3) easily identify stimuli for their own future studies.

SEARCH STRATEGY

A systematic analysis of the literature on music and emotion was conducted. Discovering musical stimuli used in studies about emotion requires a multidisciplinary, broad search. Publications come from the fields of psychology, neuroscience, music theory, music therapy, linguistics, computer science, consumer science, marketing, and engineering (e.g., Musical Emotion Recognition, MER). Accordingly, there are thousands of publications regarding this topic. For example, a cursory Google Scholar search on “music,” “stimuli,” and “emotion” results in approximately 111,000 articles. Because searching every single article on the topic would be nearly impossible, I created specific search criteria to find a representative sample of the population of music and emotion studies. The goal was to limit the search findings to English language publications in peer-reviewed journals, although I also included studies reported in conference proceedings. The searches took place between September 2017 and November 2018.

The papers chosen for this study were the result of three separate processes. First, I examined the articles in the six major reviews or meta-analyses on music and emotion cited at the beginning of the paper (Eerola & Vuoskoski, 2013; Gabrielsson & Lindström, 2010; Garrido, 2014; Juslin & Laukka, 2003; Schubert, 2013; Västfjäll, 2002). Second, I looked through the references of the papers from the first step. Finally, I conducted searches in the following Internet-based scientific databases: Google Scholar, JSTOR, PsychINFO, and Ingentia. The following search terms were included in various combinations and truncations: *emotion*, *music*, *perceived*, *induced*, and *stimuli*. No limits on dates were placed. Overall, 654 papers were examined by the author, but only articles that explicitly included musical stimuli were included in the PUMS database. The results of this exclusionary criteria resulted in a total of 306 studies involving 22,417 stimuli, which comprise the PUMS database.

OPERATIONALIZATIONS OF MUSICAL ATTRIBUTES AND METADATA

Each of the 22,417 stimuli from 306 representative studies was analyzed according to the following criteria:

Designated Emotion/Mood

The specific term the researchers used to describe the emotion or mood of the musical passage was identified. For example, a researcher may be interested in which musical samples make someone feel *sad* or portray *negative valence* and *high arousal*. The exact terminology the researcher used was specified in the PUMS, in order to further differentiate music that causes *depression* versus *melancholy*, for instance. Instances of music-related mood and music-related emotion were included in the database, as stimuli that portrayed or evoked these affective states were both deemed to be important. In addition, many authors did not clearly differentiate between mood and emotion in the original studies. Complete information about the specific emotion, mood, or arousal of the musical stimuli was published in the original study for 38% of the coded stimuli in the PUMS database.

Length of the Sample

The length of the stimulus was noted when it was available. If a range of durations was given, the range of durations and the mean duration for that particular passage was identified. In cases where the average duration of all stimuli was provided, but not the duration of the individual stimuli, the average duration was recorded as the length for each stimulus. The lengths of the musical stimuli were available in the original study in 38% of stimuli in the PUMS database.

Excerpt or Full Work

Depending on the study in question, a musical stimulus could be either an excerpt from a musical work or a complete work. When the researcher included this information in the original study, each stimulus in the PUMS database was labeled explicitly as an excerpt or full work. A full work was defined as a complete movement; for example, Mozart's *Symphony No. 40, Mvt. I* was considered a full work if the entire movement was performed. The designation of *excerpt* or *full work* was published in the original study for 88% of the PUMS database stimuli.

Induced/Perceived Emotion

One of the most common distinctions made in the music and emotion literature is the difference between how music *expresses* emotion (also: conveyed emotion, perceived emotion) and how music *induces* emotion (also: experienced emotion, felt emotion, evoked emotion) in listeners (Juslin & Sloboda, 2011). Literature on the way music conveys emotion, or how people perceive emotions in music, is often focused on the structural aspects of the composition (Hannon & Trehub, 2005; Hevner, 1935; Huron, 2008; Juslin & Laukka, 2003; Juslin, 2013a; Schubert, 2004; Sloboda & Lehmann, 2001). For example, if a passage of music emulates the sounds of humans crying (e.g., wails, breaking voice), it might be perceived as expressing sadness. When listening to this "sad" musical passage, however, it may induce either positive or negative feelings. A person's experienced emotions when listening to music are thought to arise through various processes (e.g., brain stem reflexes, rhythmic entrainment, associations with memory, and musical expectation) and often depend on demographic characteristics (e.g., age, sex), personality characteristics (e.g., Openness and trait empathy), and listening conditions (e.g., listening alone versus in a group) (Demos et al., 2012; Huron, 2006; Juslin, 2013b; Kövecses, 2000; Meyer, 1956). Therefore, studies of *perceived* emotion and *induced* emotion tend to rely on different conceptual theories and often employ different methodological designs.

When possible, the designation of each stimulus as belonging to a study of perceived emotion or induced emotion was chronicled. In addition to the description of the study aims and methodology, the exact wordings of participant instructions were examined in order to determine the locus to which the study referred. Options were given for *induced*, *perceived*, and *both*. The designation of *induced*, *perceived*, or *both* was published in the original study for 84% of the PUMS database stimuli.

Type (Style) of Music

The type of the musical stimulus was also notated. The wording of the experimenters was retained when possible, although some of the style information was summarized. For example, the label *Western Art Music* was used to describe multiple subclasses of Western Art Music, such as *Classical* and *Baroque* music. These broader classifications of style were designated and corroborated by music experts. These style designations might not be best characterized as musical genres. Future research may wish to reclassify these style designations using the clusters proposed by Pasi Saari and Tuomas Eerola (Saari & Eerola, 2014; Saari, Eerola, Fazekas, & Sandler, 2013). Additional information about the style of musical passages is also provided in the PUMS database when possible, such as the type of instrument used in the musical recording. Information about the type or style of the musical stimuli were available in the original study in 72% of stimuli in the PUMS database.

Information about the Stimuli

The composer, name, performer, track number, and measure numbers (or duration markings) of the work were identified when this information was listed in the original papers. Information about the composer of the musical stimulus was published in the original study for 17% of stimuli in the PUMS database, the specific stimulus name was published for 19% of stimuli in the PUMS database, the track number or other metadata was published for 44% of stimuli in the PUMS database, and the specific duration markings or measure numbers of the musical stimulus as published for 26% of stimuli in the PUMS database.

Selection Method & Emotional Terminology Operationalization

The methods that the researchers used in order to find their emotional stimuli were noted whenever possible. Five broad categories were denoted: *experimenter/expert chosen*, *previous studies*, *professionals asked to play/express emotions*, *pilot tested*, and *composed for study*. The exact process of how the researchers chose the stimuli is also included in the PUMS database when possible, such as the following description: “Experimenter/expert chosen: the happy music featured fast tempo, high sound level, and major mode, while the sad music featured slow tempo, low sound level, and minor mode.” In the case of *previous studies*, the study from which the stimulus was taken was identified when possible. Information regarding the selection method of the musical stimulus was available in the original study in 97% of stimuli in the PUMS database.

Date of Study

The year the study was published was denoted so that researchers can examine trends over time.

Familiarity of Participants

Musical emotion studies may differ in methodology if a participant is explicitly familiar or unfamiliar with the stimuli. For example, although chills have been successfully induced by unfamiliar music (Bannister & Eerola, 2018), participants may be comparatively more likely to experience chills when they are familiar with a musical passage (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009). However, if one wishes to minimize potential confounds, like episodic memory, it may be better to rely on unfamiliar stimuli (Gosselin, Peretz, Noulhiane, Hasboun, Beckett, Baulac, & Samson, 2005). When the familiarity of participants with the musical stimuli was explicitly stated in the original paper, the PUMS database includes markings of *unfamiliar*, *familiar*, or *both* (which indicates mixed familiarity among participants). The familiarity of participants with the musical stimuli were available in the original study in 21% of stimuli in the PUMS database.

CONCLUSIONS

This paper introduced a new corpus of Previously-Used Musical Stimuli (PUMS), which summarizes the selection of musical stimuli in over three hundred studies of perceived and evoked emotion. In 2016, Wilkinson and colleagues established several FAIR Data Principles (Wilkinson et al., 2016). The PUMS database corresponds to these principles in the following ways: the corpus is *Findable* (it has a DOI: <https://doi.org/10.17605/OSF.IO/YB2QD>), *Accessible* (it can be accessed online at <https://osf.io/p4ta9>), *Interoperable* (the vocabularies used in the PUMS database follow standard music and emotion studies and contain references to the original papers from which the stimuli come), and *Reusable* (they are described with accurate and relevant attributes).

The musical stimuli represented in the database exhibit a wide range of characteristics, such as passages ranging from two seconds to 45 minutes, passages ranging from heavy metal music to folk music to psychedelic trance music, and from piano music to music synthesized by computers. Stimuli in the PUMS include music composed by J.S. Bach, Fiona Apple, Ella Fitzgerald, and Taylor Swift and include emotions such as *fear*, *joy*, and *tenderness*. Some passages have been composed by music experts in order to portray specific affective states, while others were explicitly chosen by participants because they are able to induce an emotion in listeners. The PUMS database allows scholars to easily sort through thousands of musical stimuli in order to find passages that are optimized for the specific methodological considerations of their research. Furthermore, the PUMS database provides a way to critically examine the stimuli used by other researchers. Finally, the PUMS database allows researchers to identify trends in the musical stimuli used in psychological research across a period of 90 years. A complete review of the stimuli in the PUMS database has recently been published (Warrenburg, 2020).

The intention of this paper was to provide readers with some idea about which stimuli might be used in order to study music and emotion. The hope is that readers will use the PUMS when beginning a new experiment or when examining emotional trends over time. As can be seen with the corpus, research on emotion is flourishing!

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OPEN PRACTICES STATEMENT

The PUMS database is available as an online supplementary file at <https://osf.io/p4ta9>.

NOTES

[1] Correspondence can be addressed to: lindsay.a.warrenburg@gmail.com

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