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Abstract

The present study examined the link between affect and auditory stimuli in three parts. The first sought to determine the affective norms for the auditory stimuli. The second assessed the influence of a musical note's register on the evaluation of a positive or negative word, while the third assessed the influence of harmonic musical intervals. Participants were simultaneously presented with auditory stimuli and a word, and their task was to judge as quickly as possible whether the word was positive or negative by pressing a corresponding key. It was hypothesized that congruence between auditory valence and word valence would facilitate quicker response times, while incongruence would inhibit response times. The results supported the hypothesis. The current findings have implications for the relationship between affective metaphor and verticality in terms of musical register, the affective characteristics of consonance and dissonance, and the ability of specific musical elements to influence perceptual judgments across modalities.

The Influence of Auditory Stimuli on Judgments of Word Valence

Musicians, composers, and music enthusiasts have long known that music has the ability to communicate and evoke affect in listeners. Research has demonstrated this influence of music on affect through self-reported changes in mood and emotion (Kenealy, 1988; Sloboda, 1999; Sloboda, O'Neill, & Ivaldi, 2001). Several studies measuring physiological change have also shown the affective response to music. Krumhansl (1997) reported that participants listening to musical excerpts indicated changes in emotion through self-report and physiological data on a second by second basis. The physiological measures revealed significant emotion-specific affective effects of music compared to the pre-music interval, such that sad excerpts brought about the largest changes in heart rate, blood pressure, skin conductance, and temperature, while happy excerpts brought about the largest changes in measures of respiration. Blood, Zatorre, Bermudez, and Evans (1999) used positron emission tomography to examine changes in cerebral blood flow due to affective responses to music. Musical excerpts varied systematically in their degree of consonance and dissonance, and the PET scans indicated several paralimbic and neocortical regions that are involved in affective processing correlated differently with increasing dissonance or consonance and participants' perception of pleasantness or unpleasantness. In a functional magnetic resonance imaging study examining affective mood states induced by classical music, the blood oxygenation level dependent (BOLD) signal contrast was measured, and mood state specific increases in BOLD signal contrast implicated the involvement of the ventral and dorsal striatum, the anterior cingulate, and medial temporal areas in a musical emotion processing network (Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007).

Given music's ability to communicate and evoke affect, it has been used as an effective method of inducing mood in research settings. Bouhuys, Bloem, and Groothius (1995) had participants listen to either depressing or elating music before judging the emotional expression of several faces. They found that participants in a mood state induced by the depressing music perceived more sadness and rejection in ambiguous faces and less happiness and invitation in faces that were clearer in a particular emotional expression. Niedenthal, Halberstadt, and Setterlund (1997) used classical music to induce happy and sad emotional states in order to examine the effect of emotional state on a lexical decision task. They found that induced emotional state of the participant facilitated the response to words that were categorically related to their happy or sad emotion. For an extensive review of the music mood induction procedure, see Västfjäll (2001).

Research has indicated that both the ability to perceive emotion in music and the association between specific musical characteristics and affect are evident from an early age. Four-year-olds have demonstrated their ability to correctly discern happy, sad, angry, and fearful emotions from sung melodies (Dolgin & Adelson, 1990). Adachi and Trehub (1998) noted that when children were asked to sing a song in order to make an adult happy or sad they sang happy songs louder, faster, and at a higher pitch than sad songs. Infants have also demonstrated an ability to discriminate between happy and sad music, as well as a preference for happy and consonant music. Trainor and Heinmeiller (1998) found that 6-month-old infants listened longer to consonant intervals than dissonant intervals and that their preference for consonance was consistent in an actual musical context. In addition to findings that four-month-olds prefer consonant melodies over dissonant melodies, Zentner and Kagan (1998) observed different behavioral reactions to melodies evident through more fretting and more turning away from the source of the music during dissonant melodies and less fretting and more vocalizing during consonant melodies. Research by Schellenberg and Trehub (1998) suggests that preference for consonance over dissonance maybe be due to the mathematical frequency ratios between intervals. Intervals with simple frequency ratios are consonant, while complex frequency ratios produce dissonant intervals. Infants showed a greater ability to detect subtle changes in harmonic intervals and melodic interval patterns when intervals were related by simple frequency ratios rather than complex frequency ratios.

In studies using cross-modal methods of examining affective characteristics in music, Kastner and Crowder (1990) showed that 3-year-olds were able to match positive and negative faces to melodies accompanied by either a major or minor chord. Phillips, Wagner, Fells, and Lynch (1990) found that 7-month-old infants preferred looking at a happy face when an ascending melodic sequence was played and a sad face when a descending melodic sequence was played, which suggested there is an association between register and affect. Nawrot (2003) played infants ranging in age from 5- to 9-months a piece of happy and sad music and found that they preferred to look at an affectively congruent happy dynamic facial display. This research using infants and young children suggests that humans have an inborn ability to not only perceive emotion in music but also associate elements like register, consonance, and dissonance with affect. Music and musical elements' ability to influence perceptual judgments in the visual modality is also demonstrated in these studies.

While music contains many different elements and characteristics associated with affect, such as pitch, tempo, mode, melody, harmony, etc., the register of a single note and the harmonic quality of a musical interval will be the focus of this paper. The register of a single note can be defined as its relative height, where a high (low) register would produce a high (low) note. A musical interval can be defined as the distance between any two notes, either played successively (melodically) or simultaneously (harmonically), and for the purpose of this paper, the distance between two notes will be limited to no greater than an octave. This limitation produces twelve unique harmonic intervals that vary in their amount of consonance and dissonance and are essential musical materials in traditional Western classical music.

A growing body of research supports the notion that note register and interval quality have affective properties, which are able to exert influence across modalities. Building on research that supports associations between affect and perception (Lakoff & Johnson, 1999; Meier & Robinson, 2005), particularly verticality (Meier & Robinson, 2004; Melara & O'Brien, 1987), Weger, Meier, Robinson, and Inhoff (2007) examined the cross-modal affective influence of a word evaluation task on subsequent judgments of a high and low pitched tone. Participants verbally evaluated a positive, negative, or neutral prime word as "good," "bad," or "neutral" before determining whether a tone played through their headphones was either "Tone A" (high tone) or "Tone B" (low tone). The results and signal detection analyses demonstrated that positive word primes facilitated the judgment of the high tone, negative word primes facilitated the judgment of the low tone, and the facilitatory effect of the primes was due to their induction of a response bias rather than an influence on tone perception. These results suggest that the affective connotations of high and low registers could communicate affect similar to the way in which colloquial vertical metaphors communicate affect, where up is associated with positivity and down with negativity (e.g., "things are looking up" or "I am down in the dumps"). This research also demonstrates the ability for stimuli in the visual modality to bias perceptual judgments in the auditory modality.

In a study examining the affective characteristics of the twelve harmonic intervals evaluated on semantic scales, Costa, Ricci Bitti, and Bonfiglioli (2000) also explored the impact of register on interval affect and found that register had a significant influence on affective judgment. Intervals in the low register were judged more negatively emotionally than intervals in the high register, which were judged more neutrally emotionally than they were positively. These results are consistent with research in the affective metaphor and verticality literature. Also consistent with previous research examining the affective characteristics of consonance and dissonance, dissonant intervals were judged as more negative, tense, and unstable than consonant intervals (Costa, Ricci Bitti, & Bonfiglioli, 2000).

Research examining the affective priming of musical chords supports the association of consonance with positivity and dissonance with negativity. Sollberger, Reber, and Eckstein (2003) presented participants with either a consonant chord (comprised of an octave with its perfect fifth in between) or a dissonant chord (comprised of an octave with its augmented fourth in between) prior to evaluating a word's valence. The findings indicated that words were evaluated quicker when preceded by a chord that was congruent in valence, that is, the consonant chord facilitated positive words while the dissonant chord facilitated negative words. In the opposite direction of Weger, Meier, Robinson, and Inhoff (2007), these results revealed the ability of stimuli in the auditory modality to bias perceptual judgments in the visual modality. Multiple note chords are complex musical elements that depend up the register and intervallic interaction between notes in the chord. This necessitates the question of whether more simple musical elements with affective properties can bias perceptual judgments across modalities.

Given prior studies' findings regarding the valence of register, consonance, and dissonance, the present experiments sought to examine the affective characteristics of a single note's register and harmonic intervals' consonance and dissonance as well as their ability to bias cross-modal perceptual judgments. In Experiment 1, participants judged the valence of only the auditory stimuli in order to norm the sounds. It was hypothesized that low notes would be categorized as negative, while positive notes would be positive. It was also hypothesized that the following intervals would be categorized as consonant: major 2, major 3, perfect 4, perfect 5, major 6, and octave, and that the following intervals would be categorized as dissonant: minor 2, minor 3, augmented 4, minor 6, minor 7, and major 7.

In Experiment 2, participants were simultaneously presented with a high or low note and a positive or negative word and asked to judge the valence of the word. Based on previous research regarding affective metaphor and perceptual judgments related to verticality, it was hypothesized that congruent pairings of register and word valence (high register, positive word; low register, negative word) would reveal facilitatory tendencies as measured by response latency, while incongruent pairings of register and word valence (high register, negative word; low register, positive word) would reveal inhibitory tendencies.

In Experiment 3, the same procedure was used except that the twelve harmonic intervals took the place of single notes. Consistent with research on the valence of consonance and dissonance, it was hypothesized that congruent pairings of interval and word valence (consonant interval, positive word; dissonant interval, negative word) would facilitate response latencies, while incongruent pairings (consonant interval, negative word; dissonant interval, positive word) would inhibit response latencies.

Experiment 1

Method

Participants

Ten undergraduate students from an Introduction to Psychology course participated in the experiment, and they received partial class credit for their participation.

Materials

Musical materials, notes. A total of thirty-six digital piano samples were used, each with a duration of 2.5 seconds. The thirty-six samples consisted of eighteen low samples, which corresponded to the chromatic notes from A1 to D3 (55 to 146 Hz), and eighteen high samples, which corresponded to the chromatic notes from A5 to D7 (880 to 2349 Hz).

Musical materials, intervals. Thirty-six digital piano samples were used, each with a duration of 2.5 seconds. The thirty-six samples consisted of three sets of twelve harmonic intervals, which were: minor second, major second, minor third, major third, perfect fourth, augmented fourth, perfect fifth, minor sixth, major sixth, minor seventh, major seventh, and octave. The intervals were constructed by choosing G3, C4, and F4 as root notes upon which chromatic notes were consecutively built to obtain all twelve intervals (e.g., C and Db, C and D, C and Eb). Three root notes were chosen in order to allow each interval to be presented in a variety of tonal contexts. The total range of notes was between 196 and 698 Hz, and this middle register of the piano was used so as to eliminate any potential affective confounds due to register.

Procedure

Participants signed informed consent documents and were then seated at a computer and given headphones. The experimenter explained the instructions to the participants in addition to letting them read the instructions appearing on the screen. The instructions informed the participants that he or she would be presented with an audio file played through their headphones. The participants were told their task was to judge whether the sound had a positive or negative meaning by pressing either the ‘p’ or ‘n’ key. In between each presentation of a sound, a cue (+) appeared for a randomized variable amount of time (500ms, 800ms, or 1000ms). This was done to eliminate the potential monotony of constant auditory stimuli and to break up any type of answering rhythm. The experiment was broken up into two sections, the first presenting tones, the second presenting intervals, and there was a small rest period between sections. Each tone and interval was presented twice.

Results and Discussion

Overall, participants were more willing to respond positively in both sections of the experiment. For each participant, the percentage that they responded congruently with the predicted valence of the sound was calculated and subjected to a paired samples t-test. In the first section that presented tones, participants agreed that high tones were positive 77% of the time and low tones were negative 66% of the time, $t(9) = 2.26$, $p < .05$. In the second section that presented intervals, participants agreed that the intervals predicted as positive were positive 70% of the time and the intervals predicted as negative were negative 58% of the time, $t(9) = 2.26$, $p < .05$.

Experiment 2

Method

Participants

Thirty-seven undergraduate students (19 males, 18 females) from an Introduction to Psychology course participated in the experiment, and they received partial class credit for their participation.

Materials

Positive and negative words. Seventy-two words were used, with thirty-six of them having a positive meaning (e.g., *laughter*) and the other thirty-six having a negative meaning (e.g., *depression*). The words were taken from the normed list of Bradley and Lang (1999), and the words were balanced in terms of valence (M = 5.00; SD = 2.59), arousal (M = 5.34; SD = 0.97), frequency in the English language (M = 41; SD = 59.17), and word length (M = 6.59, SD = 1.93).

Musical materials. The same piano note samples that were used in Experiment 1 were used in Experiment 2.

Procedure

Experiment 2 was arranged in much the same fashion as Experiment 1, except that a word appeared on the screen at the same time the audio file was played through the heaphones. The instructions informed the participants that he or she would be presented with a word on the screen at the same time an audio file was played through the headphones. The participants were told their task was to judge as quickly as possible whether the word had a positive or negative meaning by pressing either the ‘p’ or ‘n’ key. The word appeared on a white background in size 18 Courier New font. In between each presentation of a word, a cue (+) appeared for a randomized variable amount of time (500ms, 800ms, or 1000ms). This was done to eliminate the potential monotony of constant auditory stimuli and to break up any type of answering rhythm. Each tone was presented twice, while each word appeared only once.

Results and Discussion

Data for one participant were excluded because the notes were judged instead of the words. Two response latencies that were less than 200 ms were excluded for being anticipatory.

Fifty response latencies greater than 3 standard deviations (about 2000 ms) from the mean were excluded to minimize the effects of outlier responses. Incorrect answers were also removed from the data. Participants averaged a word evaluation accuracy rate of 92%.

The median reaction for correct response was calculated for each participant, and these medians were subjected to a paired samples t-test. Congruent pairings of note register and word valence (high register, positive word; low register, negative word) facilitated quicker evaluations (M = 708 ms) than did incongruent pairings of note register and word valence (high register, negative word; low register, positive word) (M = 741 ms), $t(35) = 2.67$, $p < .05$.

Experiment 3

Method

Participants

Thirty-seven undergraduate students (19 males, 18 females) from an Introduction to Psychology course participated in the experiment, and they received partial class credit for their participation.

Materials

Positive and negative words. Seventy-two words, different from those in Experiment 1, were used. Thirty-six of them had a positive meaning (e.g., laughter) and the other thirty-six had a negative meaning (e.g., depression). The words were taken from the normed list of Bradley and Lang (1999), and the words were balanced in terms of valence (M = 5.00; SD = 2.59), arousal (M = 5.34; SD = 0.97), frequency in the English language (M = 41; SD = 59.17), and word length (M = 6.59, SD = 1.93).

Musical materials. The same piano interval samples that were used in Experiment 1 were used in Experiment 3.

Procedure

Experiment 3 was organized exactly the same as the second, except that the words and sounds were different. Each interval was presented twice, while each word appeared only once. After completion of the experiment, participants filled out a brief questionnaire and were debriefed.

Results and Discussion

Fifty-two response latencies greater than 3 standard deviations (about 1875 ms) from the mean were excluded to minimize the effects of outlier responses. Incorrect responses were also excluded from the data. Participants averaged a word evaluation accuracy rate of 93%.

The median reaction for correct responses was calculated for each participant, and these medians were subjected to a paired samples t-test. Congruent pairings of consonant and dissonance intervals and word valence (consonant interval, positive word; dissonant interval, negative word) facilitated quicker evaluations (M = 685 ms) than did incongruent pairings (consonant interval, negative word; dissonant interval, positive word) (M = 705 ms), $t(36) = 2.16$, $p < .05$.

General Discussion

Participants' responses in Experiment 1 indicate that the valence of the sounds was congruent with their predicted valence on a statistically significant level. As predicted in Experiment 2, congruent pairings of register and word valence (high register, positive word; low register, negative word) exhibited statistically significant facilitatory tendencies on response latencies for judgments of word valence, as compared to incongruent pairings. Similar statistically significant results were observed in Experiment 3. Response latencies were facilitated for congruent pairings of interval and word valence (consonant interval, positive word; dissonant interval, negative word) compared to incongruent pairings. The results of this research are consistent with previous findings regarding the affective characteristics of register (Weger, Meier, Robinson, & Inhoff, 2007; Costa, Ricci Bitti, & Bonfiglioli, 2000), consonance and dissonance (Costa, Ricci Bitti, & Bonfiglioli, 2000; Sollberger, Reber, & Eckstein, 2003), and the ability for affective characteristics of stimuli in the auditory modality to affect stimuli in a non-auditory modality (Sollberger, Reber, & Eckstein, 2003). The success of the cross-modal nature of these experiments suggests that specific musical elements such as register, consonance, and dissonance can carry affective connotations that affect other sensory modalities.

There are several possible explanations for why these particular results were observed. One potential explanation is that, given the age of participants, the affective characteristics of register, consonance, and dissonance have been learned and culturally established as positive or negative. Participants may have been susceptible to demand characteristics, and therefore answered according to how they thought they should answer based on culturally learned associations. Participants were encouraged both verbally and in the instructions to judge the word as quickly as possible, thus stressing instinctual reactions and reducing the possibility of demand characteristics. Given the generally quick response latencies, randomization of sound and word valence, and significant differences between congruent and incongruent pairings, demand characteristics are a less likely explanation.

It is possible that musical elements like register, consonance, and dissonance have inherent affective connotations that activate valence related cognitive networks. Therefore, when participants were presented with affectively congruent sounds and words, response latencies were facilitated because the same valence related cognitive network was simultaneously activated auditorially and visually, and participants were biased to respond in a specific valence direction automatically. Response latencies of incongruent pairings of sounds and words would then be inhibited because participants would have to switch cognitive networks and change their response bias in order to correctly judge the word. Prior research has demonstrated this cross-modal response bias using affective priming methods (Weger, Meier, Robinson, & Inhoff, 2007; Sollberger, Reber, & Eckstein, 2003), and while an interference based presentation method was utilized in the present study, it is not unrealistic to suggest the same mechanism can account for the observed results.

The limitations in this study provide several avenues for future research to explore. In Experiment 1, it may be possible that participants were able to connect the sequence of notes into a sort of melody. Research demonstrating the pleasing and positive qualities of consonant melodies over dissonant melodies (Zentner & Kagan, 1998; Trainor & Heinmeiller, 1998) would suggest that the perception of a pleasing or unpleasing melody between trials in the present study might interfere with word judgment. The randomized variable cue attempted to take this into account, but it also may be beneficial to slightly increase the amount of time between trials. Another solution to this problem would be of use in Experiment 3. The valence of musical intervals in a musical situation can be manipulated with context, so in order to study the valence of intervals alone, it is necessary to dissociate any previous interval context already established. One method ear-training educators use is to present a tone cluster of multiple notes in between presentations of a harmonic interval. This tone cluster serves to clear previous interval context and allow for the subsequent interval to be perceived as it is. Experiment 3 attempted to do something similar by having multiple interval root notes that would dissociate the previous interval's context. For both Experiment 2 and 3, presentation of a short tone cluster during the variable cue could eliminate melodic connection between notes and clear previous interval context. However, this tone cluster could also be perceived as very negative, so the combination of a tone cluster and increased time between trials would be most effective.

The present research drew from the literature pertaining to affective metaphor and verticality, the affective characteristics of consonance and dissonance, and the cross-modal affects of auditory stimuli. Hypotheses were grounded in previous findings, and we sought to examine the ability of specific musical elements with affective connotations to affect perceptual judgments in another modality. These results have implications not only for how music communicates emotions but also for how music can evoke and change emotions in the listener. An appropriate piece of music can change the way we perceive stimuli in our environment across modalities.

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