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The Influence of Mode and Musical Experience on the Attribution of Emotions to Melodic Sequences

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The connection between emotion and music runs deep, and despite a growing body of research, the influence of musical structure on emotion perception is only partially understood. The present study examined the relationship between mode and emotion attribution, as well as how musical experience influences emotion perception. Thirty-four participants listened to sequences of musical scales and melodies consisting of randomized sequences of notes in each of the seven diatonic modes and the major–minor scale, and rated the emotional content of the stimuli using a diagram of Plutchik's circumplex model of emotions (adapted from Plutchik, 2003). The attribution of emotion differed across the modes and generally conformed to historical descriptions of emotional connotations of the mode: Ionian was most often associated with ecstasy, joy, and serenity; Dorian with vigilance, anticipation, and interest; Phrygian with terror, fear, and apprehension. Emotional ratings were consistent across subjects with varying degrees of musical experience (as determined by the Goldsmith's Musical Sophistication Index); however, less experienced participants showed more variability in their selection of emotions conveyed by the modes. The results of the present study indicate that the simple distinction between common practice major and minor modality likely does not fully account for the way pitches convey emotion. Future consideration of the modes of the diatonic scale and the intervals between tonic and each scale degree might lead to a more nuanced and complete understanding of how emotions are conveyed by music.

Keywords: musical structure, musical training, emotion

The power of music to elicit emotion is intuitively understood. As Robert G. Ingersoll noted "Music expresses feeling and thought, without language. It was below and before speech, and it is above and beyond all words." (1891). The connection between emotion and music is deep, and scholars have long sought to explain the connection between melody, harmony, and emotion. One question of particular interest is how melodic structure itself conveys emotion. Despite a growing body of research on the influence of musical structure on emotion perception, the way in which specific combinations of notes communicate specific emotions is only partially understood (Costa, Fine, & Ricci Bitti, 2004; Gabrielsson & Lindström, 2010; Sloboda & Juslin, 2001). Furthermore, theories of musically induced emotions suggest that previous experience shapes our emotional reactions to music in several ways (Juslin, Liljeström, Västfjäll, & Lundqvist, 2010), which is supported by preliminary findings that specific note combinations may communicate different meanings to individuals who have received formal training in music theory or have a high degree of musical experience (Collier & Hubbard, 2001a). The present research seeks to address the issue of whether the diatonic modes convey specific emotions, and whether musical training influences perception of emotion in the diatonic modes.

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In attempting to describe the relationship between musical structure and perception of emotion, researchers have identified multiple contributing factors including mode, tempo, consonance, rhythm, harmony, and pitch register. The Modified Lens Model of communication in musical performance (Juslin & Timmers, 2010) posits that acoustic cues communicate emotion in a probabilistic fashion. For example, a fast tempo may be indicative of happiness or anger, depending on other factors, and therefore happiness is communicated through a combination of multiple acoustic cues. Below we briefly review the acoustic cues that have been proposed to be important for conveying emotions.

Temporal factors such as tempo, rhythm, and melodic contour have been shown to have a differential effect on perceived emotion. Tempo has been shown to have a large impact on perceived emotion (for a review see Gabrielsson & Lindström, 2010). Whereas some studies have found that tempo may exert a slightly bigger influence on emotion than mode (Gagnon & Peretz, 2003), other studies have found that the two are equally powerful overall (Juslin & Lindström, 2010). Lindström (2006) utilized computer-generated variations on the melody Frère Jacques where the rhythm, melodic contour, and direction were altered. Accent structure and rhythm were significant predictors of emotion, whereas there was little or no contribution by melodic direction and contour. Similarly, reversing ascending versus descending melody had a minimal effect on emotion (Hevner, 1936), while others (Collier & Hubbard, 2001a) find that pitch height and direction are important for expression of happiness.

Harmony is also known to be an important factor in emotional expression. Lindström (2006) found that harmonic progression was a significant predictor of perceived emotion. Simple, consonant harmonies may be associated with expressions like happy, relaxed, graceful, serene, dreamy, dignified, serious, and majestic whereas complex dissonant harmonies may be associated with excitement, tension, vigor, anger, sadness, and unpleasantness (Gabrielsson & Lindström, 2010). Crowder (1984) found that major triads were perceived as happier than minor triads. Kastner and Crowder (1990) found that harmonic accompaniment diminished the perceived happiness and sadness of common practice major and minor melodies, respectively.

Register and Interval Size are two additional contributors to musical emotion. Collier and Hubbard (2001a, b) found that higher pitch tones are rated as happier, brighter, and faster, and as speeding up more than tones at a lower pitch. Huron (2008), in a sample of 9788 instrumental themes, found that themes in minor keys were slightly lower in pitch and had slightly smaller interval size. Scherer (1995) showed that smaller interval sizes in speech and music corresponded with decreased affect and arousal whereas larger intervals conveyed heightened arousal and affect. Huron and Davis (2012) showed that the most effective means of lowering average pitch height of major melodies was to lower the third and sixth scale degrees (resulting in the natural minor). Thus, lower pitch and smaller intervals tend to connote decreased affect in speech and music and the present research promises to expand on this notion.

The modality of a piece has long been identified as a crucial element in musical–emotional communication (e.g., Gabrielsson & Lindström, 2010; Heinlein, 1928; Hevner, 1935; Powers, 2013). Hevner (1936, 1937) found that mode (common practice major or minor) and tempo had the largest effects on emotion, followed by pitch, rhythm, harmony, and melody. Major and minor modes induce distinct positive and negative emotional valences, respectively (Crowder, 1984). In investigations of melody, the major–minor distinction has been shown to be a relatively good predictor of happiness and sadness (Dalla Bella et al., 2001; Gerardi & Gerken, 1995; Gregory, Worrall, & Sarge, 1996; Kastner & Crowder, 1990). Costa, Fine, and Ricci Bitti (2004) looked at interval distribution, mode, and tonal strength of melodies as predictors of perceived emotion in 51 musical excerpts. Regression analyses showed that mode was the only significant predictor of valence. Similarly, in Lindström's (2006) Frère Jacques variations, mode predicted emotion. Scherer and Oshinsky (1977) found that mode was significantly more indicative of pleasantness and happiness than the minor mode, which favored impressions of disgust and anger.

In sum, many factors have been shown to influence emotional expression in musical excerpts and melodies including accent patterns, rhythmic patterns, order of intervals (Costa, Fine, & Ricci Bitti, 2004), meter, note density, pitch range, and melodic contour (Schellenberg, Krysciak, & Campbell, 2000), and among these mode is particularly salient. It should be noted that in all these studies, the term mode was used to distinguish between those musical samples in major key and those in natural, harmonic, or melodic minor keys.

In addition to the body of empirical research on modality, there is a long tradition in music composition, theory, and scholarship of conceptualizing musical structure in modal terms. The modern diatonic modes refer to a set of scales based on the diatonic scale in which the tonic has a set position. For example, if all the white notes on a piano are taken as scale degrees, and D is set as the tonic, the Dorian mode is formed. Any musical scale with the same set of whole and half steps between scale degrees would also be Dorian. Again using only white notes, the modes in order are Ionian (tonic C), Dorian, Phrygian, Lydian, Mixolydian, Aeolian, and Locrian.

The 16th century Swiss music theorist Heinrich Glarean is credited with providing the definitions of the diatonic modes as we use them today (Glareanus, 1547). However, the term mode has been used for thousands of years in discussions of musical structure and affect (see Powers, 2013, for a more comprehensive discussion). The Greek names ascribed to the modes appear in the writings of Aristotle and Plato, who used them to refer to musical styles (including specific instrument tunings, pitches, and rhythms) that were similar in affect to the tribes they were named after (Aristotle, 1919; Plato, 1941). For example, Aristotle stated that "Doric music is most serious, and fittest to inspire courage" as would befit the warlike Dorians (Aristotle, 1919, Politics, Book VIII, Ch. VII). During the middle ages, these Greek terms were used to categorize and compose liturgical chant melodies into eight categories, each of which had a certain *ethos*, and these are now referred to as the church modes (Powers, 2013). This medieval modal approach to composition was the dominant trend into the 1500s (Powers, 2013), and can be seen as framework from which modern tonality and harmonic progressions arose. Baroque music theorists in the 17th and 18th centuries went to great lengths to identify specific emotions that could be conveyed by specific scales and rhythms in melodies. A composer would use these musical devices as musical rhetoric to convey his or her intended emotion (Bartlett, 1996). In modern terminology, the term mode is used to refer to a collection of degrees of a scale, related to a single chief degree (Powers, 2001).

Although the majority of common practice music does not use modal composition, modal approaches to composition are often found in rock and popular music (Everett, 2004; Moore, 2001), various cultural music traditions, and in some contemporary music (Balkwill, Thompson, & Matsunaga, 2004; Danielou, 1968). Common-practice music typically uses the major scale (equivalent to Ionian), and the harmonic, melodic, and natural minor scales (natural minor is equivalent to Aeolian). In rock music, Ionian, Mixolydian, Dorian (e.g., Led Zeppelin's "The Battle of Evermore"), and Aeolian are particularly prevalent (Everett, 2004; Moore, 2001), and Phrygian is used in heavy music (Biamonte, 2010; Walser, 1993). Although Locrian is inherently unstable owing to its diminished tonic triad and therefore is not used as the basis of modal compositions and did not exist historically, it is included in the present study as a means of comparing the effect of overall interval size on the perception of melodic emotion. In sum, the diatonic modes have been a central concept in music structure and emotion for several hundred years, yet there is a paucity of research regarding the manner in which listeners attribute emotion to the modes themselves.

Various methods have been used to quantify the emotions expressed in musical stimuli. Many studies of music and emotion have used a two-dimensional model of emotion quantifying both valence and arousal (Bigand et al., 2005; Dibben, 2004; Gomez & Danuser, 2004; Gorn, Pham, & Sin, 2001; Grewe, Nagel, Kopiez, & Altenmüller, 2007; Witvliet & Vrana, 2007) or terms derived from basic emotion theory (Baumgartner, Esslen, & Jäncke, 2006;

Etzel, Johnsen, Dickerson, Tranel, & Adolphs, 2006; Kallinen, 2005; Krumhansl, 1997). To gain descriptive power, some studies have sought to identify the emotions associated with musical stimuli by asking subjects to provide verbal descriptions and using factor analysis techniques (Zentner & Eerola, 2010; Zentner, Grandjean, & Scherer, 2008). However, the complexity of the factor analysis technique would be difficult to use in an examination of each of the eight diatonic modes.

In the present study, participants were asked to categorize emotions using a circumplex model of emotions (Plutchik & Conte, 1997; Plutchik, 2003). This model was chosen because, with its intuitive visual layout, it has the effectiveness of basic emotion theory models. The model classifies emotions into eight basic oppositional emotions or valences (Joy, Sadness, Trust, Disgust, Fear, Anger, Surprise, Anticipation). Each valence has three levels of intensity, with the basic emotion in the center (high, medium, low; e.g., Joy—Ecstasy, Joy, Serenity), yielding a total of 24 emotions. The large number of emotions in this model (24, Figure 2) maintains some of the flexibility of free response approaches, and makes it well suited for a study of the modes because it is unclear whether specific modes convey specific emotion.

Musical experience may be a mediating factor in the perception of melodic emotion. Musicians and nonexpert music listeners may share a common understanding of the emotional connotations of acoustic cues (Juslin & Laukka, 2003; Kendall & Carterette, 1990; Seashore, 1923), so they may perceive the emotional connotations of note combinations in similar ways. There is some previous work that has validated this view (e.g., Bigand et al., 2005) when musical excerpts in common practice major and minor were used.

From another perspective, music theory classes often include ear training to help students identify melodic pitches as scale degrees or solfège syllables (e.g., do-remi), and this type of training may influence listeners to encode melodies as scale degrees rather than consecutive intervals of various sizes (Dowling, 1986). Furthermore, performers learn to manipulate pitch and other acoustic cues such as intensity, attack, and tempo to convey emotion (Juslin & Timmers, 2010), and models of emotion induction have suggested that music induced emotions are partially dependent on previous musical experiences (Juslin, Liljeström, Västfjäll, & Lundqvist, 2010). Although previous research suggests that musicians and nonmusicians typically do not differ in their emotional ratings of music (Bigand et al., 2005; Juslin & Laukka, 2003; Kendall & Carterette, 1990; Seashore, 1923), it is possible that in the present study where mode is the only manipulated factor influencing musical emotion in tone sequences, musical experience does cause individuals to perceive emotion differently.

Two studies to date have examined the emotional content of the diatonic modes. Ramos, Bueno, and Bigand (2011) had participants categorize melodies in each of the seven diatonic modes into four emotion categories: “Happiness,” “Sadness,” “Fear/Anger,” or “Serenity.” The melodies were presented at different tempos, and the authors found that in addition to increased valence with increased tempo, larger overall interval size corresponded to increased valence in a linear fashion. The exception to this trend was that Lydian was lower in valence than Ionian and thus did not differ significantly from Mixolydian, which has slightly smaller overall interval size.

Temperly and Tan (2013) composed six melodies, which were transposed into six of the seven diatonic modes (Locrian was excluded owing to its inherent instability). Participants heard pairs of melodies and were asked to judge which melody sounded happier. The authors found significant differences between all modes except Aeolian and Dorian and with the exception of Lydian, found a linear relationship between average interval size and happiness. The authors suggest that because Ionian is the most familiar of the modes, it is perceived as happiest and that, with some caveats, as familiarity decreases so does perceived happiness.

Although both of these studies offer insight into the affective quality of the diatonic modes, they do not indicate, in the manner of many music scholars throughout history, whether certain modes are clearly associated with specific emotions. Furthermore, research has not addressed whether formal music training might influence the emotions listeners perceive in specific combinations of notes. The impetus of this study was to provide a more nuanced understanding of melodic emotion and the role of musical experience in its perception. It was hypothesized that certain modes would convey specific emotions, and that individuals with musical experience might ascribe different emotions to certain modes or perceive more intense emotions in basic melodic stimuli.

Method

Participants

Thirty-four normal hearing individuals participated in the study, 18 participants were female and 16 were male. All were undergraduate students enrolled in an introductory psychology course at St. Olaf College and received partial course credit for their participation. Participants ranged in age between 18 and 22 years of age (M = 19.54 years). Participants were not selected for participation based on musical ability but rather were given the opportunity to choose from among several research participation opportunities.

All participants were given a previously developed index of musical sophistication (Goldsmith’s Musical Sophistication Index [Gold-MSI]; Müllensiefen, Gingras, Stewart, & Musil, 2011) to assess their musical sophistication and experience. Scores on the Gold-MSI ranged from a low score of 187 to 490.5 out of a possible 500 points. Participants were divided into two groups by performing a median split of their Gold-MSI scores (MDN = 356.75), representing those with less musical experience and sophistication (less experienced; n = 17, M = 294.88) and those with more musical experience and sophistication (more experienced; n = 17, M = 424.21). A median score of 356 corresponds to the 44th percentile of scores from 147,663 participants as documented by Müllensiefen and colleagues (2011).

Participants in the less experienced group (6 male, 11 female, mean age 19.75 years), played 0.9 musical instruments on average, had an average of 4.53 years of formal musical training on their instrument, 0.8 years of formal training in music theory and reported playing their instrument for an average of 1 hr a day for 3.58 years at the peak of their musical experience. Overall, seven participants reported playing no musical instruments, five reported playing Piano, two reported singing, two played stringed instruments (violin), and one reported playing the bassoon.

Participants in the more experienced group (11 male, 6 female, mean age 19.35 years) played 3.9 musical instruments on average, had 10.6 years of formal musical training on their instrument, 1.85 years of formal training in music theory, and reported practicing their instrument for an average of 3 hr per day at the peak of their musical experience. In contrast to the less experienced group, zero participants reported playing no musical instruments, four reported playing Piano, five reported singing, four played wind instruments (trombone, saxophone, French horn, clarinet), five played stringed instruments (two violin, one cello, bass, and guitar) and one reported playing percussion.

It should be noted that the less experienced group had some degree of musical sophistication, whereas many studies investigating the effects of musical experience have compared expert musicians with individuals with no musical experience whatsoever (e.g., Bigand et al., 2005; Dowling, 1986). For the present investigation, the impetus was to examine whether the high degree of familiarity with musical scales and music theory in the more experienced group would affect perception of emotion in very basic melodic material, and our split reflected this familiarity.

Materials

Data were collected using a custom script for Psyscript 5.1d3 (Bates & D'Oliveiro, 2003) running on a Power Mac G4 computer (800 MHz, 256 MB Ram, OS 9.2.2) and a 15-inch NEC LCD monitor (800 × 600 resolution, 75 Hz refresh rate). Participants indicated their responses using a standard Macintosh keyboard and mouse. Stimuli were delivered via Beyer Dynamic DT-100 circumaural headphones at 60 dBA SPL as verified with a sound level meter. The Gold-MSI questionnaire was presented in Microsoft Excel, and participants indicated their responses in individual spreadsheets.

The musical stimuli used were pure tone sequences generated using a monophonic synthesizer in Reason by Propellerhead (Propellerhead Software AB). Two scales and nine melodies were created in each of the seven diatonic modes (Ionian, Dorian, Phrygian, Lydian, Mixolydian, Aeolian, and Locrian) as well as the major–minor scale (e.g., a major–minor scale with tonic of C would be C, D, E, F, G, Ab, and Bb). This yielded a total of 72 melodies (making chance 1 in 72 or 1.3%) and 16 scales (making chance 1 in 16 or 6.25%). In each mode, there were three ascending melodies, three descending melodies, and three centered melodies (see Figure 1). These three types of melodies were included because previous findings related to melodic direction and emotion have been mixed (see Gabrielsson & Lindström, 2010 for a review). All melodies were presented in a moderate register spanning the octave between middle c and c' (average 392 Hz). The melodies were presented at three pitch levels, with the tonic being on b, c, or c# for ascending, b', c', or c#' for descending, and f, f#, or g for stationary melodies. All notes were eighth notes and quarter notes (on the tonic of scale stimuli) presented at 108 beats per minute (moderato). Each stimulus was played twice with a 250-ms gap between both presentations.

Melodic scale degrees were played exhaustively in a predetermined random order (e.g., 1, 5, 6, 7, 2, 8, 4, 3). Thus, all participants heard the same melodies. To ensure that the modality of each melody was apparent to participants at all times, the tonic of the mode was presented before and after every scale degree. Although this produced melodies that were not particularly "musical," it served to identify the combined emotional connotation of all intervals contained within each mode. The melodies were balanced so that the average interval size in the first halves of all melodies was approximately equal to the average interval size in the second halves of all melodies in each mode. This was done because it is known that larger intervals are perceived as more powerful and excited than smaller ones (Thompson & Robatille, 1992). Ascending and descending scales were included because Collier and Hubbard found that ascending and descending scales were rated as more positive and negative, respectively (2001a). Scales were constructed such that the tonic was twice in duration (quarter note) to ensure clear modality and were presented at moderate tempo (108 bpm).

Nine randomized presentation orders of all 92 scales and melodies were preconstructed with the stipulation that one scale was presented after every four melodies (e.g., M, M, M, M, S, M, M, M, M, S). In this way, the presentation order of modes and melody type was randomized. Each participant was assigned to one of the nine presentation orders to prevent possible order effects where the affect of a melody might carry over into the perception of affect in the next melody. Given that scales were only presented once per subject in an ascending and descending direction, they were ex-

Figure 1. Notation of all melodies in Mixolydian mode. Repeat signs indicate that each melody was played twice when presented. Randomized presentation order included melodies from other modes.

cluded from the final analysis and only melodies were subjected to statistical analysis.

A clickable copy of Plutchik's circumplex model of emotions was displayed on-screen from which participants selected the best-fitting emotion for each scale or melody (adapted from Plutchik, 2003). The model classifies emotions into eight basic oppositional emotional valences (Joy, Sadness, Trust, Disgust, Fear, Anger, Surprise, Anticipation). Each valence has three levels of intensity, with the basic emotion in the center (high, medium, low; e.g., Joy–Ecstasy, Joy, Serenity), yielding a total of 24 emotions. Emotions falling between the bipolar sets (e.g., aggressiveness) were not given as possible selections to simplify the analysis. Additionally, participants were given the option to select neutral or no-emotion, and were given the option to replay each stimulus one time (see Figure 2).

The Gold-MSI is a 71-item questionnaire designed to quantify multiple aspects of musical experience. In addition to an overall score, subcategories of musical experience include Importance Ascribed to Music, Perception and Production, Musical Training, Emotional Involvement, Bodily Involvement, Creativity, and Openness to New Music. Sixty-three of the items asked participants to rate their agreement to statements on a 7-point likert scale. Examples of items include "Playing or listening to music is one of my favorite hobbies," and "When I listen to music, I have a hard time hearing whether one note is a different pitch to the next." The remaining items asked participants for information about formal music theory training, instruments played, and time spent listening to certain genres of music (classical, jazz, renaissance, or ethnic).

Design and Procedure

All participants followed a common procedure, which was approved by the Institutional Review Board at St. Olaf College. After indicating their informed consent in writing, participants were instructed to listen to each stimulus and select the emotion (from the on-screen representation of Plutchik's model) that most closely corresponded with the affect of each scale or melody, or Neutral if no particular emotion was perceived. Participants were told that if they had color associations with musical stimuli (synesthesia), they should ignore the colors of the on-screen model and instead select an emotion based purely on the meaning of the emotional terms. The participants were told that although some melodies may sound like random notes, they should do their best to identify the emotion that they conveyed. Participants were instructed that they could repeat each stimulus only once by using the "Repeat" button on the screen. After completing the listening portion of the experiment, participants completed the Gold-MSI questionnaire. Finally, participants were asked to provide their email address if they wished to receive follow up information on the findings and implications of the study. Participants were then debriefed and allowed to leave the lab.

After data collection was completed, the Gold-MSI scores and demographic information were compiled for each participant. Emotional ratings were imported into Excel from Psyscript and further analyzed. Individual emotional ratings were compiled for each melody and scale for each mode for each participant. These were analyzed at both the individual emotional level and at the

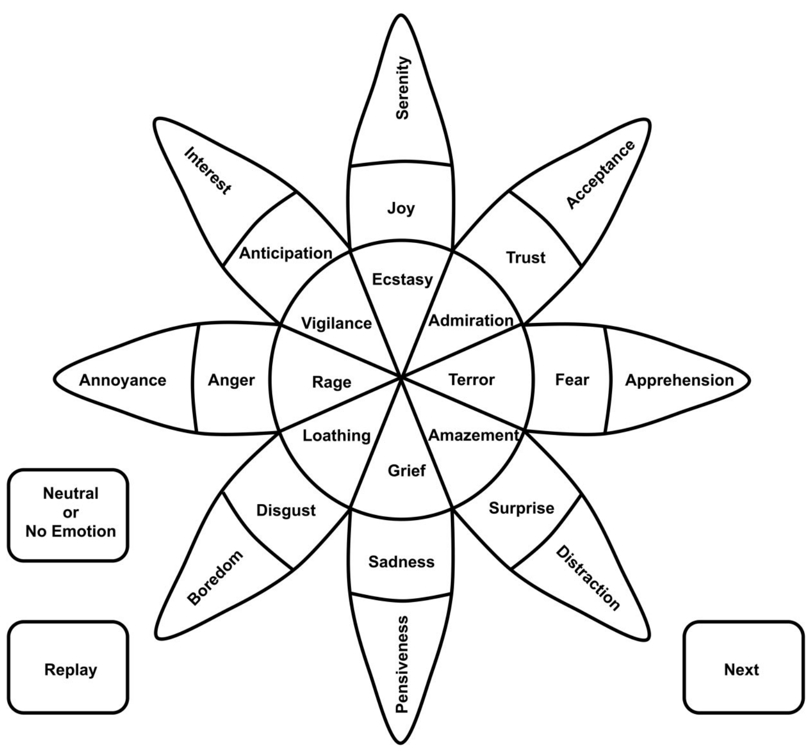

Figure 2. Example response screen used in the present experiment. Participants clicked on one of the predefined area of the screen corresponding to each emotion. Emotions were organized into eight primary valences (petal), each with three levels of intensity (from high to low, center to periphery). Adapted from Plutchik (2003). Copyright © 2003 by the American Psychological Association. Adapted with permission.

level of the bipolar emotional valence level at each intensity level (high, medium, or low). To aid in analysis, emotional ratings were summed for the following eight valences: Ecstasy, Joy, Serenity (EJS); Admiration, Trust, Acceptance (ATA); Terror, Fear, Apprehension (TFA); Amazement, Surprise, Distraction (ASD); Grief, Sadness, Pensiveness (GSP); Loathing, Disgust, Boredom (LDB); Rage, Anger, Annoyance (RAA); Vigilance, Anticipation, Interest (VAI).

All data analysis was conducted using SPSS. First, related-samples Friedman's two-way analysis of variance by ranks tests (the nonparametric within subjects equivalent of the repeated measures ANOVA) were conducted, one for each basic emotional valence, using Mode as the independent variable (eight levels) and frequency of selection as the dependent variable (e.g., individual responses of ecstasy, joy, or serenity each added one to the frequency count for the EJS valence). These nonparametric ANOVAs were used as a threshold test to determine whether the modes differed in the frequency with which a particular emotional valence was selected. If significant differences were observed, follow-up nonparametric Mann–Whitney *U* tests were conducted for each emotional valence to compare the frequency of selection of each mode. Bonferroni corrections were applied to account for multiple comparisons by multiplying the *p* values by the number of comparisons being conducted for each valence (28 pairwise comparisons), yielding a cutoff for statistical significance that is equivalent to $p = .002$. Adjusted *p* values are reported for ease of interpretation, and are compared to an adjusted alpha level of $p = .05$. To examine the influence of musical experience on valence selection, nonparametric Mann–Whitney *U* tests were conducted for each mode at each emotional valence to compare the frequency of selection of each mode using Group (more experienced and less experienced) as the independent variable.

A related-samples Friedman's two-way analysis of variance by ranks test was conducted, using Strength as the independent variable (three levels) and frequency of selection as the dependent variable. If significant differences were observed, follow up nonparametric Mann–Whitney *U* tests were conducted to compare the frequency of selection of each intensity level. To examine the influence of musical experience on intensity selection, nonparametric Mann–Whitney *U* tests were conducted for each emotional valence to compare the frequency of selection of each intensity level using Group (more experienced and less experienced) as the independent variable.

Finally, nonparametric Spearman rank-order correlations between frequencies of selected valences were conducted across each mode globally for each group (more experienced and less experienced), and for each mode across groups.

Results

The Friedman's ANOVA failed to reveal a significant main effect of Mode on the emotional valence of Amazement, Surprise, Distraction (ASD; $F(7, 33) = 12.182$, $p = .095$), indicating that musical Mode did not reliably influence the perception of these emotions (see Figure 3). The ASD valence was selected most often for Lydian ($M = 15.56\%$, $SD = 14.56\%$) and least often for Phrygian ($M = 7.76\%$, $SD = 8.78\%$), but the mean differences between the modes were not significantly different (all $p > .543$).

A significant main effect of Mode was observed for the emotional valence of Admiration, Trust, Acceptance (ATA; $F(7, 33) = 51.799$, $p < .001$), indicating that mode influenced the choice of this emotional valence. Follow-up paired comparisons indicated that Admiration, Truth, or Acceptance was chosen significantly more often following Mixolydian melodies ($M = 20.59\%$, $SD = 19.56\%$, Figure 3) than Phrygian ($M = 3.88\%$, $SD = 8.07\%$, $Z(7) = -4.821$, $p < .001$), Aeolian ($M = 5.82\%$, $SD = 8.23\%$, $Z(7) = -4.055$, $p < .001$), Locrian ($M = 2.59\%$, $SD = 4.74\%$, $Z(7) = -5.317$, $p < .001$), and MajMin melodies ($M = 7.12\%$, $SD = 9.35\%$, $Z(7) = -3.529$, $p = .012$). ATA was selected significantly more often following Ionian melodies ($M = 16.34\%$, $SD = 14.53\%$) than Locrian ($Z(7) = -4.457$, $p < .001$), Aeolian ($Z(7) = -3.193$, $p = .039$), and Phrygian ($Z(7) = -4.042$, $p < .001$), but not more often than Mixolydian melodies ($Z(7) = -.688$, $p = 1.00$). None of the other pairwise comparisons reached significance (remaining $p > .097$).

A significant main effect of Mode was observed for the emotional valence of Ecstasy, Joy, Serenity (EJS; $F(7, 33) = 113.955$, $p < .001$). Ecstasy, Joy, or Serenity was chosen more often for Ionian ($M = 34.31\%$, $SD = 22.62\%$, Figure 3) melodies than any other mode (all $p < .001$) except for Mixolydian ($M = 23.20\%$, $SD = 15.56\%$, $Z(7) = -2.191$, $p = .796$). This valence was also selected significantly more often after Mixolydian melodies than any other mode except for Lydian ($M = 14.71\%$, $SD = 14.92\%$, $Z(7) = -2.413$, $p = .443$). EJS was selected for Lydian significantly more often than Locrian, Aeolian, Phrygian, Dorian, and MajMin (all $p < .042$). None of the other pairwise comparisons were significant (remaining $p > .068$).

A significant main effect of Mode was observed for the emotional valence of Grief, Sadness, Pensiveness (GSP; $F(7, 34) = 33.503$, $p < .001$). Grief, Sadness, or Pensiveness was chosen significantly more often following MajMin ($M = 12.09\%$, $SD = 12.34\%$, Figure 3) than Ionian ($M = 2.61\%$, $SD = 4.78\%$, $Z(7) = -3.653$, $p = .007$). Similarly, GSP was chosen significantly more often after Aeolian ($M = 10.78\%$, $SD = 9.66\%$) than Ionian ($Z(7) = -3.937$, $p < .001$) and Mixolydian ($Z(7) = -3.244$, $p = .002$). Phrygian was selected significantly more often than Ionian ($M = 2.59\%$, $SD = 4.74\%$, $Z(7) = -3.134$, $p = .048$). None of the other pairwise comparisons were significant (remaining $p > .061$).

A significant main effect of Mode was observed for the emotional valence of Loathing, Disgust, Boredom (LDB; $F(7, 33) = 22.216$, $p = .002$). Loathing, Disgust, or Boredom (see Figure 4) was chosen significantly more often for Locrian ($M = 14.38\%$, $SD = 14.86\%$) than Mixolydian ($M = 3.92\%$, $SD = 6.64\%$, $Z(7) = -3.571$, $p < .001$). None of the other pairwise comparisons were significant (remaining $p > .135$).

A significant main effect of Mode was observed for the emotional valence of Rage, Anger, Annoyance (RAA; $F(7, 33) = 38.087$, $p < .001$). Rage, Anger, or Annoyance was chosen significantly more often for Locrian ($M = 14.38\%$, $SD = 14.61\%$, Figure 4), Phrygian ($M = 13.07\%$, $SD = 13.25\%$), Aeolian ($M = 11.97\%$, $SD = 12.81\%$), and Lydian ($M = 11.35\%$, $SD = 13.86\%$) than Ionian ($M = 3.27\%$, $SD = 6.99\%$, all $p < .048$) or Mixolydian ($M = 3.59\%$, $SD = 7.60\%$, all $p < .023$). None of the other pairwise comparisons were significant (remaining $p > .061$).

A significant main effect of Mode was observed for the emotional valence of Terror, Fear, Apprehension (TFA; $F(7, 33) =$

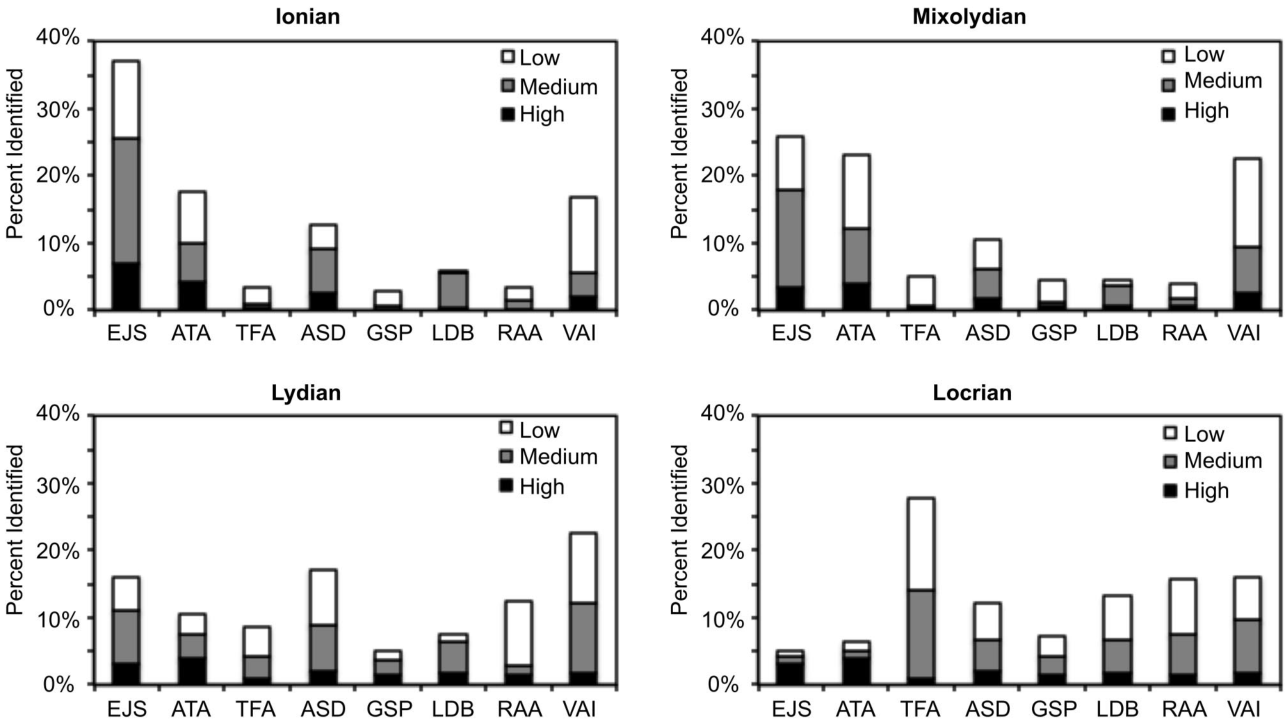

Figure 3. Proportion of the emotional ratings elicited by the melodies for four of the eight modes (Ionian, Mixolydian, Lydian, and Locrian). Emotional valence (*x*-axis) is divided into the eight bipolar scales of Plutchik (EJS: Ecstasy, Joy, Serenity; ATA: Admiration, Trust, Acceptance; TFA: Terror, Fear, Apprehension; ASD: Amazement, Surprise, Distraction; GSP: Grief, Sadness, Pensiveness; LDB: Loathing, Disgust, Boredom; RAA: Rage, Anger, Annoyance; VAI: Vigilance, Anticipation, Interest). Stacked bars indicate proportion of low, medium, and high emotional intensity responses (white, gray, black, respectively).

89.459, $p < .001$) indicating that for this valence, the musical Mode differentially influenced the perception of emotional affect. Terror, Fear, or Apprehension (see Figure 4) was chosen more often for Phrygian ($M = 32.35\%$, $SD = 22.78\%$) than other modes, except Locrian ($M = 27.45\%$, $SD = 17.98\%$, $Z(7) = -.774$, $p = 1.00$), Aeolian ($M = 23.53\%$, $SD = 17.46\%$, $Z(7) = -1.671$, $p = 1.0$), and MajMin ($M = 2.09\%$, $SD = 17.10\%$, $Z(7) = -1.537$, $p = .638$). Similarly, TFA was chosen significantly more often for Locrian than Ionian, Mixolydian, Lydian, and Dorian (all $p < .027$), and for Aeolian than Ionian, Mixolydian, and Lydian (all $p < .028$). Dorian was chosen for TFA significantly more often than Ionian, Mixolydian, and Lydian ($p < .027$). Finally, MajMin was chosen for TFA significantly more than Ionian ($M = 3.24\%$, $SD = 6.39\%$, $Z(7) = -4.658$, $p < .001$). None of the other pairwise comparisons were significant (remaining $p > .208$).

Main effects were not observed for the valences of Vigilance, Anticipation, Interest (VAI; $F(7, 33) = 15.857$, $p = .028$), indicating that for this valence, the musical Mode differentially influenced the perception of emotional affect (see Figure 4). However, none of the paired comparisons reached threshold for criteria based on the adjusted p values (all $p > .210$).

In most cases, performance was similar for the more experienced and less experienced groups (see Figure 5). For the ASD valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p > .346$). A marginally significant effect was observed for Dorian ($Z(1) = 1.989$, $p = .057$), where the more experienced group selected ASD for Dorian more often ($M = 17.471\%$, $SD = 12.334\%$) than the less experienced group did ($M = 10.352\%$, $SD = 14.247\%$).

For the ATA valence, the more experienced group showed a slightly different pattern than the less experienced group. The Mann–Whitney U test failed to reveal significant differences between the emotional ratings of the more experienced group and less experienced group for Ionian, Dorian, Lydian, Mixolydian, Locrian, and MajMin (all $p > .160$). A significant effect was found for Aeolian ($Z(1) = -2.287$, $p = .045$), and the less experienced group selected ATA for Aeolian twice as often ($M = 7.764\%$, $SD = 6.647\%$) as the more experienced group ($M = 3.884\%$, $SD = 9.479\%$). A marginally significant effect was observed for Phrygian ($Z(1) = -2.276$, $p = .092$), where the less experienced group selected ATA for Phrygian more often ($M = 6.470\%$, $SD = 9.573\%$) than the less experienced group did ($M = 1.294\%$, $SD = 5.336\%$).

For the EJS valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p > .160$). A marginally significant effect was observed for Ionian ($Z(1) = -1.775$, $p = .085$), where the more experienced group selected EJS for Ionian more often ($M = 41.243\%$, $SD =$

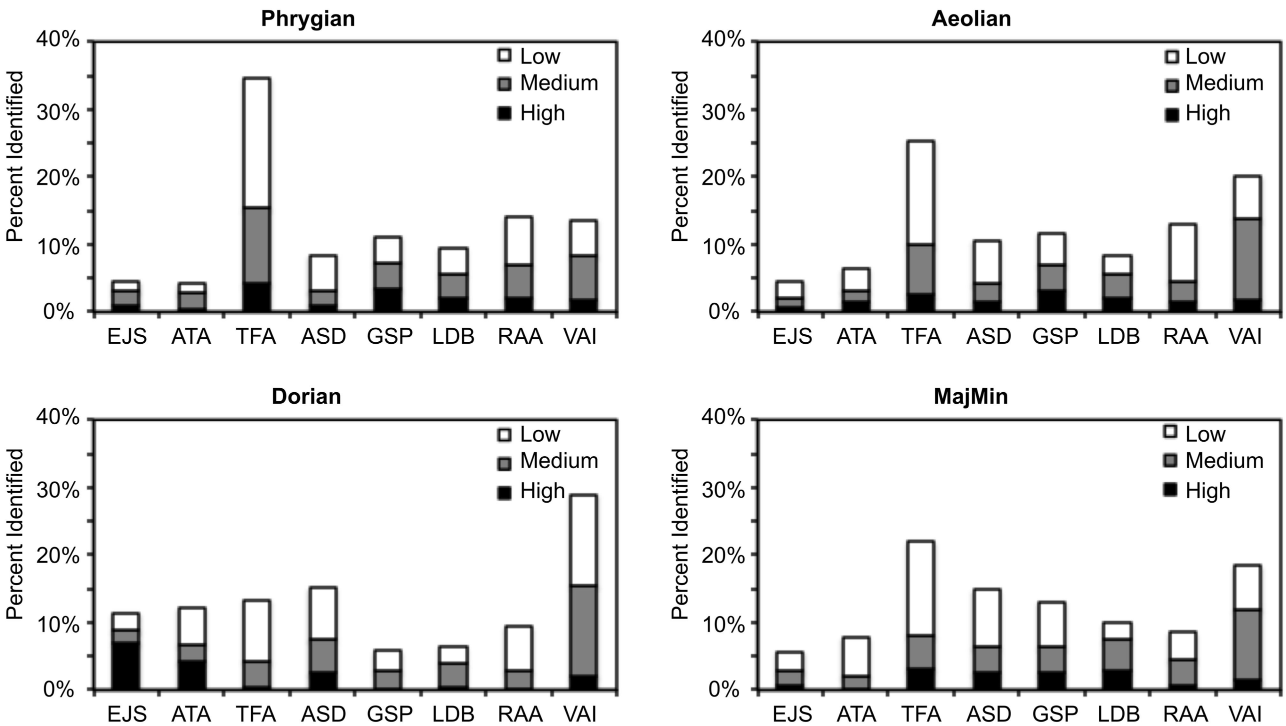

Figure 4. Proportion of the emotional ratings elicited by the melodies for four of the eight modes (Phrygian, Aeolian, MajMin, and Dorian). Emotional valence (*x*-axis) is divided into the eight bipolar scales of Plutchik (EJS: Ecstasy, Joy, Serenity; ATA: Admiration, Trust, Acceptance; TFA: Terror, Fear, Apprehension; ASD: Amazement, Surprise, Distraction; GSP: Grief, Sadness, Pensiveness; LDB: Loathing, Disgust, Boredom; RAA: Rage, Anger, Annoyance; VAI: Vigilance, Anticipation, Interest). Stacked bars indicate proportion of low, medium, and high emotional intensity responses (white, gray, black, respectively).

25.528%) than the less experienced group did (M = 27.352%, SD = 17.745%).

For the GSP valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p >$ .274).

For the LBD valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p >$ .339).

For the RAA valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p >$ .454).

For the TFA valence, the more experienced group showed a slightly different pattern than the less experienced group. The Mann–Whitney U test failed to reveal significant differences between the emotional ratings of the more experienced group and less experienced group for Ionian, Dorian, Lydian, Mixolydian, Locrian, and MajMin (all $p >$ .290). A significant effect was found for Aeolian ($Z(1) = -2.054$, p = .045), and the more experienced group selected TFA for Aeolian significantly more often (M = 28.588%, SD = 17.650%) than the less experienced group (M = 18.184%, SD = 16.153%). A marginally significant effect was observed for Phrygian ($Z(1) = -2.276$, p = .092), where the more experienced group selected TFA for Phrygian more often (M = 40.470%, SD = 23.704%) than the less experienced group did (M = 24.063%, SD = 18.386%).

For the VAI valence, the more experienced and less experienced groups had similar emotional ratings for all modes, and the Mann–Whitney U tests failed to find a significant effect of Group (all $p >$ .160).

The proportion of responses across intensity levels for each mode was calculated for the melody data to determine the strength of the emotions most commonly associated with particular modes within each valence set. The intensities followed the same pattern for all modes (Figures 3 and 4) with low intensity being most commonly selected (ranging from 45.6% to 53.3% frequency). Middle intensity was selected second most frequently for all modes (ranging from 33.1% to 39.5%), and high intensity was selected least often for all modes (ranging from 12.3% to 15.5%). A nonparametric Friedman's ANOVA revealed main effect of Intensity ($F(2) = 153.09$, $p < .001$). The low intensity emotions (M = 44.24%, SD = 24.60%) were selected significantly more often than the medium (M = 33.86%, SD = 19.28%, $Z(1)$ = 6.766, p = .009) and high intensity emotions (M = 13.73%, SD = 16.07%, $Z(1) = -14.267$, $p < .001$), which differed from each other ($Z(1) = -11.838$, $p < .001$).

Group differences were observed for intensity rankings, and the more experienced group showed a slightly different pattern than the less experienced group. The Mann–Whitney U test revealed a significant main effect of Group ($Z(1) = -2.601$, p = .009),

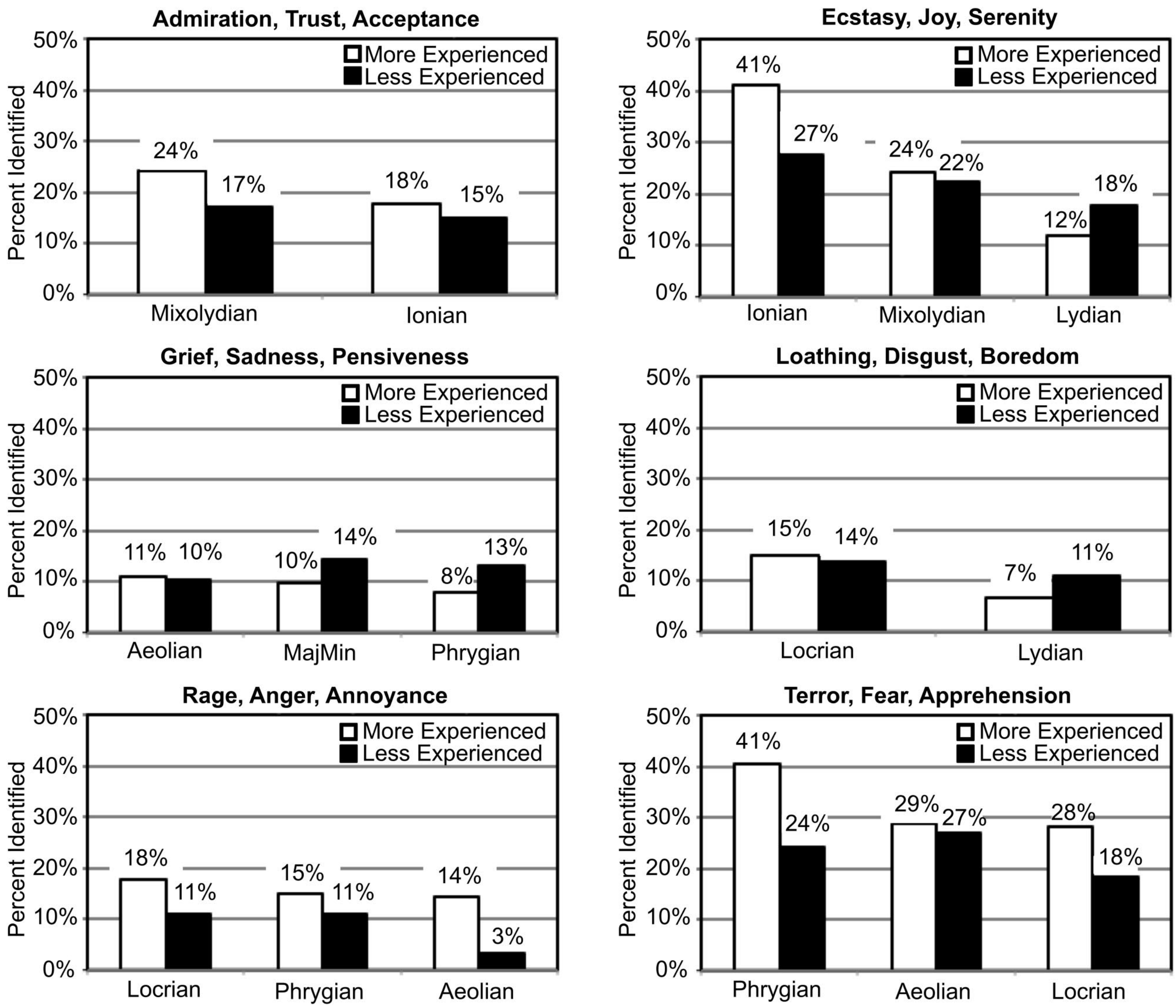

Figure 5. Proportion of emotional responses in experienced and inexperienced subjects elicited by melodies for selected emotional valences. Most commonly selected modes for each valence are represented on the *x*-axis.

indicating that the more experienced group selected low intensity emotions significantly more often ($M = 47.630\%$, $SD = 22.667\%$) than the less experienced group ($M = 40.851\%$, $SD = 26.150\%$). Group differences were not observed between the less experienced ($M = 32.273\%$, $SD = 19.358\%$; $M = 14.951\%$, $SD = 17.444\%$) and more experienced groups ($M = 35.462\%$, $SD = 19.150\%$; $M = 12.501\%$, $SD = 14.530\%$) for mid ($Z(1) = -1.187$, $p = .235$) or high intensity emotions ($Z(1) = -.878$, $p = .380$), indicating that both groups chose these intensities equally.

Correlations between the frequencies of emotional sets selected for each mode were calculated using nonparametric Spearman's rank-order correlations to look for emotional associations between modes (see Table 1). Overall, Ionian was significantly positively correlated with Mixolydian ($r(8) = .892$, $p = .003$) and negatively correlated with Phrygian ($r(8) = -.707$, $p = .050$). Aeolian was positively correlated with Phrygian ($r(8) = .929$, $p = .001$), Locrian ($r(8) = .874$, $p = .003$), and MajMin ($r(8) = .833$, $p = .010$).

To analyze the difference between the more experienced and less experienced groups' evaluation of the modes, correlations were calculated using Spearman's rho. There was a high degree of agreement between more experienced musical and nonmusical groups across all of the modes. Particularly strong correlations were found for Ionian: ($r(8) = .934$, $p = .001$), Aeolian ($r(8) = .976$, $p = .001$), Locrian ($r(8) = .916$, $p = .001$), and MajMin ($r(8) = .897$, $p = .003$). Strong correlations were also found for the other modes of Dorian ($r(8) = .822$, $p = .012$), Phrygian ($r(8) = .753$, $p = .031$), Mixolydian ($r(8) = .773$, $p = .024$), and Lydian ($r(8) = .711$, $p = .048$).

Although there was high agreement across the two groups, additional variability can be seen in Table 2, which shows slightly different patterns owing to musical experience (see Figure 5). For

Table 1
Correlation Table Showing Overall Relationship Between Modes for All Participants

Mode	Ionian	Dorian	Phrygian	Lydian	Mixolydian	Aeolian	Locrian	MajMin
Ionian	— (—)	.02 (.97)	**−.71 (.06)**	.63 (.10)	**.9 (.01)**	−.63 (.10)	−.47 (.25)	−.47 (.25)
Dorian	.02 (.97)	— (—)	.36 (.39)	.57 (.15)	.04 (.94)	.63 (.10)	.66 (.08)	**.71 (.06)**
Phrygian	**−.71 (.05)**	.36 (.39)	— (—)	−.12 (.78)	−.64 (.10)	**.93 (.01)**	**.85 (.01)**	.67 (.08)
Lydian	.63 (.10)	.57 (.15)	−.12 (.78)	— (—)	.52 (.20)	.03 (.96)	.04 (.94)	.05 (.92)
Mixolydian	**.9 (.01)**	.04 (.94)	−.64 (.10)	.52 (.20)	— (—)	−.48 (.23)	−.47 (.25)	−.26 (.55)
Aeolian	−.63 (.10)	.63 (.10)	**.93 (.01)**	.03 (.96)	−.48 (.23)	— (—)	**.88 (.01)**	**.84 (.02)**
Locrian	−.47 (.25)	.66 (.08)	**.85 (.01)**	.04 (.94)	−.47 (.25)	**.88 (.01)**	— (—)	**.81 (.02)**
MajMin	−.47 (.25)	.71 (.06)	.67 (.08)	.05 (.92)	−.26 (.55)	**.84 (.02)**	**.81 (.02)**	— (—)

Note. Spearman rho values lead, p-values appear within parentheses, and bolded font indicates correlations significant at $p < 0$; $p < .05$; $n = 8$.

the less experienced group, Ionian showed much stronger correlations with Mixolydian ($r(8) = .910$, $p = .002$) compared with the more experienced group ($r(8) = .781$, $p = .022$). However, for the more experienced group, Phrygian showed much stronger correlations with Aeolian ($r(8) = .970$, $p < .001$), Locrian ($r(8) = .892$, $p = .003$), and MajMin ($r(8) = .830$, $p = .011$). For the less experienced group, these associations with Phrygian were weaker (Aeolian: $r(8) = .790$, $p = .020$) or absent (Locrian: $r(8) = .705$, $p = .051$; MajMin: $r(8) = .566$, $p = .143$).

Discussion

The present study demonstrates that that mode influences perceived emotion in consistent ways for more and less experienced participants beyond mere associations with Ionian and Aeolian. Using sine wave tones to generate simple melodies, the emotional content of each mode was isolated and evaluated empirically. Modes had specific emotional connotations that were largely consistent across musically experienced and less experienced participants. Although modes had emotional connotations, the emotions selected were generally of low intensity. Given the simplistic quality of the sine wave tones comprising the melodies, it is not surprising that middle and low intensities were picked most often across all modes. However, the uniformity of intensities suggests that the synthesis process was successful in removing any extraneous influences of timbre, tempo, and rhythm.

Interestingly, the frequencies of bipolar emotional sets assigned to the modes conform generally to historical interpretations of mode and emotion associations. In her book about the performance of music during the renaissance, Anne Smith includes a historical summary of the many emotional connotations ascribed to the church modes by music theorists of the Middle Ages and Renaissance (2011). Ionian, formed by flatting the fourth degree of the

Table 2
Correlation Table Showing Overall Relationship Between Modes for the Less Experienced Group (L) and More Experienced Group (M)

Mode	Ionian	Dorian	Phrygian	Lydian	Mixolydian	Aeolian	Locrian	MajMin
Ionian								
L	— (—)	.16 (.72)	**−.83 (.02)**	**.76 (.03)**	**.91 (.01)**	−.5 (.22)	−.35 (.4)	−.28 (.52)
M	— (—)	.05 (.91)	−.66 (.08)	.58 (.14)	**.79 (.03)**	−.65 (.09)	−.57 (.15)	−.54 (.18)
Dorian								
L	.16 (.72)	— (—)	.20 (.64)	.33 (.44)	−.05 (.93)	.59 (.13)	.66 (.09)	**.75 (.04)**
M	.05 (.91)	— (—)	.56 (.16)	.66 (.08)	.25 (.56)	.64 (.10)	.54 (.17)	.68 (.07)
Phrygian								
L	**−.83 (.02)**	.2 (.64)	— (—)	−.54 (.17)	**−.96 (.01)**	**.79 (.02)**	**.71 (.06)**	.57 (.15)
M	−.66 (.08)	.56 (.16)	— (—)	.03 (.96)	−.4 (.34)	**.97 (.01)**	**.90 (.01)**	**.83 (.02)**
Lydian								
L	**.76 (.03)**	.33 (.44)	−.54 (.17)	— (—)	.68 (.07)	−.04 (.94)	−.04 (.95)	−.01 (.99)
M	.58 (.14)	.66 (.08)	.03 (.96)	— (—)	.37 (.38)	.03 (.96)	.09 (.85)	.05 (.91)
Mixolydian								
L	**.91 (.01)**	−.05 (.93)	**−.96 (.01)**	.68 (.07)	— (—)	−.68 (.07)	−.53 (.19)	−.55 (.17)
M	**.79 (.03)**	.25 (.56)	−.40 (.34)	.37 (.38)	— (—)	−.32 (.45)	−.52 (.20)	−.12 (.8)
Aeolian								
L	−.5 (.22)	.59 (.13)	**.79 (.02)**	−.04 (.94)	−.68 (.07)	— (—)	**.75 (.04)**	**.74 (.04)**
M	−.65 (.09)	.64 (.10)	**.97 (.01)**	.03 (.96)	−.32 (.45)	— (—)	**.88 (.01)**	**.87 (.01)**
Locrian								
L	−.35 (.40)	.66 (.09)	**.71 (.06)**	−.04 (.95)	−.53 (.19)	**.75 (.04)**	— (—)	.61 (.11)
M	−.57 (.15)	.54 (.17)	**.90 (.01)**	.09 (.85)	−.52 (.2)	**.88 (.01)**	— (—)	**.72 (.05)**
MajMin								
L	−.28 (.52)	**.75 (.04)**	.57 (.15)	−.01 (.99)	−.55 (.17)	**.74 (.04)**	.61 (.11)	— (—)
M	−.53 (.18)	.68 (.07)	**.83 (.02)**	.05 (.91)	−.12 (.80)	**.87 (.01)**	**.72 (.05)**	— (—)

Note. Spearman rho values lead, p-values appear within parentheses, and bolded font indicates correlations significant at $p < .05$; $n = 8$.

Lydian mode, was typically identified as possessing sweetness, charm, gaiety, pleasantness, and cheerfulness. Lydian had mixed associations with liveliness, simplicity, pleasantness, harshness, softness, haughtiness, and modesty (although Lydian was frequently changed to Ionian to avoid the interval of a tritone; Powers, 2013). Dorian had somewhat mixed association with seriousness, brilliance, constancy, severity, cheerfulness, and virtuousness. Phrygian was associated with harshness, anger, cruelty, indignation, and lamentation. Mixolydian was often identified as having two natures representing its features reminiscent of Dorian and Ionian. It was called querulous, pleasant, excited, calm, modest, lascivious, and cheerful. Aeolian was associated with calmness, weightiness, suavity, sweetness, and sadness (Smith, 2011). It is important to consider that the church modes as they were used in the medieval ages and the Renaissance differ from the modern diatonic modes, both in tuning systems (i.e., modern equal temperament) and in compositional style. As Samson states, "any comparison of medieval and modern modality would recognize that the latter takes place against a background of some three centuries of harmonic tonality, permitting, and in the 19th century requiring, a dialogue between modal and diatonic procedure" (Samson, 1977, 148).

It is remarkable that despite the difference between historical and modern modality, many of the associations found between the modes and emotion in the present study mirror what music scholars said hundreds of years ago (Figures 3 and 4). Phrygian was most strongly identified as expressing fear, apprehension, and sadness. Major was very strongly identified with joy and serenity. Mixolydian was most frequently selected as conveying admiration, joy, and serenity. Dorian and Lydian had mixed associations. It is likely that for the modes with mixed associations, the position and emphasis of certain scale degrees has a distinct influence on the emotion perceived. For example, the antiquated hypodorian mode, which had scale degrees 5, 6, and 7 in the lowest positions, was identified by theorists as having more positive connotations (Smith, 2011). One limitation of this study was that not enough centered, ascending, and descending melodies were played in these particular modes to determine whether the register and melodic direction of certain scale degrees has a significant influence on emotion. In addition, varied accent patterns and rhythmic structures could influence the perception of emotion within each mode as thought by historical theorists (Smith, 2011). Future studies should examine these possibilities. It is fascinating that the general emotional characteristics of many of the modes remain the same despite the fact that tuning systems and compositional styles have been changed in various ways throughout the history of western music.

The present findings regarding the overall emotional connotations of the modes tie nicely into a body of research regarding melodic interval size and emotional connotations of melody. Huron, Yim, and Chordia (2010) suggested that the difference between affective connotations of common practice major and minor may be related to pitch height, with smaller average intervals in minor conveying decreased affect (Huron & Davis, 2012). Similarly, lower pitch expresses sadness in speech (Scherer, 1995), and it has been suggested that smaller average interval sizes in the diatonic modes corresponds in a linear fashion with a "darker" sound (Slonimsky, 1947). Additional research by Collier and Hubbard provides support for this notion in major and minor scales (2004).

However, the present findings do not support this simple relationship between interval size and affect in the diatonic modes because Phrygian was more often associated with Terror, Fear, and Apprehension followed by Aeolian, and then Locrian, which has the smallest interval size. Temperly and Tan (2013) who did not include Locrian in their examination of the modes suggest that Phrygian is perceived more negatively than Aeolian owing to the decreased familiarity listeners would have with Phrygian as well as the decreased interval size. The fact that Locrian, which has the smallest interval size and smallest degree of familiarity, was more strongly associated with loathing, boredom, and disgust than terror, fear, and apprehension suggests that lack of melodic resolution conveys LBD. TFA then are likely best conveyed by small average interval size in minor modes such as Aeolian and particularly Phrygian.

Interestingly, MajMin also conveyed TFA more clearly than any other emotions. Huron and Davis (2012) showed that lowering the sixth scale degree in major melodies was the most effective means of decreasing average interval size. MajMin, Phrygian, Aeolian, and Locrian all contain a lowered sixth scale degree whereas Dorian, which was not reliably associated with TFA, does not. Together this evidence suggests that the lowered sixth scale degree is particularly important in conveying terror, fear, and apprehension.

In addition to overall emotional connotations, the results suggest that more experienced and less experienced participants generally agree on emotion in many modal melodies. The fact that both groups generally identified the same emotional sets for each mode suggests that musical experience has only a small degree of influence on perceived melodic emotion, which is consistent with previous research (e.g., Bigand et al., 2005; Juslin & Laukka, 2001; Kendall & Carterette, 1990; Seashore, 1923). However, the agreement between groups was greater for certain modes than others. Both groups identified Ionian, Aeolian, MajMin, and Locrian in similar ways with highly significant correlation coefficients (*r's* $> .90$, *p's* $< .005$), indicating that their responses were highly consistent despite their listening habits or musical experience. In contrast, there was greater disagreement about the emotions conveyed by Lydian ($r(8) = .711$, $p = .048$) and Mixolydian scales ($r(8) = .773$, $p = .024$). It may be the case that because Lydian and Mixolydian only differ from the Ionian scale (which is common and stable) by one pitch, they cause more varied responses. Less experienced participants most commonly selected anticipation and interest for Lydian followed by surprise and distraction, while experienced participants selected joy, serenity, anticipation, and interest equally often. For Mixolydian, less experienced participants selected joy, serenity, anticipation, trust, acceptance, and interest equally often. Experienced participants selected the same emotions but selected joy and serenity most often. It may be that experienced participants are more able to hear the raised third scale degree of both modes independently from the differing pitches.

Interestingly, less experienced participants showed less consensus about the emotion conveyed by the modes (see Figure 5). Although their distribution of ratings across the circumplex model was narrow, with the highest ratings across emotional valences between 11 and 27%, their average ratings were only 18.3%. In contrast, highest ratings for experienced participants ranged from 11% to 41% with an average of 24.8%. Additionally, in every case except one, the experienced group had higher overall proportions for the most frequent emotional set than the less experienced group, indicating that they had higher agreement on the mode/emotion association. This suggests that musically experienced listeners may interpret emotions with less variability when listening to basic stimuli. This could be indicative of an increased awareness of relationships between individual scale degrees. This is also reflected in the correlations between modes for the two groups.

Although there was significant agreement between the two groups, the more experienced participants had higher correlations between Phrygian, Aeolian, Locrian, and MajMin than their less experienced counterparts. The less experienced listeners showed stronger correlations between Ionian and Mixolydian, and were the only group to show significant negative correlations (Ionian and Phrygian, $r(8) = -.825$, $p = .012$; Phrygian and Mixolydian, $r(8) = -.952$, $p < .001$). It seems likely that individuals with musical experience latch on to emotional connotations of specific intervals more readily than less experienced individuals who perceive melodic emotion in a more holistic sense.

In addition to the slight differences in emotional interpretation of the modes, it is intriguing that musically less experienced participants rated Locrian as more intense than their experienced counterparts. The tritone present in Locrian's tonic triad (e.g., C to F#) is an interval that has been associated with danger and violence in a study among South African children (Smith & Williams, 1999) and in fact was termed "diabolus in musica" (devil in music) and avoided at all costs during the middle ages and renaissance (Smith, 2011). Lydian also contains a tritone involving the tonic, but not as part of its tonic triad. Locrian is rarely used in modern compositions because it has a diminished tonic triad and exhibits a strong tendency to resolve to Ionian. Overall, this finding suggests that musical experience may cause individuals to become more comfortable with melodies that do not resolve.

Another consideration in these findings is that the overall emotional connotation of modes (Slonimsky, 1947). In a previous study by Collier and Hubbard, the perceived visual darkness and lightness of the modes was directly related to the size of the intervals between the tonic and all of the remaining pitches in a mode (2004). The present findings suggest that this linear relationship may only partially describe emotion for the modes. For example, Dorian and MajMin are close in terms of overall interval size but only partially correlated in emotional connotation. Similarly, Lydian has the largest total interval size, but it was most often associated with anticipation and interest. Phrygian was rated as more strongly associated with fear and apprehension than any other mode followed by Locrian (which should be darkest according to Collier & Hubbard, 2004). Based on the present findings, it is likely that certain interval sizes do affect emotional connotation, but the position of intervals within a scale is equally important.

Several limitations in this study should be addressed in future studies of musical experience, musical structure, and emotion. Melodies were not randomized for each trial, rather the same nine randomized melodies in each mode were played for all participants. This presents the possibility that order effects of interval presentation might have been introduced. This might be especially true for melodies that ended with nonstandard intervals (e.g., scale degree six to one). However, given the tempo of the presentation, and the lack of rhythmic accent given to scale degrees, it seems unlikely that this would present a major confound.

Another limitation was that response times for answers were not collected in this study, but they might have provided a useful method of evaluating the difficulty that more experienced and less experienced participants had in identifying emotions. Musically experienced participants might have been faster at selecting the appropriate emotion for each stimulus. Additionally, time limitations made it impossible to test modal harmonies for emotional correlations with modal melodies, but this is a promising avenue for future investigations. For example, the harmonic progression I–IV–V–I may be indicative of Ionian or Mixolydian, and similar emotional response patterns may arise. Finally, participants in this study were most familiar with western music. Future investigations might examine cross-cultural interpretations of emotions in modal musical material such as Indian classical music (Balkwill, Thompson, & Matsunaga, 2004; Deva, 1967) or Phrygian music in Spain, which may lend themselves more easily to mode and emotional associations.

This study confirms the findings of previous research that suggests that musical emotion is related to mode (e.g., Costa, Fine, & Ricci Bitti, 2004; Gabrielsson & Lindström, 2010; Gagnon & Peretz, 2003; Meyer, 1956). However, the simple distinction between common practice major and minor modality that is often made likely does not fully account for the way pitches may convey emotion. By distinguishing between modes of the diatonic scale and the intervals between tonic and each scale degree, it may be possible to more clearly understand the emotions conveyed by certain scales, melodies, and harmonies. The findings of this study suggest that emotional associations with modes are perceived similarly to how they were in antiquity. In particular, Phrygian is associated clearly with fear and apprehension and Ionian is associated with joy and serenity. It is clear that musically experienced and less experienced individuals generally perceive melodic emotion in similar ways although less experienced participants may perceive emotion more holistically rather than in relation to specific intervals.

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