Musical scales and evaluations of happiness and awkwardness: Effects of pitch, direction, and scale mode

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Participants rated the perceived happiness, brightness, awkwardness, pitch velocity, and tempo change of ascending and descending musical scales in four modes (natural, melodic, and harmonic minor modes and the major mode). Only minor differences between ratings of natural, harmonic, or melodic minor scales or between ratings of parallel and relative major scales were found. Ascending scales were rated as happier, brighter, and more accelerating than were descending scales; ascending minor scales were rated as faster and more awkward than were descending minor scales. Musical keys in each mode were compared, and significant differences were found. Musical keys that started on a higher pitch were rated as happier, brighter, and faster and as speeding up more than were keys that started on a lower pitch. The data were consistent with previous findings and suggest that pitch and direction (contour), rather than mode or key, influence listeners' judgments of musical stimuli.

Music has long been an important part of human life, and some researchers suggest that music is both a universal and a species-specific trait of humanity (Hodges, 1996). Music, like language, may function as a communication system (Aiello, 1994; Jones & Holleran, 1992) capable of distinguishing between subtle shades of experience in highly structured ways. Many studies of musical structure have focused on contributions of that structure to music recognition (Bharucha, 1984, 1994; Dowling, 1978) or production (Sloboda, 1985). Less systematic attention has been given to the emotional valence contributed by specific forms of musical structure. Musical structure includes elements of harmony and stability (Bharucha & Krumhansl, 1983; Krumhansl, 1979), and musical scales and keys form an integral aspect of musical structure. The studies reported here focus on the effects of different musical structures on participants' reported emotions; more specifically,

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participants' emotional responses to ascending or descending forms of major and minor scales were examined.

The relationship between music and emotion has been an area of speculation for some time, and the question of how music may evoke emotional responses has been addressed in several ways (for reviews, see Radocy & Boyle, 1997; Sloboda, 1992). However, researchers have not reached consensus on the appropriate level of analysis at which emotional effects are most strongly or clearly produced. One possibility is that emotional responses to music are determined primarily by sequences of individual tones within a tonal hierarchy of stability and are not influenced by the broader harmonic context in which those notes occur; such an approach focuses on the melodic (or horizontal) aspects of music. A second possibility is that emotional responses to music are determined primarily by the chords, key, and harmonic structure of the music and are not influenced by the individual tones and sequences of tones per se; such an approach focuses on the harmonic (or vertical) aspects of music. One way to begin to separate the relative contributions of the horizontal or vertical aspects of music would be to examine whether emotion is influenced by the mode of a musical composition; for example, would a musical scale in a minor mode be perceived as less "happy" than a musical scale in a major mode?

The roles of both individual tone sequences (horizontal) and harmonic context (vertical) were demonstrated in a study by Kastner and Crowder (1990) in which children (ages 3–12) listened to simple folk songs and, while listening to each song, pointed to one of four faces representing the emotions of either happy, contented, sad, or angry. Each folk song was presented in four different versions: major mode with harmonic accompaniment, minor mode with harmonic accompaniment, major mode without harmonic accompaniment, and minor mode without harmonic accompaniment. Major modes were associated with happier faces more than were minor modes, and this occurred regardless of whether accompanying harmony was presented. Such a pattern is consistent with findings that minor chords are perceived as sadder than major chords (see Crowder, 1984) and suggests that effects of mode may influence responses to both the horizontal and vertical aspects of music. Intriguingly, the major mode without harmonic accompaniment was perceived as happier than the major mode with harmonic accompaniment, and the unaccompanied minor mode was perceived as sadder than the accompanied minor mode; harmonic accompaniment seemed to diminish the perceived emotional valence of the music.

The differences between emotional responses to melodies in a major or minor mode suggests that emotional valence may be determined in part by the musical mode of a piece of music. Examination of this

hypothesis is limited by the lack of control for factors such as pitch contour, range, and height that occur when melodic segments are taken from orchestral compositions (as in Hevner, 1935; Lehman, 1972). Similarly, previous studies examining the relationship between emotional response and musical key used stimuli consisting of single chords presented in isolation, but these studies did not consider effects of factors such as pitch height, pitch direction, and tempo (as in Crowder, 1984). One recent study attempted to explicitly examine the effects of pitch height, tempo, and pitch contour on ratings of happiness or sadness by presenting either a repeated C tone (261.6 Hz [C4] or 1,046.4 Hz [C6]) or an ascending or descending C major scale, and the presentation rate of the repeated or the scale tones was either 60 or 120 beats per minute (Collier & Hubbard, in press). Higher pitch tones, ascending scales, and faster tempi were rated as happier than lower pitch tones, descending scales, and slower tempi. Pitch height, direction, and tempo influenced ratings of happiness or sadness; however, because stimuli were limited to tones drawn from the C major scale, it was not possible to assess any effect of musical mode per se on the emotional valence of the tones.

Trehub, Cohen, and Guerriero (1987; cited in Trehub, 1993) presented children and adults with ascending and descending major or minor scales from several keys. Although the main effect of direction was significant, only musically trained adults consistently associated the major scales with happiness and the minor scales with sadness. The general direction effect suggests that musical key per se does not influence the valence of the melody line and also suggests that any effect of mode is based on prior learning and experience and is not intrinsic to music. The results of Trehub et al. are consistent with the hypothesis suggested by the results of Kastner and Crowder that harmonic accompaniment is not necessary for the production of emotional valence and hence that emotional valence may be based more on the horizontal rather than the vertical aspect of music. However, it is not clear how the direction effect noted by Trehub et al. can account for the difference between major and minor modes reported by Kastner and Crowder.

If musical mode contributes to emotional valence, then differences between major and minor modes should be found on ratings of happiness or sadness. Past research on the emotional effects of music have used a wide variety of emotion word checklists (see Hevner, 1937; Rigg, 1940; Watson, 1942; Wedin, 1972), and this lack of consistency has made it difficult to determine the precise emotional effect music may have on listeners. More recently, Barrett and Russell (1999) summarized a developing consensus that affect is composed of only two dimensions: a

happy or sad hedonistic dimension and an activation dimension. Given that the exact nature of the activation dimension is not fully understood, we opted to focus on the happiness or sadness dimension of affect. The use of ratings of happiness or sadness is also consistent with previous research on emotion and music that used ratings of happiness or sadness (see Trehub et al., 1987; Gerardi & Gerken, 1995; Collier & Hubbard, in press). Previous findings suggest that listeners should rate the ascending musical scales as being happy and the descending musical scales as being sad, and that this pattern should occur regardless of whether the mode is major or minor. Indeed, the irrelevance of mode could be predicted on the basis of previous findings that people rely more on contour in the recognition of music (Dowling, 1978), and an importance of contour might also be predicted on the basis of listeners possessing a "template" for scales (Jordan & Shepard, 1987).

Given that the basic structure of the Western tonal melodic and harmonic system is based primarily on four musical modes (i.e., three minor scale modes and one major scale mode with two variations in relation to the minor scale), it is possible that the emotional effects we see in response to musical compositions could arise in part from effects of the musical mode; however, such musical mode effects have not been tapped by previous research that focused on integrated melodies or isolated chords. An examination of musical mode is also responsive to previous calls to examine perceptual qualities of different scale forms (as suggested by Lundin, 1985). Accordingly, in the studies presented here, participants were presented with an ascending or descending scale, and the scale could be in any of the minor or major musical modes. After the scale was presented, judgments along several dimensions were obtained from the participants, but only the data pertaining to judgments of happiness or sadness and judgments of awkwardness are presented here.

EXPERIMENT 1

Participants heard ascending or descending musical scales from minor musical modes (natural, harmonic, or melodic minor). These minor musical modes differ in the spacing between the individual tones of the minor scales (Table 1), so any potential effects of spacing or interval size should be reflected in the ratings of happiness or sadness. Also, it is commonly accepted in music theory (see Kostka & Payne, 1995) that these differences in spacing result in the perception that the harmonic and melodic minor modes more naturally "lead up," whereas the natural minor mode more naturally "leads down," and such asymmetries in perceived direction might also influence the perceived awkwardness of the scale (e.g., a scale that more naturally "leads up" might

Table 1. Scale forms

	Tone chroma													
Chromatic scale[a]														
C	C♯	D	E♭	E	F	F♯	G	A♭	A	B♭	B	C′		
c Natural minor (ascending and descending)[b]														
C		D	E♭		F		G	A♭		B♭		C′		
c Melodic minor (ascending)[c]														
C		D	E♭		F		G		A		B	C′		
c Harmonic minor (ascending and descending)														
C		D	E♭		F		G	A♭			B	C′		
Relative E♭ major scale (ascending and descending)														
			E♭		F		G	A♭		B♭		C′	D′	E♭′
Parallel C major scale (ascending and descending)														
C		D		E	F		G		A		B	C′		

[a]There is a half-step interval between each tone in the chromatic scale.

[b]The intervals between the sequences of tones in each scale are true for any key within the mode.

[c]The descending form of the melodic minor scale is the same as that of the descending natural minor scale.

be perceived as more awkward in descending than in ascending form). Effects of gender and musical experience on differences in rated happiness or sadness and rated awkwardness also were considered.

METHOD

Participants

The participants in all experiments were undergraduates at Texas Christian University who received partial course credit in introductory or intermediate psychology courses, and they were not selected for musical background or experience. Twenty-four students (12 men and 12 women) participated in Experiment 1.

Apparatus

The auditory stimuli were generated by a Macintosh IIsi microcomputer and presented through headphones connected directly to the microcomputer. The rating scales were displayed on an Apple RGB color monitor connected to the microcomputer, and the computer recorded the participants' responses.

Stimuli

Auditory scale stimuli. The auditory stimuli consisted of minor scales composed of eight sequential sine wave tones. The scales were based on an equal-tempered tuning, and on each trial the scale was in one of six keys: g, a, b, f,

c♯, or d♯.[1] These different keys were equally spaced around the circle of fifths, and over the course of the trials each key was presented equally often. The scales were based on one of five minor scale forms: ascending natural, descending natural, ascending harmonic, descending harmonic, and ascending melodic (the descending melodic is identical to the descending natural minor, so in an effort to decrease the total number of trials, the descending melodic was not presented). The lowest tone of each scale was in the C4 octave, and the highest tone of each scale was in the C5 octave. Differences between the spacing of the notes in each scale form are listed in Table 1. The scales were presented at a constant tempo, with each note being presented for 750 ms (i.e., the duration of a quarter note at a tempo of 90 beats per minute).

Rating scales. Likert scales were used to rate the perceived happiness or sadness and the perceived awkwardness of each musical scale. Each Likert scale was printed in the middle of the screen, with the numbers 1 through 7 equally spaced across the screen and the appropriate anchor terms outside the 1 and outside the 7. Anchor terms for ratings of happiness or sadness were *sad* (1) and *happy* (7), and the anchor terms for ratings of awkwardness were *not awkward* (1) and *awkward* (7).

Design

After the presentation of each scale, participants made a judgment about that scale, and there were five types of judgments. Our focus in this report is on ratings of happiness or sadness and on ratings of awkwardness. A discussion of judgments of brightness, tempo, and tempo change is in preparation and will be reported separately. Each participant received 150 trials (6 keys × 5 mode forms [ascending natural, descending natural/melodic, ascending melodic, ascending harmonic, and descending harmonic] × 5 judgments) in a different random order.

Procedure

Participants were tested individually, and they initiated each trial by pressing a designated key. A single ascending or descending musical scale was then immediately presented, and after the musical scale had been presented, a single rating scale was visually presented on the monitor. Participants entered their judgments directly via the keyboard, and then they initiated the next trial. They were given five practice trials at the beginning of the session, and the practice trials were drawn randomly from the experimental trials. After completing the experimental trials, each participant filled out a brief musical background questionnaire. The entire session lasted approximately 30 min.

RESULTS

A preliminary analysis focusing on possible effects of experience and gender was carried out. The primary analyses of ratings of perceived happiness or sadness and ratings of perceived awkwardness were then carried out, and two types of analyses were done on these ratings. The

first type of analysis, across-key analyses, collapsed across keys and examined more general effects of musical mode on the responses to each of the rating scales. Given that musical composers and theorists have attributed different characteristics to individual keys (see Sachs, 1955), the second type of analysis, individual key analyses, examined more specific effects of key on the responses to each of the rating scales. The mean ratings are presented in Table 2.

Preliminary analyses

A median split of the scores on the musical background questionnaire classified participants as musically inexperienced, $M = 0.13$, range = 0.0 to 0.6 years, or musically experienced, $M = 2.97$, range = 0.8 to 9.2 years. The only effect of experience was that inexperienced participants, $M = 3.61$, rated ascending melodic minor scales as more awkward than did experienced participants, $M = 2.76$, $t(19.33) = 2.05$, $p = .05$. No gender differences were found. Subsequent analyses collapsed over gender and experience, and ratings of happiness or sadness and ratings of awkwardness were analyzed in separate within-subject analyses of variance (ANOVAs).

Table 2. Mean ratings of minor keys in Experiment 1

	Key					
	b	a	g	f	d♯	c♯
Ascending natural minor						
Happiness	4.79	4.38	4.46	4.00	3.67	3.54
Awkwardness	4.00	4.00	4.17	3.87	4.17	3.71
Ascending melodic minor						
Happiness	5.21	4.87	4.33	3.71	3.79	3.96
Awkwardness	3.21	3.17	2.79	3.42	3.25	3.29
Ascending harmonic minor						
Happiness	4.42	4.21	4.42	3.96	3.83	3.46
Awkwardness	3.62	3.75	3.25	3.92	4.12	4.25
Descending natural/melodic minor						
Happiness	3.83	3.25	3.38	3.00	2.67	2.63
Awkwardness	3.04	2.83	3.38	3.75	3.42	3.67
Descending harmonic minor						
Happiness	3.67	3.38	3.17	2.92	3.08	2.75
Awkwardness	3.46	3.88	3.21	3.75	3.42	3.58

Note. All ratings were based on a 7-point scale, with smaller numbers indicating less (i.e., less happy, not awkward) and larger numbers indicating more (i.e., more happy, awkward).

Happiness

Across-key analyses. Minor scale form influenced ratings of happiness or sadness, $F(4, 92) = 18.77$, $p < .0001$, and several a priori comparisons were carried out:

Ascending minor scales, $M = 4.17$, were rated as happier than descending minor scales, $M = 3.15$, $F(1, 23) = 43.59$, $p < .0001$.

Natural minor scales, $M = 3.64$, did not differ in rated happiness from harmonic minor scales, $M = 3.61$, $F(1, 23) = .1$, n.s.

Ascending natural minor scales, $M = 4.14$, were rated as happier than descending natural minor scales, $M = 3.13$, $F(1, 23) = 17.34$, $p < .0001$.

Ascending harmonic minor scales, $M = 4.05$, were rated as happier than descending harmonic minor scales, $M = 3.16$, $F(1, 23) = 17.26$, $p < .0001$.

Ascending minor modes did not differ in rated happiness, $F(2, 46) = 1.9$, n.s.

Descending minor modes did not differ in rated happiness, $F(1, 23) = 0.15$, n.s.

Individual key analyses. Comparisons of individual keys within each of the modes was also carried out:

Ascending natural minor modes, $F(5, 115) = 5.73$, $p < .0001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that g, $M = 4.46$, and b, $M = 4.79$, were rated as happier than c♯, $M = 3.54$, and that b was rated as happier than d♯, $M = 3.67$.

Ascending melodic minor modes, $F(5, 115) = 6.83$, $p < .0001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that b, $M = 5.21$, was rated as happier than f, $M = 3.71$, and d♯, $M = 3.79$, and that c♯, $M = 3.96$, and a, $M = 4.87$, were happier than f and d♯.

Descending natural/melodic minor modes, $F(5, 115) = 4.67$, $p < .001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that b, $M = 3.83$, was rated as happier than d♯, $M = 2.67$, and c♯, $M = 2.63$.

Ascending harmonic minor modes, $F(5, 115) = 2.45$, $p < .05$, but a post hoc Tukey's HSD test, $p < .05$, revealed that no pairwise comparisons were significantly different.

Descending harmonic minor modes did not differ significantly as a function of key, $F(5, 115) = 2.11$, $p = .069$, although this difference approached significance.

Awkwardness

Across-key analyses. Minor scale form influenced ratings of awkwardness, $F(4, 92) = 4.69$, $p < .002$, and several a priori comparisons were carried out:

Ascending minor scales, $M = 3.67$, were rated as more awkward than descending minor scales, $M = 3.45$, $F(1, 23) = 8.22$, $p < .009$.

Natural minor scales, $M = 3.67$, were not rated as significantly more awkward than harmonic minor scales, $M = 3.69$, $F(1, 23) = .014$, n.s.

Ascending natural minor scales, $M = 3.99$, were rated as more awkward than descending natural minor scales, $M = 3.35$, $F(1, 23) = 5.95$, $p < .023$.

Ascending harmonic minor scales, $M = 3.82$, were not rated as more awkward than descending harmonic minor scales, $M = 3.55$, $F(1, 23) = 2.96$, $p < .099$, although this difference approached significance.

Ascending minor modes were rated significantly different, $F(2, 46) = 7.44$, $p < .01$. The ascending melodic mode, $M = 3.19$, was rated as less awkward than the ascending harmonic mode, $M = 3.82$, $t(23) = 3.27$, $p < .01$, and the ascending natural mode, $M = 3.99$, $t(23) = 3.07$, $p < .01$.

Descending minor modes were not rated differently from each other, $F(1, 23) = 1.30$, n.s.

Individual key analyses. The mean ratings for the awkwardness of the ascending natural minor mode, ascending melodic minor mode, descending natural/melodic minor mode, ascending harmonic minor mode, and the descending harmonic minor mode are listed in Table 2 for each of the individual keys. No significant differences between keys were found for ratings of awkwardness.

DISCUSSION

Ratings of perceived happiness or sadness and ratings of perceived awkwardness were influenced by the direction and form of the scales. The ascending variations of all minor modes were perceived as happier than were the descending variations. These findings are consistent with those of Collier and Hubbard (in press), who found that the ascending C major scale was rated as happier, brighter, and faster and as speeding up more than the descending C major scale. The findings are also consistent with Trehub et al.'s (1987) findings that both children

and adults rotated a pointer to a happy face for ascending sequences and to a sad face for descending sequences.

In addition, the ascending melodic minor mode was rated as being less awkward than the ascending natural and harmonic minor modes. The ascending melodic minor mode ends with a whole step followed by a half step, whereas the ascending harmonic minor mode ends with a one-and-a-half step followed by a half step, and the ascending natural minor mode ends with a whole step followed by another whole step. It may be that the smaller ascending final step results in the ascending melodic mode being perceived as less awkward. Thus, it is not step size per se that influences awkwardness; rather, it may be the step size relative to the previous pitch motion.

A closer examination of the intervals in the minor modes reveals another difference in the scale step size between the melodic, harmonic, and natural minor modes. The ascending melodic minor mode raises both the sixth and seventh notes a half step, resulting in the last two intervals in the melodic mode being a whole step and a half step. The last two intervals in the natural minor mode are whole steps, whereas the last two intervals for the harmonic mode are one and a half and one half steps. The smaller intervals at the end of the melodic mode may lead participants to judge the melodic mode as being less awkward because the jump from note to note is smaller and so the end of the scale is perceived as being more stable. Another possibility may be musical education. People with more musical experience and education in music theory may be taught that the melodic minor mode "tends to lead up" because the sixth and seventh scale degrees are both raised a half step. This could explain why participants with more musical experience rated the ascending melodic mode as being less awkward than did those with less musical experience.

Ratings of perceived happiness or sadness were also influenced by musical key, with scales in b rated as happier and scales in d♯ or c♯ rated as sadder. This may result from effects of pitch height because keys starting at higher pitches were rated as happier, brighter, and faster and as speeding up more than keys starting at lower pitches. This conclusion agrees with Collier and Hubbard's (in press) finding that tones at a higher pitch are rated as happier, brighter, and faster and as speeding up more than tones at a lower pitch. However, there is one exception in the ascending melodic minor mode, where c♯ was rated as happier than f and d♯. It is unclear what would explain this outcome. The key of the scale did not influence ratings of perceived awkwardness. The dissociation between ratings of happiness or sadness and ratings of awkwardness for individual keys is interesting because it suggests that the perceived happiness or sadness of a scale is not a function solely of the extent to which a scale more naturally "leads up" or "leads down."

Overall, the results of Experiment 1 suggest that neither mode structure nor musical key is a determining factor for judgments of happiness or sadness and of awkwardness. Rather, the direction of the pitch movement (i.e., contour) and pitch height are primary. Ascending sequences were perceived as happier, and descending sequences were perceived as sadder. Although it was predicted that tones in the melodic and harmonic natural minor mode would more naturally "lead up," the greater perceived awkwardness of all three ascending variations of the minor modes is consistent with suggestions that all forms of the minor mode more naturally "lead down." Such a general tendency of minor scales to "lead down" is consistent with previous observations that minor chords and music in minor keys are perceived to be sadder than major chords and music in major keys (as in Crowder, 1984; Trehub et al., 1987).

EXPERIMENT 2

If the musical structure of a specific scale is important in determining perceived happiness or sadness and perceived awkwardness, then it should be possible to observe differences in perceived happiness or sadness and perceived awkwardness when the key of a scale is held constant and the spacing between the elements of the scale is varied. Experiment 2 tested this hypothesis and the generalizability of the findings from the three minor modes by having participants rate the perceived happiness or sadness and perceived awkwardness of scales based on the relative major mode. The relative major mode contains musical scales that have the same key signature as scales in the minor modes but in which the relative spacing of the adjacent notes differs. In other words, scales in the relative major mode have the same key signature but begin and end on different tone pitches, with the relative major mode beginning three half steps above the minor mode (see Table 1). If the structure of a scale is important, then we would not expect relative major scales to result in the same pattern of ratings as the minor scales in Experiment 1. However, if direction or key contributes more to perceived happiness or sadness and to perceived awkwardness, then we would expect relative major scales to result in a pattern of ratings similar to those of the minor scales in Experiment 1.

METHOD

Participants

Twenty-two participants (11 men and 11 women) from the same pool used in Experiment 1 were recruited, and none of them had participated in Experiment 1.

Apparatus

The apparatus was the same as in Experiment 1.

Stimuli

The timbre, tempo, and duration of scale tones were the same as in Experiment 1. The scales either ascended or descended and were relative major scales (B♭, C, D, A♭, E, F♯) based on the minor keys (g, a, b, f, c♯, d♯) used in Experiment 1. The rating scales were the same as in Experiment 1.

Design

Each participant received 60 trials (6 keys × 2 directions × 5 ratings) in a different random order.

Procedure

The procedure was the same as in Experiment 1.

RESULTS

As in Experiment 1, a preliminary analysis examining potential effects of musical experience and gender was carried out. Across-key analyses and individual key analyses (which collapsed across musical experience and gender) were then carried out on ratings of perceived happiness or sadness and ratings of perceived awkwardness.

Preliminary analyses

As in Experiment 1, a preliminary analysis using a median split of musical experience was carried out. Musically inexperienced participants, $M = 0.53$, range = 0 to 1 year, and musically experienced participants, $M = 2.88$, range = 1 to 5.3 years, did not differ in ratings of perceived happiness or sadness or in ratings of perceived awkwardness. No gender differences were found. Subsequent analyses collapsed over gender and experience factors, with ratings of perceived happiness or sadness and ratings of perceived awkwardness analyzed in separate within-subject ANOVAs. The mean ratings for Experiment 2 are presented in Table 3.

Happiness

Across-key analyses. As predicted, the ascending relative major scale was rated as being happier, $M = 4.70$, than the descending relative major scale, $M = 3.79$, $F(1, 21) = 18.4$, $p < .0001$.

Individual key analyses. The mean ratings for individual keys differed on ratings of happiness or sadness, $F(5, 105) = 6.44$, $p < .0001$. Comparisons of individual keys within each of the directions for the relative major scale were also carried out. The mean ratings for happiness of the relative major scale for each of the individual keys are listed in Table 3.

Table 3. Mean ratings of relative major keys in Experiment 2

	Key					
	B♭	C	D	A♭	E	F♯
Ascending relative major						
Happiness	5.45	3.95	4.27	4.82	4.82	4.91
Awkwardness	3.18	2.77	3.05	3.82	2.73	2.77
Descending relative major						
Happiness	4.50	3.27	3.64	3.82	3.68	3.82
Awkwardness	3.41	3.32	3.36	4.27	2.86	3.27

Note. All ratings were based on a 7-point scale, with smaller numbers indicating less (i.e., less happy, not awkward) and larger numbers indicating more (i.e., more happy, awkward).

Ascending relative major scale, $F(5, 105) = 4.83$, $p < .001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that B♭, $M = 5.45$, was rated as happier than C, $M = 3.95$, and D, $M = 4.27$.

Descending relative major scale, $F(5, 105) = 2.82$, $p < .05$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that B♭, $M = 4.50$, was rated as happier than C, $M = 3.27$.

Awkwardness

Across-key analyses. The awkwardness ratings of ascending and descending relative major scales were not significantly different.

Individual key analyses. The mean ratings for individual keys differed on ratings of awkwardness, $F(5, 105) = 5.05$, $p < .0001$. Comparisons of individual keys within each of the directions of the relative major scale were also carried out. The mean ratings for awkwardness of the relative major scale for each of the individual keys are listed in Table 3.

Ascending relative major scale, $F(5, 105) = 1.99$, $p = .085$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed no significant differences.

Descending relative major scale, $F(5, 105) = 3.51$, $p < .01$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that A♭, $M = 4.27$, was rated as being more awkward than E, $M = 2.86$.

DISCUSSION

Ratings of perceived happiness or sadness were influenced by the direction of the relative major scale, but ratings of perceived awkwardness were not influenced by the direction of the relative major scale.

The effect of direction on ratings of happiness or sadness is consistent with the findings for minor mode scales observed in Experiment 1, but the lack of an effect of direction on ratings of awkwardness differs from the findings for minor mode scales observed in Experiment 1. The scales used in Experiments 1 and 2 were based on the same key signatures, so the primary difference between the scales used in Experiments 1 and 2 involves the pitch intervals between the adjacent tones of the scales in the different musical modes (i.e., minor mode versus major mode). Therefore, one possible conclusion is that differences in rated awkwardness are largely a function of differences in pitch intervals but that differences in rated happiness are not influenced by differences in pitch intervals. Ratings of perceived happiness were also influenced by the key of an individual scale, with scales in B♭ rated as happier than scales in C.

As in Experiment 1, ratings of awkwardness generally were not influenced by musical key, but there was one notable exception: In Experiment 2, the descending A♭ scale, $M = 4.27$, was rated as being more awkward than the descending E scale, $M = 2.86$. In the A♭ major scale four notes are lowered by a one half step (i.e., the A♭ major scale contains four flats), and participants may attribute the flats in the descending A♭ scale as "overshooting" the appropriate tone. In the E major scale, on the other hand, four notes are raised by one half step (i.e., the E major scale contains four sharps) that participants might hear as slowing down or being more stable than the A♭ scale. In this case, participants are expecting to hear a normal tone; instead they hear four lowered tones in the A♭ scale, and it sounds more awkward or less stable. However, if the number of flats or lowered notes were the explanation, then this pattern should have also been found in the relative minor scale of f (relative to A♭ major) in Experiment 1 as compared to the c♯ (relative to E major scale) relative minor scale, and it was not.

EXPERIMENT 3

The musical scales in the relative major modes used in Experiment 2 had the same key signatures as the scales in the minor modes used in Experiment 1; thus, the key signature was constant, but the starting and stopping pitches of the scales in the minor and relative major modes varied. Varying the starting and stopping pitches resulted in the scales used in Experiments 1 and 2 covering slightly different pitch ranges. Given that higher pitches are perceived as happier, brighter, and faster and as speeding up more than lower pitches (Collier & Hubbard, in press), it may be that the findings of Experiments 1 and 2 on scale direction were simply a result of pitch height. To test this notion, it was

necessary to keep the starting and stopping notes constant while varying the key signature. One way to do this is to have participants make the same judgments as in Experiments 1 and 2 on ascending and descending scales in the parallel major mode. As has already been pointed out, scales in the relative major and minor modes begin and end on different notes while maintaining the same key signature. However, musical scales in the parallel major and minor modes begin and end on the same tone but differ in the sequence of intervals that result from their different key signatures (see Table 1). Accordingly, in Experiment 3, participants' perceptions of happiness or sadness and of awkwardness for ascending and descending scales in the parallel major mode were measured.

METHOD

Participants

Twenty-two participants (9 men and 13 women) from the same pool used in Experiment 1 were recruited, and none of them had participated in Experiments 1 or 2.

Apparatus

The apparatus was the same as in Experiment 1.

Stimuli

The timbre, tempo, and duration of scale tones were the same as in Experiment 1. The scales either ascended or descended and were parallel major scales (G, A, B, F, C♯, and E♭) based on the minor keys (g, a, b, f, c♯, and d♯) used in Experiment 1. The rating scales were the same as in Experiment 1.

Design

Each participant received 60 trials (6 keys × 2 directions × 5 ratings) in a different random order.

Procedure

The procedure was the same as in Experiments 1 and 2.

RESULTS

As in Experiments 1 and 2, a preliminary analysis examining potential effects of musical experience and gender was carried out. Across-key analyses and individual key analyses (which collapsed across musical experience and gender) were then carried out on ratings of perceived happiness or sadness and ratings of perceived awkwardness.

Preliminary analyses

As in Experiments 1 and 2, a preliminary analysis using a median split of musical experience was carried out. Musically inexperienced participants, $M = 0.44$, range = 0 to 1 year, and musically experienced participants, $M = 2.73$, range = 1.2 to 4.8 years, did not differ in ratings of perceived happiness or sadness or in ratings of perceived awkwardness. No effects of gender were found, and subsequent analyses collapsed over gender and experience factors. The mean ratings for Experiment 3 are presented in Table 4.

Happiness

Across-key analyses. As predicted, the ascending parallel major scale was rated as being happier, $M = 4.39$, than the descending parallel major scale, $M = 3.63$, $F(1, 21) = 14.97$, $p < .001$.

Individual key analyses. The individual keys differed significantly from each other on ratings of happiness or sadness, $F(5, 100) = 9.24$, $p < .0001$. Comparisons of individual keys within each direction of the parallel major scale were also carried out. The means for each individual key are presented in Table 4.

Ascending parallel major scale, $F(5, 100) = 4.56$, $p < .001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that G, $M = 4.90$, and B, $M = 5.19$, were rated as happier than C♯, $M = 3.62$. In addition, B, $M = 5.19$, was also rated as happier than F, $M = 3.95$.

Descending parallel major scale, $F(5, 100) = 6.09$, $p < .001$, and a post hoc Tukey's HSD test, $p < .05$, of all pairwise comparisons revealed that G, $M = 3.95$, A, $M = 4.29$, and B, $M = 4.33$, were rated as happier than

Table 4. Mean ratings of parallel major keys in Experiment 3

	Key					
	B	A	G	F	E♭	C♯
Ascending parallel major						
Happiness	5.19	4.62	4.90	3.95	4.29	3.62
Awkwardness	3.05	2.33	2.29	2.95	2.67	3.00
Descending parallel major						
Happiness	4.33	4.29	3.95	3.43	3.00	2.81
Awkwardness	3.14	3.48	2.76	2.71	3.00	2.95

Note. All ratings were based on a 7-point scale, with smaller numbers indicating less (i.e., less happy, not awkward) and larger numbers indicating more (i.e., more happy, awkward).

C♯, $M = 2.81$. In addition, A, $M = 4.29$, and B, $M = 4.33$, were rated as happier than E♭, $M = 3.00$.

Awkwardness

Across-key analyses. The awkwardness ratings of ascending and descending parallel major scales were not significantly different.

Individual key analyses. The individual keys were not significantly different from each other on ratings of awkwardness.

DISCUSSION

Ratings of perceived happiness or sadness were influenced by the direction of the parallel major scale, but ratings of perceived awkwardness were not influenced by the direction of the parallel major scale. This pattern is similar to that observed with scales in the relative major mode in Experiment 2 and differs from the patterns observed with scales in the minor modes in Experiment 1. Experiment 3 kept the beginning and ending pitches of the scales the same as those used in Experiment 1, ruling out the effect of pitch range for the difference in findings between the minor and major modes. The most likely explanation is that the difference in ratings of happiness or sadness and ratings of awkwardness between the major and minor modes in Experiments 2 and 3 and in Experiment 1 resulted from modal structure. Ratings of perceived happiness or sadness were also influenced by the key of an individual scale, with scales in G and B rated as happier than scales in C♯ and scales in B rated as happier than scales in F. As in Experiments 1 and 2, awkwardness ratings were not influenced by key.

GENERAL DISCUSSION

Musical scales in the ascending minor, relative major, and parallel major modes were rated as happier than scales in the descending minor, relative major, and parallel major modes. The failure to find consistent differences between musical scales in the melodic, harmonic, and natural minor modes, coupled with the similarity in patterns of ratings for scales in the relative and parallel major modes, suggests that pitch direction may be more responsible for ratings of happiness or sadness than either individual tones per se or the musical mode. Additionally, ascending minor scales were rated as more awkward than descending minor scales, but effects of direction on awkwardness ratings were not found with either relative major or parallel major scales. This pattern suggests that descending versions of scales in all the minor modes may

more naturally lead down, resulting in the descending version of scales in the minor modes being more stable. Although such a pattern was predicted for scales in the natural minor mode, it was not predicted for scales in the harmonic and melodic minor modes.

The particular key of a given scale also influenced ratings of happiness or sadness, and this was true for minor, relative major, and parallel major scales. Usually, scales beginning (and ending) on higher pitches were rated as happier than scales beginning (and ending) on lower pitches. This linking of higher pitch and more positive affect is consistent with Collier and Hubbard's (in press) finding that tones at a higher pitch are rated as being happier, brighter, and faster and as speeding up more than tones at a lower pitch. Unlike ratings of happiness or sadness, ratings of awkwardness were not influenced by the particular key of the scale. The dissociation between ratings of happiness or sadness and ratings of awkwardness for individual keys is interesting because it suggests that the perceived happiness or sadness of a scale is not a function solely of the extent to which a scale more naturally "leads up" or "leads down"; rather, the results of Experiments 1, 2, and 3 suggest that the perceived happiness of a scale is related more to pitch height and to the direction of pitch motion.

The data reported here suggest that emotional responses to music do not depend on the mode or other harmonic aspects of music. Although chord structure and other elements of key may certainly contribute to the overall affective response, the data from Experiments 1, 2, and 3 suggest that the rise and fall of the melody (or perhaps other pitches) may define whether the emotional response is of happiness or sadness. Such a pattern is consistent with Kastner and Crowder's (1990) otherwise puzzling finding that harmonic accompaniment diminished the emotional valence of music. The data from Experiments 1, 2, and 3 are also consistent with Trehub et al.'s (1987) finding that ascending musical scales were perceived as happy and descending musical scales were perceived as sad. Crowder (1984) reported that minor chords were perceived as sadder than major chords, and on this basis we might have predicted that minor scales would be perceived as sadder than major scales in both Trehub et al. and in the data reported here. Experiments 1, 2, and 3 did not directly compare minor, relative major, and parallel major scales, but inspection of Tables 2, 3, and 4 reveals a general similarity of ratings. By having different groups of participants rate different scale types, it was possible to avoid stereotypic responding (e.g., participants' judging minor keys as sadder than major keys because of cultural convention, as in cinema soundtracks), so the data reported here offer a useful control for previous reports.

In conclusion, the musical mode per se does not seem to contribute to the perception of happiness or sadness. Rather, whether a given sequence of notes in a musical scale is perceived as happy or sad is determined primarily by the direction of pitch motion and by pitch height; for scales in both the minor and major modes of music, ascending higher-pitch sequences were rated as happier than were descending lower-pitch sequences. Musical accompaniment or harmony per se would not thus be necessary for evoking happiness or sadness. Indeed, to the extent that such accompaniment detracts from the pitch motion and pitch height of the melody, we might even expect accompaniment to decrease the evocation of happiness, and although counterintuitive, such a notion is consistent with the data of Kastner and Crowder (1990) that suggested that emotional response was decreased by harmonic accompaniment. However, musical mode does seem to influence ratings of awkwardness of a sequence of notes in a musical scale. Ascending scales in the minor modes were rated as more awkward than descending scales in the minor modes, whereas no effect of direction on awkwardness was seen with scales in the major mode.

Notes

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1. By convention, the names of minor scales are denoted by lowercase letters, and the names of major scales are denoted by uppercase letters.

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