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Manipulating Greek musical modes and tempo affects perceived musical emotion in musicians and nonmusicians

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Abstract

The combined influence of tempo and mode on emotional responses to music was studied by crossing 7 changes in mode with 3 changes in tempo. Twenty-four musicians aged 19 to 25 years (12 males and 12 females) and 24 nonmusicians aged 17 to 25 years (12 males and 12 females) were required to perform two tasks: 1) listening to different musical excerpts, and 2) associating an emotion to them such as happiness, serenity, fear, anger, or sadness. ANOVA showed that increasing the tempo strongly affected the arousal ($F(2,116) = 268.62$, mean square error (MSE) = 0.6676, $P < 0.001$) and, to a lesser extent, the valence of emotional responses ($F(6,348) = 8.71$, MSE = 0.6196, $P < 0.001$). Changes in modes modulated the affective valence of the perceived emotions ($F(6,348) = 4.24$, MSE = 0.6764, $P < 0.001$). Some interactive effects were found between tempo and mode ($F(1,58) = 115.6$, MSE = 0.6428, $P < 0.001$), but, in most cases, the two parameters had additive effects. This finding demonstrates that small changes in the pitch structures of modes modulate the emotions associated with the pieces, confirming the cognitive foundation of emotional responses to music.

Key words: Greek musical modes; Musical tempo; Emotional responses to music; Musical expertise

Introduction

During the last decade, an increasing amount of research has been devoted to the emotional response to music. One aim was to show that listeners' musical emotions are aroused in a consistent way. Such consistency was indeed found in both adults and children (1), among participants of different cultures (2) and when participants reran the experiment after an interval of several weeks (3). Musical emotion is, thus, suitable for scientific investigation and several issues of interest are currently being addressed. For example, what is the psychological structure of the emotional response to music? Which musical parameters govern emotional responses? What is the time course of emotional responses? What processes are involved in the induction of emotion? (4).

Two of these questions have been the subject of extensive debate. The first addresses the relationship between the categorical and dimensional aspects of emotional experience in music. It is generally considered that emotions associated with musical pieces belong to four main categories: happiness, serenity, anger (or fear), and sadness. However, these categories are not mutually exclusive: in some cases, mixed feelings have been reported, with music being perceived as both happy and sad at the same time (1,5,6). An alternative view is that these four categories are organized along the two main dimensions of arousal and valence. In Russel's circumplex model of affect (7), happiness and anger are located at the top of the vertical (arousal) axis, and serenity and sadness are located at the bottom. On the horizontal axis (valence), happiness and serenity are more positive emotions than anger and sadness and so these pairs are located on the right and left side, respectively, of this axis of Russel's space. It should be noted that the valence dimension in music does not deal with emotional pleasantness or unpleasantness, as is the case for most emotional measures. A sad piece of music (negative valence) may be perceived as very pleasant,

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and vice versa (3). The dimensional approach assumes that manipulating appropriate features of a piece of music changes the emotion experienced by listeners along both arousal and valence axes. Support for a dimensional approach was reported both in multivariate studies (3), and in brain-imaging studies, which identified the neural correlates of each of these axes (8).

A second main research question addresses the parameters that influence emotional responses to music. Several parameters have been identified, such as interval (8), melodic contour (6), tonal function and harmony (9), texture (10), and mode and tempo (1). The effects of the latter parameters have been the most systematically investigated, and it is remarkable that this investigation started at the beginning of the last century (11).

There are several modes in western music, of which two have predominated since the XVII century: the major and the minor modes. Each one has its particular scale or set of pitch intervals (see below for more details). Many studies have demonstrated that the major mode is associated with happiness, and the minor mode with sadness. The effect of the mode transpires outside the musical domain: prosodic sentences containing a minor 3rd are thought to be sadder than those having a major 3rd (12). Several explanations have been proposed to account for the effect of major versus minor mode. According to some investigators, the mode effect has its origin in the relationship between the 1st and the 3rd formant of the human voice (13). Other investigators have suggested that the effect of mode comes from the psychoacoustic constraints that govern perceptual organization. The minor 3rd, but not the major, lies at the boundary of a perceptual fusion of sounds. This suggestion may explain why a small change in pitch interval can have such a strong emotional effect on listeners (4).

The effect of mode prompts consideration of the possible influences of the organization of pitch structures (14). In addition to the modal effect, it was shown that temporal structures (rhythm or tempo) contribute to emotion. Slow pieces tend to be perceived as less happy than fast pieces. Interestingly, the effect of mode qualifies the effect of tempo, with pieces in major mode being judged as happier when played at a faster tempo. Similarly, pieces in minor mode are judged as sadder when played in a slow tempo. Musical pieces of mixed cues (major mode with slow tempo, or minor mode with fast tempo) are ambiguous stimuli that can be judged as moderately sad, or happy (1), or that can result in mixed feelings (sad and happy experienced at the same time) (6).

The effects of tempo and mode may also be accounted for, in a multidimensional approach to emotion, by considering that both parameters modify the arousal and the valence of the emotions. Tempo is generally assumed to influence the arousal more than the valence of emotion: the faster the tempo, the higher the arousal. Some authors also report an effect of tempo on happiness judgments: the faster the tempo, the happier the evaluation (10). By contrast, mode was generally shown to influence more the valence of emotion than the arousal, with the major mode being associated with positive emotions, and the minor mode with negative emotions (1).

Most of the current research used a 2 mode (major versus minor) x 2 tempo (fast versus slow) factorial design (1) and focused on the effects that these parameters have on happiness versus sadness. This design may result in a possibly oversimplified understanding of emotional responses to music: musical emotions are sad or happy and the strength of these emotions is modulated by the tempo. Major and minor modes are two examples of the seven Greek modes of western music. Interestingly, Greek modes have a longer history in western culture than the major and minor modes. In antiquity, they were associated with different social contexts, suggesting that they were inducing a specific mood in listeners, some of them being more appropriate to one context than another. The seven modes dominated western music, most notably all the religious plainsong chants of the middle ages, up to the beginning of the Renaissance (16th century). From this time, the major mode (Ionian) and minor mode (directly deriving from the Aeolian mode) started to dominate the music of all subsequent periods: baroque, classical, romantic, and modern. But the seven modes never completely disappeared, either in serious music (several great composers used them), or in popular music. They are often heard in jazz improvisation and in Brazilian popular music. The seven modes have thus a long history, and are still alive in several musical styles, suggesting that their specific scales or organization of intervals tap into a robust process governing emotional responses to music.

From a cognitive point of view, the main feature of the modes is that each is built from the fixed set of 7 tones (C, D, E, F, G, A, B), and, consequently, on the same set of pitch intervals. The critical difference is that a different tone acts as the reference tone in each mode. The mode is actually defined by the pitch intervals between all the other tones and this reference tone. In the Ionian mode (corresponding to the well-known "major mode"), the note C acts as the reference tone. In the Dorian mode, it is the note D. The other modes (Phrygian, Lydian, Mixolydian, Aeolian, and Locrian) have the notes E, F, G, A, and B, respectively, as reference tones. The modes may be transposed to different keys but, for convenience, we will refer to the modes in the C major key (on the piano, using just the white notes), as described above. The pitch intervals and reference tones contribute to a musical expression specific to each mode. In the Ionian, Lydian, and Mixolydian modes, the interval between the 3rd and the reference tone is of four semitones, which defines a major 3rd. For this reason, these modes are usually said to be "major modes". By contrast, this interval is of three semitones in all other modes, which are therefore said to be "minor modes".

Modes differ in several other pitch intervals. For example, in the Lydian mode, the pitch interval between the reference tone (F) and the 4th tone (B) is a very dissonant interval of six semitones. This interval (augmented 4th) was referred to in the past as the “diabolus in musica”, suggesting that it has a very specific “diabolic” emotional effect (15). This interval is replaced by a perfect 4th in the Ionian and Mixolydian modes (C-F and G-C), respectively. The Mixolydian mode differs from the Ionian mode in having an interval of a minor seventh between the reference tone (G) and the last tone (F).

According to Wisnik (16), these differences in pitch intervals in reference to the 1st tone of the mode allow the obscurity/clarity sensations evoked by the seven modes to be scored in a linear way. The clearest mode is the Lydian, followed in order by the Ionian, Mixolydian, Dorian, Aeolian, Phrygian, and the Locrian modes. This last mode is considered to evoke the darkest sensations, because it exhibits numerous minor intervals with the reference tone, plus the diminished 5th noted above. Wisnik’s theory (16) suggests that the valence of musical emotion would tend more to the negative as the darkness of the mode increases: that is to say, when the pitch intervals with the reference note of the mode more frequently correspond to minor or diminished intervals. Addressing the psychological impact of these modes would further our understanding of the effect of scale structures on musical emotion. If it is shown that modifying the reference note of a given set of notes is enough to modulate perceived emotions in listeners, this would provide some evidence that emotional responses to music are deeply rooted in cognition. As such, this would contribute to the understanding of the process involved in music emotion (4).

Manipulating the effects these modes and tempi allow can lead to the investigation of several other issues of interest. The processing of the pitch and time dimensions of music has long been a matter of debate in cognitive psychology. How do the pitch and time dimensions combine for emotion? The effect of modes is likely to be modulated by tempo, but it remains difficult to anticipate how the two structures will combine. An additive model would suppose that changes in tempo would have more or less the same effect in all modes. An interactive model predicts that changes in tempo would result in different effects, as a function of mode. Some findings reported by Webster and Weir (10) support the interactive model. Increasing the tempo of non-harmonized melodies in the major modes renders the music happier; but a reverse effect of tempo was found for minor music. Independent effects, however, were not found for harmonized pieces. These studies, however, contrasted only two modes, and focused on the distinction between happy and sad only. The present study further investigated this issue. Since we manipulated two changes in tempo with seven changes in mode, the present design has more power to address the interdependence of the pitch and time dimensions.

The manipulation of several modes and tempi also contributes to understanding the structure of emotional responses to music. If emotional responses are organized along four main categories of emotion, changes in mode and tempo would result in sudden changes of perceived emotion from one category to another (serene, happy, sad, and angry). By contrast, if the responses are multidimensional, manipulating modes and tempi will result in progressive changes in perceived emotions along the arousal and valence dimension.

Subjects and Methods

Participants

We studied 30 participants who had at least 6 years of systematic study of at least one musical instrument (musicians), and 30 participants who had no experience in any study of music (nonmusicians). All participants were 18 to 25 years old (mean age 23.1 years).

Musical stimuli

The musical stimuli were three musical pieces, each of a 36-s duration, composed in the Ionian mode for the purpose of the experiment. These three excerpts were then played in other musical modes (Dorian, Phrygian, Lydian, Mixolydian, Aeolian, and Locrian). The change of mode does not affect the melodic contour, the rhythm or the loudness of a piece. The 3 x 7 excerpts were played at three different tempi of 72 (slow tempo), 114 (moderate) and 184 (fast) beats per minute. Thus, there were 63 musical excerpts in all. The volume at the average frequency of each stimulus was 50 dB. A piano timbre was chosen for the stimuli. The 63 musical excerpts were organized in blocks of 21, each block compiled randomly, the only constraints being that, within each block, the seven modes should occur with at least two different tempi, and at least one musical piece should appear in all three tempi.

Procedure

The study was approved by the Ethics Committee of the Faculty of Philosophy, Sciences and Letters of Ribeirão Preto (University of São Paulo) and all participants gave informed written consent before entering the study. Each participant performed the experiment with one block of 21 musical excerpts. The block icon appeared on a computer screen, each excerpt being represented by a loudspeaker. Participants listened freely to the excerpts by clicking on the icons. They then dragged in one of the following four categories: “happiness”, “sadness”, “serenity”, or “fear”/“anger” that were represented on the screen. They were told that they should drag icons of the pieces that were the most appropriate to one of the emotions. Participants were allowed to listen to the excerpts as many times as they wished. However, once a choice had been made, the

1st screen appeared again without the icon of the music chosen previously. The experiment lasted approximately 25 min while participants scored all the pieces. Once outside the experimental room, the participants completed an associated questionnaire, related to the degree of musical knowledge of each one.

Results

Table 1 presents the categories of emotion that were most often chosen by the participants, as a function of mode and tempo. Some of the excerpts parenthesized were not clearly associated with a dominant emotion. Percentage of responses found for other categories is also presented. None of these percentages approached the random level and in most cases (17 of 21 for both groups), a clear dominant emotion (receiving more than 50% of the responses) was found for the excerpts. For both groups, the most negatively correlated perceptions were those of happiness and sadness, r(20) = -0.77, $P < 0.001$, in musicians, and, r(20) = -0.66, in nonmusicians, $P < 0.001$. The suggestion is, then, that these two emotions are the most contrasted.

Table 1 shows that happiness was associated with fast tempi, and sadness with slow tempi. Sadness tended to be replaced by serenity and happiness as tempo increased. This tendency was found for all modes except the Phrygian and Locrian modes; in these cases, sadness tended to evolve toward fear-anger with increasing tempo. In order to take into account the complete set of emotions reported by the participants, we recoded the data by replacing each response with a non-parametric coordinate pair, depending on the valence and arousal values of the perceived emotions. Happiness responses were thus replaced with the pair (1, 1), because happiness can be understood as having high arousal (1) and positive valence (1). "Serenity" responses were replaced with the pair (-1, 1), since serenity can be understood as having low arousal, and positive valence. In the same way, "fear/anger" was replaced with the pair (1, -1) and "sadness" with the pair (-1, -1). By doing so, we could compute an average value of arousal and of valence for each of the 21 experimental conditions tested in this study.

Figure 1 displays the averaged values of arousal and valence found for musicians and nonmusicians as a function of mode and tempo for each experimental condition, confirming some of the tendencies exhibited in Table 1. When tempo increased, the emotions tended to have more positive valence and stronger arousal. This effect seemed to have been modulated by the mode.

In order to assess the effect of mode and tempo, we ran a first 3 (tempi) x 7 (modes) x 2 (musical expertise) ANOVA, with the 1st two factors as within-subject variables and the last one as the between-subject variable. The dependent measure was the coordinate of the pieces on the arousal dimension. An analysis was done to verify the combined effect of these variables on arousal values. The main effect

Table 1. Emotions most frequently chosen by musicians and nonmusicians listening to three pieces in different modes and tempi.

Mode	Tempo (beats per minute)		
	72	108	184
Musicians			
Lydian	Sadness (56.7%)*	Serenity (63.3%)	Happiness (90%)
Ionian	Serenity (63.3%)	Happiness (50%)	Happpiness (96.7%)
Mixolydian	Sadness (53.3%)*	Serenity (66.7%)	Happiness (80%)
Dorian	Sadness (56.7%)	Serenity (60%)	Happiness (73.3%)*
Aeolian	Sadness (53.3%)*	Serenity (46.7%)*	Happiness (53.3%)*
Phrygian	Sadness (70%)	(Serenity 33.3%; Sadness 33.3%; Fear/anger 30%)	(Happines 43.3%; Fear/anger 40%)*
Locrian	Sadness (60%)*	(Serenity 33.3%; Sadness 33.3%)*	Fear/anger (50%)
Nonmusicians			
Lydian	Serenity (63.3%)*	Serenity (56.7%)	Happiness (80%)
Ionian	Serenity (70%)	Happiness (66.7%)	Happpiness (100%)
Mixolydian	Serenity (70%)*	Serenity (50%)	Happiness (83.3%)
Dorian	Sadness (66.7%)	Serenity (50%)	Happiness (43.3%)*
Aeolian	Sadness (83.3%)*	Sadness (60%)*	(Happiness 43.4%; Fear/anger 40%)*
Phrygian	Sadness (63.3%)	(Serenity 33.3%; Sadness 33.3%)	Fear/anger (40%)
Locrian	Fear/anger (56.7%)*	Fear/anger (56.7%)*	Fear/anger (60%)

Data are reported as percent (mean). Pieces that were not associated with a dominant emotion are given in parentheses. *$P \leq 0.005$ compared to musicians' or nonmusicians' responses (ANOVA).

came from tempo, $F(2,116) = 268.62$, mean square error (MSE) = 0.6676, $P < 0.001$, with higher arousal values for faster tempi (see Figure 1). This effect was found on the change from slow to fast tempi, $F(1,58) = 429.73$, MSE = 0.755, $P < 0.001$, and it also reached statistical significance when slow and moderate tempi were compared, $F(1,58) = 23.43$, MSE = 0.6602, $P < 0.001$. The effect of tempo was slightly dependent on musical training, $F(6,348) = 2.62$, MSE = 0.6657, $P < 0.02$, with musicians being less sensitive to a change from slow to moderate tempi than nonmusicians.

ANOVA confirmed the significance of the effect of changes in mode on arousal, $F(6,348) = 8.71$; MSE = 0.6657, $P < 0.001$, which were nevertheless modulated

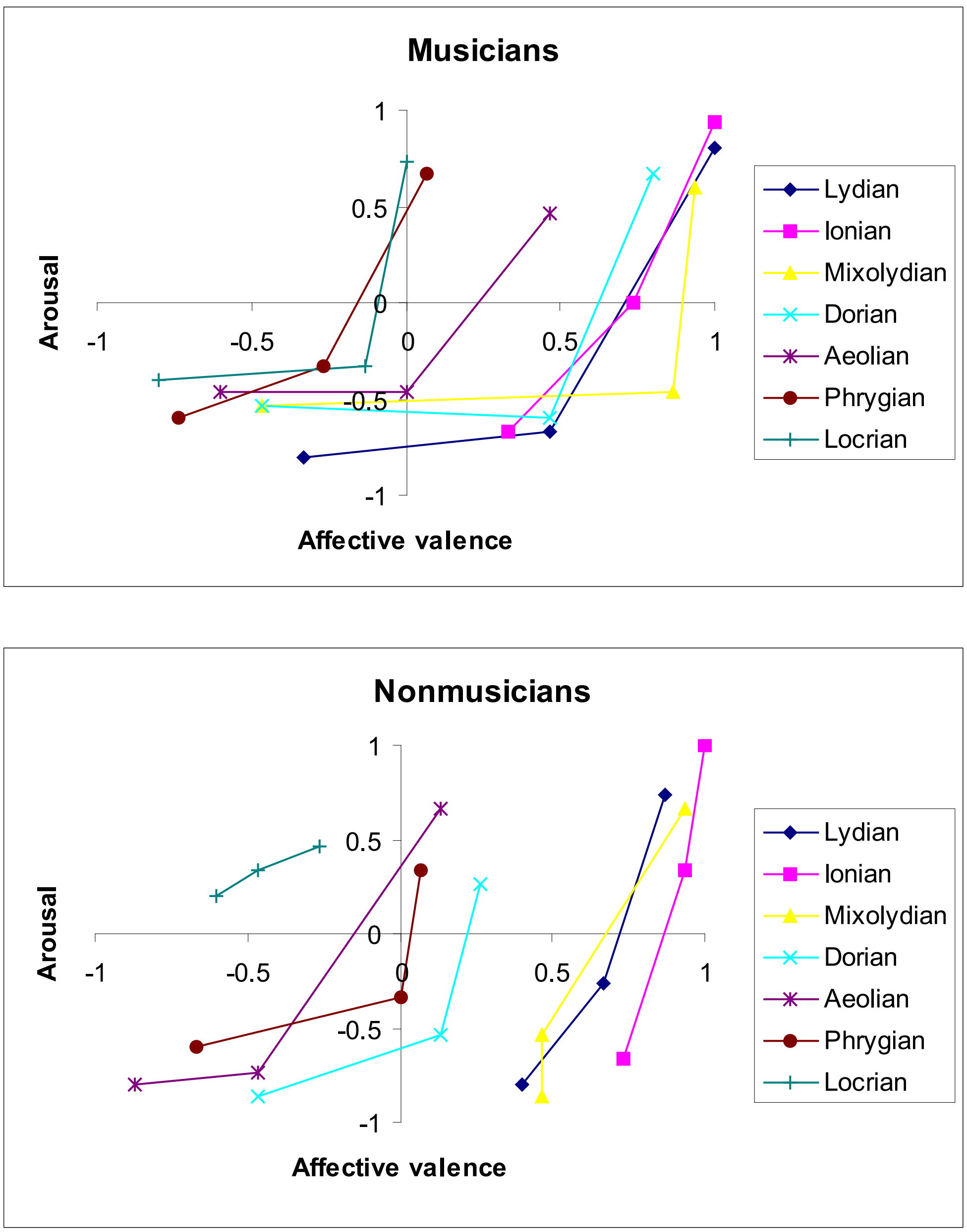

Figure 1. Arousal and affective valence of emotional responses to the modal excerpts (Lydian, Ionian, Mixolydian, Dorian, Aeolian, Phrygian, and Locrian) by nonmusicians and musicians. The three levels of each upward line indicate the three tempi employed: 72, 114, and 184 beats per minute.

by tempo, $F(12,696) = 3.60$, MSE = 0.6196, $P < 0.001$, and were further qualified by musical expertise, $F(6,348) = 2.62$, MSE = 0.6657, $P < 0.02$. The most arousing mode was the Ionian one for both groups of participants, $F(1,58) = 25.98$, MSE = 0.5082, $P < 0.001$. Among nonmusicians, the 2nd most arousing mode was the Locrian one, $F(1,58) = 25.60$, MSE = 0.9778, $P < 0.001$. The Lydian, Mixolydian, Dorian, Aeolian, and Phrygian modes did not significantly affect the perceived values of arousal. The two-way interaction between mode and tempo was seen in the change of tempo from slow to moderate, which had a stronger effect in the Ionian (and, for nonmusicians, Locrian) mode than in any other. By contrast, the arousal value of other modes (Lydian, Mixolydian, Dorian, Aeolian, and Phrygian) increased only with the fastest tempo. There was no other significant effect.

A similar analysis was carried out with the valence values of the chosen emotion.

Valence values changed considerably with mode and tempo. To assess the statistical significance of these changes, we ran a 3 (tempi) x 7 (modes) x 2 (musical expertise) ANOVA, with the 1st two factors as within-subject variables, and the last one as the between-subject variable, and with the coordinates of the musical excerpts on the valence dimension as the dependent measure. Tempo had a significant effect on valence, $F(2,116) = 84.81$, MSE = 0.8385, $P < 0.001$. Negative valence was associated with a slow tempo (-0.29), evolving toward positive values only when the tempo increased from moderate to fast (0.24 and 0.52, respectively). This tempo effect on valence was felt more by musically trained participants, as indicated by a significant two-way interaction, $F(2,116) = 8.46$, MSE = 0.8385, $P < 0.001$. There was a significant effect of mode, $F(6,348) = 56.21$, MSE = 0.6764, $P < 0.001$, which was modulated by musical training, $F(6,348) = 4.24$, MSE = 0.6764, $P < 0.001$. In both groups of participants, the three major modes (Lydian, Ionian, and Mixolydian) were more strongly associated with positive valence than were the four minor modes.

Furthermore, we were able to show that, beyond this straightforward effect of major versus minor modes, small changes in the scale structure caused by mode changes affected the valence of perceived emotion. Contrast analysis revealed a significant linear trend, $F(1,58) = 115.60$, MSE = 0.6428, $P < 0.001$, that supported Wisnik's theory (16) of modal clarity/darkness, i.e., negative valence significantly increased with darkness. Wisnik's theory, however, was not entirely confirmed for the three major modes. The Ionian mode was associated with a higher positive valence than the Lydian mode, $F(1,58) = 19.85$, MSE = 0.3498, $P < 0.001$, and there was no significant difference between the valences for the Lydian and Mixolydian modes. Wisnik's theory, however, was fully supported regarding the minor modes. Valence values became progressively more negative as pieces were presented first in Dorian, then Aeolian, Phrygian and Locrian modes: the linear trend was statistically significant, $F(1,58) = 13.59$, MSE = 0.7219, $P < 0.001$, in nonmusicians, but less so in musicians, $F(1,58) = 9.85$, MSE = 0.7219, $P < 0.01$. A further finding was that the Phrygian mode was associated with weaker negative valences than either the Aeolian or Locrian mode. This finding does not fit Wisnik's theory, and our data suggest that one permutation in the theory would allow a better fit. We propose a clarity/darkness axis as follows: Ionian, Lydian, Mixolydian, Dorian, Aeolian, Phrygian, and Locrian.

Discussion

Our data are very consistent with the effect of mode and tempo studies: minor modes are associated with emotions of greater negative valence than major modes, and this association is modulated by tempo. Faster tempi result in emotional judgments of higher arousal and more positive valence. The first new finding of the present study is that, beyond the usual "major/minor" distinction, small changes in the scalar structure, as found in other modes, modulated emotional responses. Differences in both arousal and valence were found between all major and all minor modes. Thus, the pitch interval between the 1st and the 3rd tone of the mode is not the only one that determines the emotional expression of the mode. For example, the Dorian and Aeolian modes have the same minor interval between the 1st and the 3rd tone of the mode; they differ only by one pitch interval between the 1st and the 6th tone. In the Dorian mode, the interval is a major 6th, and in the Aeolian mode, a minor 6th. This single difference in interval sufficed to modulate the valence value of the emotion associated with these modes. Similar comments may be made on other modes differing from each other only in one interval (such as Ionian versus Mixolydian or Lydian, and Locrian versus Phrygian). These results are consistent with those reported by Bueno and Ramos (14), with subtle changes in scale structure having a significant expressive effect on listeners.

This finding is important since it suggests that the well-established difference between major and minor modes is merely one special case of a more general process that governs musical emotion. As we noted above, the Greek modes all use the same set of tones. One of the main differences among them arises from their respective reference tones. Thus, musical events are perceived in relation to specific cognitive reference points that differ for each mode. The importance of cognitive reference points for music cognition in western tonal music was deeply investigated by Krumhansl (17). It is also well established that changes in cognitive reference point caused by changes in key are associated with highly expressive effects in tonal music. The present study extends this finding by showing that modifying the reference note of a given set of notes (i.e., change in mode) is enough to modulate emotional judgments. Hence, the cognitive foundation of emotional responses to music is supported.

The second main contribution of the present study was our investigation of the mutual contributions of pitch and time to the emotional response to music. This issue had been previously addressed mainly by experiments on cognitive tasks, but rarely investigated by analysis of emotional response.

As far as we know, the study by Webster and Weir (10) was the only one to report the interactive effect of changes in mode and tempo for unaccompanied melodies. This interaction leads to a very striking phenomenon, i.e., an increase in tempo makes the major melodies seem happier and the minor melodies angrier. This interactive effect suggests that tempo increases mostly the arousal value of the emotion: emotions of positive valence thus become "happy" when arousal increases. In contrast, emotions of negative valence become "angry" when arousal is increased due to a speeding up of tempo. Webster and Weir (10) did not replicate this experiment in accompanied melodies. The present data do not replicate similar interactions between mode and tempo. As illustrated by Figure 1, when tempo increased, emotional judgments increased both in arousal and in valence. In Russel's circumplex model, pieces thought to be sad tend to move up and right with increasing tempo. The statistical analysis showed some interactive effect of mode and tempo on the arousal dimension; this interactive effect was caused mostly by a moderate increase in tempo, being sufficient to increase the arousal value of melodies in the Ionian and Locrian mode (in nonmusicians only). In sum, our data fit better an additive model, suggesting that mode and tempo make independent contributions to emotional judgment.

The present data also contribute to our understanding of the structure of emotional experience in listening to music. Although it is believed that emotions associated with musical pieces belong to the four main categories of emotion, it is not clear whether emotional experience may be satisfactorily captured by this categorical approach. A two-dimensional model of emotion may provide a better explanation. The model postulates that an infinite number of emotions may be experienced with music, characterized by the combination of their valence and arousal values. Performing variations in musical parameters (such as mode and tempo) offers the opportunity to contrast the categorical and dimensional models. Indeed, if emotions are perceived as categorical, the responses of the participants to these variations should be of a categorical nature. That is to say, up to a certain point, manipulations of the stimuli should not have a strong effect on the category of emotion perceived. At this categorical boundary, a small change in stimuli should result in a shift in the category of emotion perceived. The two-dimensional approach to musical emotion allowed us to forecast that manipulations of one parameter (scale structure or tempo) are likely to modulate progressively the emotions perceived along the other dimension (arousal or valence, as the case may be). As such, some changes in categories (happy to sad or serene to angry) were unlikely to occur, or, at least, less likely to occur than changes in category along one dimension. Figure 1 provides some evidence that manipulating parameters like mode and tempo did not result in sudden changes between the four categories. Sad music tended to become serene before being perceived as happy as tempo increased, and vice versa. Within the constraint of mode-specific expression, this effect of tempo results in trajectories covering different points of Russel space. This in turn suggests that appropriate manipulations of pitch and time structure could lead composers to induce a wide variety of emotions measured by both valence and arousal.

The last issue investigated in the present study was the possible influence of musical expertise on musical emotion. The effect of musical expertise on cognition has been documented, with some investigators emphasizing the difference between the two groups of listeners (3,18), and others emphasizing the paucity of these differences in the light of the large difference in musical training. The way musical expertise influences emotional responses to music has rarely been assessed and several hypotheses may be considered. It is usually believed that musical experts process musical structure in a more refined way than nonmusicians. This hypothesis may suggest that nonmusicians tend to respond to subtle musical structure in a way comparable to that of musicians. One possibility is to consider that the emotional response of experts is less refined because experts process music in more of a cognitive than an affective mode. However, if we consider that the emotional response is (at least in part) rooted in the processing of musical structures, we could anticipate experts and novices to have different emotional responses because experts process these structures in a more accurate way. The present study goes toward this point. As described above, the difference between modes is so refined, that musically trained listeners were likely to be more sensitive than novices to the differences. It turned out that both groups were highly responsive to the manipulations of modes and tempi; there were only slight differences between them, consistent with other studies on emotion (3).

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