Music Perception
Fall 2004, Vol. 22, No. 1, 79–115

The Role of Peripheral Feedback in Emotional Experience With Music

NICOLA DIBBEN
University of Sheffield, U.K.

Given evidence from other domains that peripheral feedback can influence emotional experience, two experiments are reported that investigate the role of physiological arousal in determining the intensity and valence of emotion experienced when listening to music. In the first experiment, two groups of participants, with different levels of induced physiological arousal, rated four excerpts of music on 10 emotion scales in terms of the emotion they felt while listening to the music and the emotion they thought the music was intended to express. Participants who had exercised immediately before making the emotion judgments reported more intense experiences of emotion felt while listening to the music than did participants who had relaxed. Arousal manipulation had no effect on ratings of the emotion thought to be expressed by the music. These results suggest that arousal influences the intensity of emotion experienced with music and therefore that people use their body state as information about the emotion felt while listening to music. A second experiment investigated this effect in more detail. Independent groups were used to test three different types of induced arousal, with separate groups for ratings of emotion felt and emotion expressed by the music. Participants who had exercised reported intensified experience of positive emotions, in response to pieces that were positive in valence, than did a control group. The article concludes that body state can influence emotional experience with music and presents this as evidence for the role of personal and situational factors in the emotional experience of music.

Received December 9, 2002, accepted March 25, 2004

THE focus of this research is the role of body feedback in the emotion experienced while listening to music, the study of which contributes to a growing understanding of emotion and music. There are many competing views about how best to conceptualize emotion; however, the general consensus from psychological research is that emotion is a process constituted by a number of components, including cognitive appraisal, physio-

Address correspondence to Nicola Dibben, Department of Music, University of Sheffield, 38 Taptonville Road, Sheffield, S10 5BR, U.K. (e-mail: n.j.dibben@sheffield.ac.uk)
ISSN: 0730-7829. Send requests for permission to reprint to Rights and Permissions, University of California Press, 2000 Center St., Ste. 303, Berkeley, CA 94704-1223.

logical arousal, subjective feeling, expressive behavior, and action tendencies (Oatley & Jenkins, 1996; Scherer & Zentner, 2001). This article focuses on the role of just one of these components: feedback from physiological arousal. Previous research into music and physiological arousal has focused on the extent to which music produces specific bodily changes (see Bartlett, 1996 for a review). This article looks at the obverse of this relationship by considering the effect of physiology on the perception of music. As well as being accepted as one component of emotion theories, feedback from body states is one of the "production rules" identified by Scherer and Zentner (2001) as a possible route of emotion elicitation: there is evidence that peripheral feedback can influence the intensity and valence of emotion felt. Within psychology and musicology, there is a growing consensus that emotional experience with music is related to situational and personal factors as well as musical characteristics. The premise of this article (that body state is one source of emotional experience with music) therefore extends existing psychological theory to a novel domain and provides empirical evidence of a specific kind about one such personal/situational factor.

The main question this article addresses is whether increased arousal heightens emotional experience with music. Related to this, I consider two further questions: first, whether arousal increases the intensity of all emotions, or only those congruent with the emotion-provoking music stimulus; and second, whether arousal influences emotion felt, or the emotion thought to be expressed by the music (a distinction commonly made and debated in the musicological literature). While recognizing that feedback from body states forms only one component of a much more complex process of emotional experience, it is isolated for investigation here in order to better understand its possible contribution to emotional experience of music.

Emotion Feeling States and Body States

Following William James' (1884) work on emotion, the idea that the phenomenological experience of emotion lies in self-perception of visceral activities has been a recurrent theme in psychological research. The prevailing psychological model of emotion proposes a process in which the event (appraised via cortical or subcortical routes) elicits physiological changes that facilitate action and expressive behavior, all of which is accompanied by, and contributes to, an affective feeling state. Within this model, motoric and visceral feedback can contribute to the intensity and valence of an emotional experience because, consciously or subconsciously, individuals use their body state as a clue as to the valence and intensity of the emotion they feel.

Evidence for the role of peripheral feedback in emotional experience comes from a variety of sources. Schachter and Singer (1962) theorized that physiological arousal combined with cognitive labeling resulted in an emotion. More specifically, they argued that when individuals have no immediate explanation for their arousal, they will label their emotion in terms of the cognitions available to them; when they have an explanation at hand, they are unlikely to use other information to "label" their feeling state; and they will describe their feelings as emotions according to the extent of their physiological arousal. Their evidence for these claims came from an experiment in which they injected subjects with either epinephrine (an "arousing" drug) or a control and placed the subjects in social situations designed to elicit either euphoria or anger. Some subjects were told that the drug would induce arousal, whereas others were deceived about the effects of the drug. Those subjects who had been deceived about the drug's effects reported experiencing emotions more intensely in the euphoria condition than subjects who were not deceived about the drug's effects. This led the authors to conclude that unattributed arousal is labeled in terms of the individual's appraisal of a situation when no other explanation is available.

Schachter and Singer's conclusions have been criticized on the basis of a number of methodological shortcomings. One recent study used better controlled emotion induction, better measures of arousal, and a wider range of emotion measures. Those researchers concluded that physiological arousal influences emotion generation, but that epinephrine biases cognition toward negative affect because the physiological symptoms it elicits are normally paired with feelings of fear (Mezzacappa, Katkin, & Palmer, 1999). Thus, particular physiological changes may be associated with particular feeling states, making the type of arousal induced an important factor in the emotional experience. Although this highlights the methodological shortcomings of Schachter and Singer's original study, it confirms that arousal can influence the intensity, and perhaps the valence, of emotional experience, and provides further evidence that there is feedback from body state to emotional feeling state. By implication, this suggests that those individuals who are more viscerally self-perceptive should report intensified emotional experience over those who are less self-perceptive. Some evidence for this has recently been found: individuals who are better at detecting their own heart rate report more intense emotions than those who are poor detectors (Wiens, Mezzacappa, & Katkin, 2000).

One difficulty with this type of research is that "arousal" has tended to be conceptualized in terms of a single dimension, from deep sleep at one end, through alertness, to excitement. However, this unitary theorization looks increasingly untenable (Robbins, 1997). For example, adopting Frijda's (1986, pp. 170–171) definition, arousal includes four response systems: autonomic arousal, attentional arousal, electrocortical arousal, and behavioral arousal. Furthermore, "autonomic arousal" is itself a crude measure, consisting as it does of changes in the functioning of a range of internal organs and muscles, and referring to changes in the sympathetic and parasympathetic systems. However, given the early stage of research into the role of body sensations in emotion, and in the absence of strong evidence for the specificity of arousal, the term "arousal" is used here to generalize across these different systems. The focus of these studies is on whether arousal can influence the intensity of emotion experienced with music, rather than on the valence of the emotional experience. Evidence for these two aspects is reviewed briefly here.

A wide range of empirical studies have provided evidence that arousal can influence the intensity of emotion feeling states and that the process is mediated by causal attributions as to the source of the arousal. A group of studies theorized within the "misattribution" paradigm have shown that participants can misattribute arousal due to one source to another (although the precise mechanisms involved are debated): for example, Nisbett and Schachter (1966) found that subjects who were given a pill described as inducing certain symptoms similar to those associated with anxiety tolerated higher levels of painful electric shocks than subjects who had taken the same pill described as inducing anxiety-irrelevant effects. Nisbett and Schachter argue that subjects were attributing the arousal caused by the shocks to the pill and not to the shocks and so they experienced less pain. A second group of studies of "excitation transfer" have shown that arousal induced by a nonemotional source facilitates the experience of emotion in an emotion-provoking situation: for example, subjects who are aroused (e.g., through exercise, caffeine, or being in a dangerous environment) make the most extreme ratings of their feelings, are likely to retaliate more (Konečni, 1975; Zillman, Katcher, & Milavsky, 1972; Zillman, 1978), and are more likely to attribute arousal to sexual attraction (Cantor, Zillman, & Bryant, 1975; Dutton & Aron, 1974). As with Schachter and Singer's classic study, there is some evidence that the transfer effect obtains only so long as subjects do not attribute their feelings to something external to the judgment (Martin, Harlow, & Strack, 1992).

In addition to evidence of undifferentiated arousal (such as the studies cited earlier), there is some indication that specific kinds of body state may be associated with specific kinds of emotional experience. Studies of facial feedback have found that manipulation of facial expressions can influence self-reports of feeling states (McIntosh, 1996) and the intensity and valence of emotional ratings of stimuli: when induced to hold a facial expression of happiness, nonaroused subjects reported more favorable reactions to an ambivalent story than when they held an angry facial expression (Martin et al., 1992), and sadness ratings of pictures were also found to be affected by facial expressions (Larsen, Kasimati, & Frey, 1992). Studies of peripheral feedback have also shown that body posture can influence feelings of pride and achievement (Stepper & Strack, 1993), arm flexion and extension can influence evaluations of the attractiveness of people (Forster, 1998) and preferences towards nonword letter sequences (Priester, Cacioppo, & Petty, 1996), and type of breathing pattern can produce different emotional feeling states (Philippot, Chapelle, & Blairy 2002). The idea that peripheral feedback can influence the valence of emotional experience is congruent with the notion that specific kinesthetic and physiological changes are associated with particular kinds of emotion.

Whether there are emotion-specific patterns of psychophysiology is still a matter of controversy. A number of theorists argue that different emotions are associated with unique patterns of physiological changes (e.g., Ekman, Levenson, & Friesen, 1983): studies have found consistent differentiation in some physiological correlates of anger, fear, sadness, and happiness (e.g., heart rate increases more in anger and fear conditions than in happiness) and there is strong differentiation of the valence of emotion by physiological changes (Ekman et al., 1983). Proponents of this research argue that these patterns are the kinds of differences to be expected given the role of the emotions in survival. (For example, both fear and anger involve increases in heart rate because the organism is preparing to run away in the former case, and fight, in the latter case, and differences of blood pressure and supply reflect the differences of behavior associated with each emotion: for example, fear requires more blood in the larger muscles associated with locomotion, resulting in lower diastolic blood pressure and lower finger temperature than for anger.) Thus there is some evidence that autonomic differentiation for a small set of emotions does exist, although it does not seem to be necessary for the experience of emotion.

What, then, is the process by which body state can influence emotional experience? Philippot et al. (2002, pp. 606–607) provide a useful conceptualization of emotion and body states in terms of three strands of thinking. The first conception of emotion and body state, the “undifferentiated arousal model,” argues that arousal feedback can intensify emotional states and that the arousal-emotion relationship is mediated by causal attributions regarding the source of the arousal (Reisenzein, 1983, p. 258; Schachter, 1964) but does not differentiate between different emotions. The second conceptualization, the “cognitive appraisal model,” suggests that body changes are the result of cognitive appraisal or action readiness (Frijda, 1986). This suggests that the body changes that accompany emotion feeling states are differentiated according to the kind of appraisal or the kind of response readiness required to deal with the environment (Frijda, 1986, p. 165). The third conception, which Philippot et al. term the "central network model," argues that the different components that make up emotion are connected by a neural or cognitive network. This group of theories suggests that body changes are differentiated according to the emotion experienced. One feature of the network model is that it allows for automatic and implicit feedback: activation of a particular body state will cause a particular emotion to be experienced even if the individual is unaware of the process (Cacioppo, Berntson, & Klein, 1992; Damasio, 1994). Which of these accounts is correct is not the focus of this study. However, the idea that there is feedback from the association of certain body states to emotions with which they are usually paired provides a basis for explaining the influence of extraneous physiological arousal on emotional experience.

Given the psychological evidence just cited, one could expect to find similar effects of peripheral feedback on the experience of emotion with music. However, research into music and physiological arousal has focused upon the effect of music on physiology, finding evidence that music produces specific body changes, rather than on the effect of body states on emotional experience with music. This reflects what has been, until recently, a dominant ideology in music research: the notion that emotion is "caused" by music's internal structures, rather than by other situational factors. The research reported here is an attempt to rectify this imbalance. One study that investigates the relationship between emotional experience of music and physiological arousal provides some indication that heightened arousal can intensify the dominant response. Cantor and Zillman (1973) exposed participants to four film segments, chosen to represent a factorial variation in valence (positive and negative) and energy (high and low "excitatory potential"), and then asked participants to rate rock songs. The authors observed an excitation transfer effect for a song heard 2 min 45 sec after the film, in which the arousal produced by the highly arousing film intensified positive responses to music. This suggests that arousal due to one source (in this case, a film) can intensify emotionally valenced responses to another (music), but the influence of the arousal character on the experience of the emotional "energy" of the music was unclear.

The research reported in this article investigates the influence of arousal on emotional experience directly for the first time, by focusing on the effect of induced arousal on emotional experience of music and on how this is mediated by the valence and energy (arousal) characteristics of the music. By inducing arousal through exercise, rather than through a film, which has its own valence characteristics, the experiments carried out here aim to investigate the effects of undifferentiated arousal on emotional experience of music.

Is Emotion "Expressed by Music" or "Felt by Listeners"?

As noted earlier, studies of the role of body state on emotion have focused primarily on emotion felt by individuals. However, the situation with regard to music is slightly different, allowing as it does for a distinction between emotion felt by listeners and emotion thought to be expressed by the music. If arousal does cause an intensification of the emotion felt, this may not apply to emotion expressed, where, it can be hypothesized, listeners are less likely to rely on their own body state as an indication of emotional intensity and type. This seems to be the case, looking at comparable phenomena in other domains. Strack, Martin, and Stepper (1988) asked subjects to rate cartoons, having first induced them to adopt (unknowingly) either a smile or a frown. Participants who had adopted a smiling facial expression rated themselves as being more amused by the cartoons than did the subjects who had adopted a frown. However, the two groups did not differ with respect to how funny they thought the cartoon was in relation to an objective standard. One further indication that the influence of body state is mediated by cognitive processes is suggested by research with people who have suffered spinal cord injuries (Chwalisz, Diener, & Gallagher, 1988). The relationship between emotion "felt" and emotion "expressed" is, therefore, an important issue in the context of this research.

Self-reports of both emotion experienced and of the physiological changes accompanying music listening have been used to argue that listeners do indeed "feel" emotions when they listen to music (Gabrielsson, 2002, pp. 129–130; Krumhansl, 1997; Nyklicek, Thayer, & van Doornen, 1997; Witvliet & Vrana, 1996; Witvliet, Vrana, & Webb-Talmadge, 1998). However, few studies have directly investigated the relationship between emotion felt while listening to music and recognition of emotion expressed by it. Some researchers have suggested that the emotions that music induces in listeners may be a different subset from the emotions that the music is heard as expressing (Scherer & Zentner, 2001). Indeed, Zentner, Meylan, and Scherer (2000) concluded that listeners feel emotions as well as perceive them to be expressed by music, but that different emotions may be felt than are perceived according to the genre of the music. This highlights the differences that can arise according to whether subjects are asked to evaluate emotions felt or emotions heard to be expressed by music. In a recent article on the subject, Gabrielsson (2002, p. 139) argues that, although there is evidence for a positive relationship between emotion perception and induction, it is far from general, and that the dominant belief that there must be congruence between perception and induction reflects an assumption that listeners' responses are determined primarily by musical factors. Once the role of personal and situational factors is acknowledged, the possibility that perception and induction of emotion are different processes becomes more likely.

Aim of the Empirical Studies

Given evidence from other domains that induced arousal can intensify emotional experience, an empirical study was designed to test whether listeners' emotional experiences with music are influenced by physiological arousal. Previous research suggests that arousal from another source influences the experience of an emotion only if that emotion has already been independently provoked, and when the individual is unaware of the source of extraneous arousal and misattributes it to the event that instigated the emotion. If it can be shown that peripheral feedback can influence emotion experienced with music, then it suggests that personal and situational factors can play a role in emotional experience with music. The importance of situational factors is often mentioned in accounts of emotion and music, but rarely is it empirically verified. This research also allows comparison of the influence of physiological arousal on emotion felt, and the emotion thought to be expressed by music, and it therefore sheds light on the relationship between these two: one might expect reports of emotion felt to be intensified to a greater extent than emotion expressed, because it is more likely that participants will use their body state as a clue to the emotion they are feeling. If physiological arousal does influence listeners' emotional experience with music, then it provides evidence for the role of one personal factor in the experience of emotion with music and will extend understanding of emotion and music. It should be stressed again that physical response alone does not account for the emotions humans experience: emotional information from body feedback is always integrated with information from the person's environment.

Experiment 1

The aim of the first experiment was to discover whether arousal causes intensification of emotion felt while listening to music, or thought to be expressed by music, and how this is mediated by the valence and arousal character of the music. Two groups of listeners participated in either 5 min of vigorous exercise or 5 min of relaxation and were asked to rate extracts of music in terms of the intensity with which the music induced and expressed 10 emotions. Participants' pulse rates were taken before the arousal manipulation and immediately before and after the listening task. Pulse rate was chosen as the measure of arousal, and hence of peripheral feedback, because it is easy to measure and record by using self-reporting. It was hypothesized that the two levels of the arousal condition (exercise and relaxation) would cause different degrees of arousal (measured by pulse rate) and that this would affect the ratings of the music: the aroused group would rate emotions experienced in response to music more highly because they would interpret their increased physiological arousal as a heightened emotional response to the music. Ratings of emotion felt were expected to be heightened more than ratings of emotion thought to be expressed by the music, because listeners are more likely to use their body as a clue to emotion felt. If arousal does increase the dominant valence of the response, as previous research suggests, then only those emotions congruent with the valence of the piece should be intensified, and not those congruent with its arousal character.

METHOD

Participants

Forty-eight music students, from Sheffield University in England, participated in the experiment. All participants had played and studied music for at least 7 years and were between 18 and 60 years old. Half of the participants were randomly assigned to the "exercise" condition (of whom 13 heard the materials in Order 1, and 11 heard the materials in Order 2), and the remaining half of the participants were randomly assigned to the "relaxation" condition (of whom 13 heard the materials in Order 1, and 11 heard the materials in Order 2).

Equipment

Musical excerpts were played at a comfortable loudness level from a compact disc recording over a high quality amplifier and loudspeakers. Subjects made self-measurements of pulse at either the wrist or neck during a 30-s period indicated by an experimenter using a watch with a second hand. A pilot study with two participants compared self-reports of pulse with an electronic measure (a heart rate monitor worn around the chest). Comparison of self-reports and the electronic measure revealed 100% agreement, therefore self-reports were used in this experiment to minimize attention being drawn to the participants' body state during the music listening section of the procedure and to allow testing in groups.

Materials

The stimulus materials consisted of four excerpts of music chosen by a university music lecturer, other than the author, to illustrate the combination of two factors: valence (positive or negative) and energy (high or low). Extracts were chosen so as to be from the same instrumental genre (classical orchestral and string ensemble), and, although in a style familiar to participants, to be unknown to the participants. The intention was that choice of relatively unknown pieces, which lacked a strong narrative context, would avoid any confounding emotional effects due to autobiographical associations with the music. The excerpts were all approximately 40 s in duration and taken from the beginning of the pieces indicated in Table 1.

Immediately after each excerpt, there was a silence during which participants completed the appropriate part of an answer sheet, which asked participants to rate the degree to

TABLE 1
Musical Materials Used in Experiment 1

Piece	Music	Valence	Energy	Description
1	Mozart Quintet in C Major, KV515, 2nd movement	Positive	Low	Major mode; slow tempo; quiet dynamics; smooth, step-wise pitch movement
2	Haydn, Symphony No. 39 in G Minor, Finale: Allegro di molto	Negative	High	Minor mode; fast tempo with rapid, scalic passages; thick texture; some large interval leaps and sudden changes in dynamics
3	Haydn Symphony No. 35 in B flat Major, Finale: Presto	Positive	High	Major mode; fast tempo; sudden changes in dynamics and density
4	Mozart Quintet in G Minor, KV516, 4th Movement: Adagio	Negative	Low	Minor mode; slow tempo; quiet dynamics; step-wise movement in pitch, and descending, legato lines

which they felt and perceived 10 emotions on a scale from "1," representing "not at all," to "5," representing "very much": nostalgia, love, agitated-excitement, peacefulness, spirituality, triumph, happiness, sadness, anger, anxiety. The adjectives used in these ratings were derived from Zentner et al. (2000) and were intended to represent a range of emotions distributed across the four quadrants of the circumplex for emotion qualities as identified by Russell (1989; cited in Plutchik, 1994, p. 71). The answer sheet also asked participants to indicate if they had heard the piece before and, if so, whether it had any particular associations for them, and gathered information on age, sex, and musical experience.

Procedure

Participants were told that they were taking part in an investigation into the effect of different states of alertness on making musical judgments. At the start of the experiment, both groups were taught to take their own pulse by pressing their fingers either against the underside of their wrist or against a vein in their neck. After this training session, both groups took their pulse for a 30-s period indicated by the experimenter, using whichever method the individual preferred. Participants wrote this figure on the answer sheet. The "relaxation" group were then instructed to assume a comfortable sitting position and spent 5 min listening to a relaxation tape (Complete Relaxation, Harrold, 2000). The tape consisted of a single voice with no background music and talked participants through a breathing exercise that encouraged an alert but relaxed state. They then took their pulse a second time, using the same procedure, before being played the four extracts of music and performing the rating task. After completing the rating task, they took their pulse a third time. The "exercise" group followed exactly the same procedure, except, after being trained to take their pulse a first time, they engaged in 5 min vigorous exercise consisting of a brisk walk down and up a hill, accompanied by the experimenter. On returning, participants immediately took their pulse a second time and performed the rating task. Instructions for the rating task were identical for all participants: "To what extent do you feel the following emotions while listening to this music?" and "To what extent does this music express the following emotions?" Participants indicated when they were ready to proceed to the next excerpt. They took their own pulse rate a third time at the end of the rating task by using the same procedure as before. In order to partially control for the effects of the ordering of materials, pieces were run in two different orders within each arousal condition group: piece 1, 2, 3, 4 and 2, 1, 4, 3. Participants were debriefed at the end of the experiment. Although not systematically questioned, informal conversation revealed that none of the participants had guessed the true purpose of the experiment. Participants were tested in groups of between 6 and 10, and the whole procedure took 25 min to perform.

RESULTS

Familiarity With the Musical Materials

None of the participants reported having heard any of the extracts of music before. It can therefore be assumed that the emotion ratings given to the four extracts are due to emotional effects arising at the time of the experiment and previous exposure to the genre, rather than being due to particular autobiographical memories associated with the particular pieces of music used.

Arousal Induction

Before the emotion rating task and mood self-reports were analyzed, the pulse rate data were analyzed as a manipulation check on the effectiveness of the exercise. As expected, those participants who exercised showed an increase in their pulse rate immediately after exercise relative to before, although the pulse rate had returned near to the baseline by the end of the rating task. Figure 1 illustrates this effect as a function of arousal manipulation. A two-factor, repeated-measures analysis of variance (ANOVA), with arousal condition and order of presentation as the between-subject factors, and point of pulse measurement as the within-subject repeated measure, revealed a statistically significant difference between pulse rates at the three points of measurement, at a specified

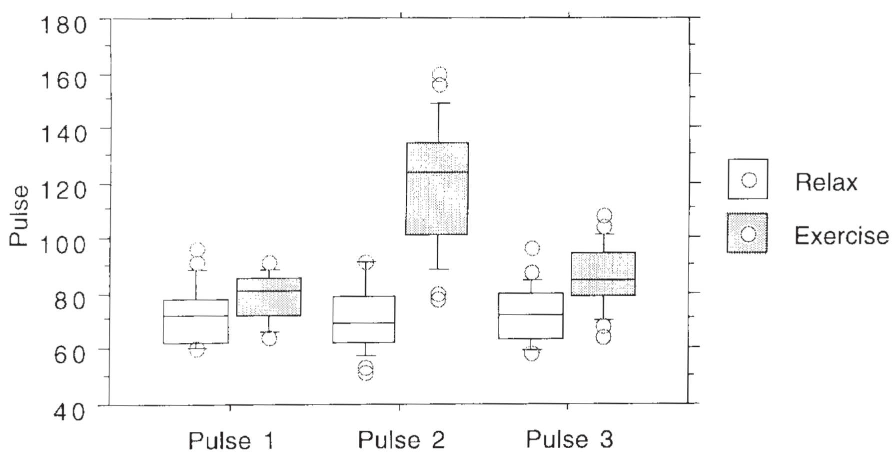

Fig. 1. Mean pulse rates before (Pulse 1) and after (Pulse 2) exercise or relaxation, and after the rating task (Pulse 3) (collapsed across order of presentation).

alpha level of .05, $F(2, 88) = 52.77$, $p < .0001$, and a significant difference between pulse rates according to the arousal manipulation, $F(1, 44) = 60.18$, $p < .0001$. There was no significant effect of order on ratings. A significant interaction between arousal condition and point of pulse measurement, $F(2, 88) = 61.12$, $p < .0001$, was explored by using post-hoc comparisons. This revealed significant differences between the pulse rate before and after the arousal manipulation ($p < .0001$) and between the pulse rate immediately after arousal manipulation and after the emotion rating ($p < .0001$), but not between the pulse rates before arousal manipulation and after the rating task. This suggests that by the end of the experiment the difference between the arousal level of the groups (as indicated by pulse rate) had disappeared.

The Effect of Arousal Manipulation on the Quality and Intensity of Emotion Felt and Emotion Expressed

Valence of the Music

In order to reduce the amount of information to be analyzed regarding valence, ratings were averaged across negative and positive emotion scales for Pieces 1 and 3 together (the pieces with positive valence) and for Pieces 2 and 4 together (the pieces with negative valence). The emotion scales aggregated into the "positive" category were triumph, happiness, love, peace, and spirituality; the emotion scales aggregated into the "negative" category were nostalgia, sadness, anxiety, anger, and agitated-excitement. This method of data reduction lumps together emotion feeling states that may differ (in terms of arousal, for instance), and that may therefore represent a very crude "average" affective response rating. However, this is an economical means of dealing with multiple responses and is consistent with the two-dimensional theorization of emotion terms proposed in the circumplex model of emotions. Furthermore, the use of reasonably unambiguous emotion terms reduced the likelihood that this data reduction would place a emotion rating in the "wrong" affective category. (An alternative method of data reduction would have been to use a factor analysis to reduce the data to four dimensions corresponding to positive and negative valence and high and low energy. Principal components analysis did not reveal a clear solution of this sort, therefore a more simple, word-based classification has been used in the following analysis). A series of paired *t*-tests, comparing the means of emotion expressed and emotion felt for each piece and each rating scale, revealed a number of significant differences; therefore, all subsequent analyses are carried out separately for ratings of emotion expressed and emotion felt.

The relatively low aggregated mean ratings suggest that the emotional experience reported was not very intense (Table 2). As hypothesized, the

TABLE 2

Mean (SD) Ratings of Emotion Felt and Expressed, Aggregated Across Positive and Negative Emotion Scales, As a Function of the Arousal Manipulation

Arousal		Pieces 1 & 3 (Positive Valence)				Pieces 2 & 4 (Negative Valence)			
Condition	Mode	Positive		Negative		Positive		Negative	
Exercise	Felt	2.55	(0.66)	2.12	(0.55)	2.08	(0.60)	2.69	(0.68)
	Expressed	2.83	(0.51)	2.04	(0.43)	2.25	(0.56)	2.90	(0.54)
Relaxation	Felt	2.36	(0.43)	2.32	(0.52)	2.38	(0.61)	2.49	(0.38)
	Expressed	2.75	(0.48)	2.16	(0.35)	2.36	(0.52)	2.63	(0.41)

exercise group reported higher ratings of emotions congruent with the valence of each piece, and lower ratings of emotions incongruent with each piece, than did the relaxation group. In order to confirm the reliability of these differences, four separate two-factor, repeated-measures analyses of variance (ANOVAs) were run on this data, with arousal group (relaxation or exercise) and order as the between-subject independent variables, and the aggregated emotion ratings (positive emotions and negative emotions) as the within-subject repeated measure.

The Pieces With Positive Valence

The ANOVA on the aggregated data from Pieces 1 and 3 revealed a significant difference between ratings of positive and negative emotions for both emotion expressed, $F(1, 44) = 90.23$, $p < .0001$, and emotion felt, $F(1, 44) = 12.55$, $p = .001$: as is congruent with the intended positive valence of Pieces 1 and 3, positive emotions received a higher rating than negative emotions. Significant interactions were found, at the specified alpha level of .05, between the ratings of emotions felt and arousal manipulation, $F(1, 44) = 5.64$, $p = .02$: participants in the exercise condition gave significantly higher ratings of positive emotions felt ($M = 2.6$, $SD = 0.66$) than did participants in the relaxation condition ($M = 2.4$, $SD = 0.43$). No significant interactions were found for emotion expressed.

There was also a significant interaction between order and ratings of emotion felt, $F(1, 44) = 50.89$, $p < .0001$. This was investigated by examining the effect of order on the ratings for each piece separately. This revealed a significant interaction between the order of presentation and ratings of emotion felt for piece 1 only, $F(1, 44) = 81.11$, $p < .0001$: those who heard the materials in Order 1 (Piece 1 heard first), reported feeling more negative emotions ($M = 2.45$, $SD = 0.56$) than positive emotions ($M = 2.19$, $SD = 0.43$) in relation to Piece 1, whereas those who heard the materials in Order 2 (Piece 1 heard after Piece 2) rated positive emotions more highly ($M = 2.46$, $SD = 0.54$) than negative emotions ($M = 2.00$, $SD = 0.40$). This can be explained as a contrast effect in which the positive valence of Piece 1 (positive and low in valence) is enhanced when it follows Piece 2 (negative and high in valence). An alternative possibility is that participants who heard the materials in Order 1 happened to start the experiment in a more negative mood state. It is not possible to speculate on this further in the absence of measures of mood state at the start of the experiment. A third possibility is that the pieces did not reflect the intended valence and that Piece 1 was ambiguous in terms of valence. However, this is not supported by the ratings of valence for each piece, which are congruent with the intended character of the piece. Possible reasons for this order effect are discussed later.

The Pieces With Negative Valence

The ANOVA on Pieces 2 and 4 revealed a significant difference between ratings of positive and negative emotions for both emotion expressed, $F(1, 44) = 17.67$, $p = .0001$, and emotion felt, $F(1, 44) = 13.22$, $p = .0007$: as is congruent with the negative valence of these pieces, negative emotions were rated higher than positive emotions. There was a significant interaction between the ratings of positive or negative emotions felt and the arousal manipulation, $F(1, 44) = 5.3$, $p = .026$: the exercise group reported feeling more of the negative emotions ($M = 2.69$, $SD = 0.68$) and less of the positive emotions ($M = 2.08$, $SD = 0.60$) than did the relaxation group (negative emotion rating $M = 2.49$, $SD = 0.38$; positive emotion rating $M = 2.38$, $SD = 0.61$). No significant interactions were found for emotion expressed, and there were no significant effects of order.

Energy Level of the Music

The data were reduced by taking the averaged ratings across high- and low-energy emotion scales for Pieces 1 and 4 together (the low-energy pieces) and for Pieces 2 and 3 together (the high-energy pieces). The emotion scales aggregated into the "low-energy" category were nostalgia, sadness, peace, spirituality, and love; the emotion scales aggregated into the "high-energy" category were anxiety, anger, agitated-excitement, triumph, and happiness. Mean aggregated emotion ratings are shown in Table 3. There is a slight tendency for the arousal group to report higher ratings of high-energy emotions than the relaxation group, whatever the energy of the piece. To investigate whether these are reliable differences, four separate ANOVAs were carried out, with the aggregated emotion scales (high- and low-energy emotions) as the within-subject repeated measure, and with arousal manipulation and order as the between-subjects independent variables. All statistics are at an alpha level of .05.

There was a significant difference between the ratings given on the aggregated emotion scales (high or low energy) for both emotion felt (Pieces 1 and 4 (low energy): $F(1, 44) = 38.04$, $p < .0001$; Pieces 2 and 3 (high energy): $F(1, 44) = 165.46$, $p < .0001$) and emotion expressed (Pieces 1 and 4: $F(1, 44) = 88.36$, $p < .0001$; Pieces 2 and 3: $F(1, 44) = 319.71$, p

TABLE 3

Mean (SD) Ratings of Emotion Felt and Expressed, Aggregated Across High- and Low-Energy Scales, As a Function of the Arousal Manipulation

Arousal		Pieces 2 & 3 (High Energy)				Pieces 1 & 4 (Low Energy)			
Condition	Mode	Low		High		Low		High	
Exercise	Felt	1.69	(0.58)	2.98	(0.67)	2.98	(0.78)	1.86	(0.48)
	Expressed	1.60	(0.48)	3.31	(0.52)	3.52	(0.65)	1.65	(0.45)
Relaxation	Felt	1.81	(0.41)	2.84	(0.55)	3.11	(0.45)	1.77	(0.35)
	Expressed	1.74	(0.47)	3.16	(0.41)	3.51	(0.44)	1.55	(0.34)

$< .0001$). These ratings are congruent with the intended energy levels of the pieces: Pieces 1 and 4 received higher ratings of low-energy emotions, and lower ratings of high-energy emotions, and Pieces 2 and 3 received higher ratings of high-energy emotions and lower ratings of low-energy emotions. No significant effect of arousal manipulation was found on any of the emotion ratings aggregated by arousal. This suggests that the tendency observed in the means, for the exercise group to give higher ratings of high-energy emotions, was not significant. However, there was a significant interaction of order with the ratings given for the low-energy pieces (Pieces 1 and 4): $F(2, 88) = 28.5$, $p < .0001$. Participants in Order 1 gave less extreme ratings than did those in Order 2: the mean ratings of low-energy emotions was 2.85 ($SD = 0.56$) for Order 1, and 3.28 ($SD = 0.65$) for Order 2, whereas the mean ratings of high-energy emotions was 1.99 ($SD = 0.41$) for Order 1 and 1.61 ($SD = 0.33$) for Order 2. This could be explained as a contrast effect, as discussed earlier: in this case, the low-energy characteristics of pieces may be highlighted when preceded by a high-energy piece, and vice versa.

Investigation of the Order Effects

To investigate the observed order effects on the data in more detail, a post-test was carried out with a separate group of participants ($N = 18$), who listened to each extract in a fully counterbalanced design and were asked to indicate to what extent the music was "positive in mood," "negative in mood," "high energy," and "low energy" on a scale of 1 ("not at all") to 5 ("very much"). Separate ANOVAs were carried out for each piece, with order as the between-subject independent variable and with ratings of valence and energy as separate repeated-measures analyses. There were no significant effects of order on ratings. Ratings of energy were significantly different for every piece, and in the intended direction, Piece 1 $F(1, 17) = 9.18$, $p = .008$; Piece 2 $F(1, 17) = 46.88$, $p < .0001$; Piece 3 $F(1, 17) = 92.32$, $p < .0001$; Piece 4 $F(1, 17) = 38.8$, $p < .0001$. Ratings of valence were significantly different for Piece 3, $F(1, 17) = 33.85$, $p < .0001$, and Piece 4 only, $F(1, 17) = 11.14$, $p = .004$). The failure to find a significant difference between ratings of positive and negative valence in relation to Pieces 1 and 2 suggests that these two pieces did not have a clear emotional valence within this experimental context. Although the reported valence of Piece 1 was in the intended, positive, direction (positive valence: $M = 3.2$, $SD = 0.9$; negative valence: $M = 2.5$, $SD = 1.0$), ratings of Piece 2 (intended to be of negative valence) were higher for emotions with a positive valence ($M = 3.3$, $SD = 1.0$) than for emotions with a negative valence ($M = 2.6$, $SD = 1.3$). This suggests that the order effect found in the ratings of Piece 1 in Experiment 1 may result from the less clearly defined valence of Piece 2. It is significant that valence appeared to be more ambiguous with the two pieces that went against the optimal combination of arousal and valence: positive valence and low energy (Piece 1) and negative valence and high energy (Piece 2) are pairings that are at odds with the usual association between high energy and positive valence and between low energy and negative valence. Therefore, this appears to be a general feature of valenced responses to this combination of characteristics and not simply an experimental flaw.

DISCUSSION

Experiment 1 set out to discover whether physiological arousal can influence the experience of emotion when listening to music and how this is mediated by the character of the music. It was found that two groups of participants with different levels of induced arousal reported different emotional experiences: an exercise group, with elevated pulse rates, reported feeling a greater intensity of emotions congruent with the valence of the music than did a relaxation group. This result suggests that physiological arousal can influence listeners' experience of emotion in relation to music, as hypothesized. The association of elevated arousal levels with increased ratings of emotions congruent with the valence of the piece suggests that physiological arousal intensifies the dominant valence of the response and confirms the pattern found in nonmusical studies. These findings are consistent with undifferentiated arousal models, which suggest that arousal facilitates performance of the dominant response. Failure to find any influence of physiological arousal on the energy (arousal) dimension of emotional response suggests that listeners do not use their body state as information about the emotional energy of the music. Further evidence in support of these conclusion is the observed effect for emotion felt only and not for the emotion expressed by the music. This supports the idea that listeners are more likely to reflect on body state to determine feelings of emotion rather than emotion attributed to an external object (as per Strack, Martin, & Stepper, 1988). In sum, the findings support the hypothesis that listeners can use their body state to evaluate the emotion felt while listening to music.

This experiment raises a number of issues that require further research. One possibility is that the intensification of emotion felt, which is associated with increased arousal, is due to a general improvement in mood state as a consequence of exercising rather than to arousal. The intensification of the valence of the response, found here, would suggest that the effect is not due to a general improvement in mood. However, the only way to be certain would be to measure participants' mood states before and after the experiment to test for a correlation between improvements of mood state and induced physiological arousal.

A second possibility is that the observed effect of arousal on increasing the dominant response for emotion felt could be due to the arousal group being more alert than the relaxation group. In other words, the control condition, which was intended to maintain participants' same level of physiological arousal and alertness, may have made participants less alert. Further studies using a control that keeps physiological arousal constant, but ensures that participants remain alert, would avoid this possible flaw.

Added to this, the method of data collection may have biased participants toward using their body state in judgments of emotion more than they might otherwise, because they were asked to report their own pulse rate at three points during the experiment. Electronic collection of measures rather than the self-report method employed in this study would ensure accuracy and might reduce the focus on the body entailed by the use of self-measurements. If reflection on one's body state is indeed a factor in determining the intensity of emotions felt and perceived to be expressed by music, then a more dynamic measure of physiological change is needed in order to determine whether and which physiological changes persisted throughout the experiment. In Experiment 1, the measurement of pulse rate revealed a decrease for the exercise group over the duration of the experiment, with pulse rates at the end nearing their starting levels. It could be argued that, from the evidence of pulse rates alone, arousal is no longer a factor by the end of the experiment. The counterargument to this is that pulse rate is only one measure of arousal, with its own particular response and decay characteristics, and that increased arousal will have been maintained even after pulse rates returned to their resting rate. However, in order to confirm that this is the case, additional physiological measures are needed.

As mentioned previously, the relationship between emotion felt and emotion expressed by music, and the role of body sensations in these two phenomena, is not well understood at present. In Experiment 1, all listeners were asked to rate both the emotion they felt and the emotion they thought the music was intended to express. Gabrielsson (2002, p. 127) has argued that asking participants to switch between judging the emotion felt by them and the emotion expressed by the music may interfere with the very experience of emotion it is trying to capture. A follow-up study is needed to investigate the relationship between body state and emotion expressed or felt by using two different groups of participants to report each of the two kinds of emotional experience.

Last, although this experiment provided confirmation that listeners can use their body state as a cue to the emotion they are feeling, the cause of this effect requires further investigation. The timing of the rating task offers a means to investigate the misattribution hypothesis: previous studies have shown that when appraisals are made immediately after an arousal condition, participants tend not to use their body sensations as an input into judgments (because they rightly attribute their arousal to an extraneous source; Martin et al., 1992; Zillman, 1978). In the study reported here, subjects were asked to take their pulse between the exercise and the emotion ratings of the music, providing a temporal gap of about 1½ min, in keeping with other studies. However, if a delayed and an immediate rating task were used, this could help determine whether misattribution is occurring.

Experiment 2

Experiment 2 aims (1) to verify the effect of physiological arousal on emotion felt while listening to music and (2) to extend this by discovering whether it can be explained as peripheral feedback or whether it is due to mood changes associated with exercise. The experimental procedure remained the same in general outline, but a number of alterations were made in response to the issues raised by Experiment 1. In order to avoid any bias, electronic measurements of arousal were used rather than self-reports; heart rate and finger temperature were chosen because of their different latencies. A more controlled method of arousal induction was also used, corresponding to that used in studies of excitation transfer, and subjects were asked to report either emotion expressed or emotion felt, rather than both. Rather than the two different levels of the arousal condition used previously, the second experiment used three levels: an exercise group, a delayed exercise group, and a control group. Inclusion of immediate and delayed conditions was intended to allow comparison with previous studies that have shown increased effects of arousal on emotion when response is delayed (Cantor, Zillman, & Bryant, 1975; Martin, Harlow, & Strack, 1992), while the control group engaged in a task that was not open to the possible confounds associated with a relaxation task. Mood state was measured before and after the experiment to determine whether this has a bearing on emotional response to music. Different pieces of music were also used: a pretest ensured these were differentiated in terms of arousal and valence, and pieces by the same composer and using the same instrumental forces were chosen to avoid confounds.

It was hypothesized that the three types of arousal manipulation would be associated with different ratings of emotion felt while listening to music: the two exercise groups were expected to rate emotions felt in response to music more highly than the control group because they would interpret their increased physiological arousal as a heightened emotional response. No difference was expected between the two exercise groups, given that Experiment 1 revealed an effect of arousal on emotion even when participants proceeded straight from exercise to the rating task. It was expected that arousal would increase the dominant valenced response; therefore, only those emotions congruent with the valence of the piece should be intensified.

METHOD

Participants

The participants were 48 university music students (33 female and 15 male) from 18 to 28 years of age (M = 20, SD = 2.6). Participants were volunteers and were recruited from music classes at the University of Sheffield. None had participated in the previous experiment.

Equipment

Musical excerpts were presented to participants through high quality headphones from a portable minidisk. Participants in the two exercise conditions rode an exercise bike. Physiological measures were taken by using a heart rate monitor and a finger thermometer. The heart rate monitor consisted of a strap fastened around the chest next to the skin that transmitted to a receiver observed by the experimenter and recorded the participant's heart rate at 5-s intervals throughout the experiment. The thermometer sensor was attached to the index finger of the participant's nondominant hand using micropore tape and showed the temperature reading on an LCD screen which updated every 3 s.

Stimuli and Measures

The experiment used the revised version of the Profile of Mood States (POMS) short form (McNair, Lorr, & Droppleman, 1992) to measure self-reported levels of arousal and mood at the start and end of the experiment (i.e., before the arousal manipulation and after the rating task). The POMS short form consists of 30 items, each requiring participants to rate on a scale of 1 to 5 the extent to which the item describes how the participant feels at that moment in time. POMS measures six affective mood states: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. A global estimate of mood is obtained by summing the scores across the six factors (weighting vigor negatively).

The Affect Grid (Russell, Weiss, & Mendelsohn, 1989) was used to measure arousal and mood simultaneously. The grid treats arousal and mood as orthogonal dimensions and requires participants to rate their combined arousal and mood by placing a cross in one square of a nine by nine matrix. The vertical axis corresponds to arousal (ranging from "extremely low" at the bottom to "extremely high" at the top), and the horizontal axis corresponds to valence (from "extremely unpleasant feelings" on the left to "extremely pleasant feelings" on the right). Both scores range from 1 to 9.

In addition to subjective measures of mood and arousal, physiological measures were taken in order to confirm the increased physiological arousal for those participants in the exercise conditions. To this end, heart rate and finger temperature were recorded throughout the experiment. Heart rate is a good indicator of the physiological effects of exertion, because it has a fairly rapid rise rate. In contrast, finger temperature has a longer delay. Together these provide an indication of physiological arousal across the duration of the experiment.

Musical excerpts were chosen by using a pretest, with a separate participant sample, which included trained musicians and listeners without formal musical training. The pretest required listeners to rate 16 excerpts in terms of their valence and energy by using five-point scales. The criteria for the four excerpts used in Experiment 2 were that they should be highly differentiated by valence (positive/negative) and energy (high/low). For reasons of consistency, all excerpts used in the final experiment had to be by the same composer and for the same size and type of ensemble. The four excerpts that met these criteria are shown in Table 4. Excerpts were taken from commercially available recordings and edited using computer software to produce clean cutoffs at logical phrase boundaries, resulting in extracts approximately 40 s in duration. These excerpts were recorded to minidisk in four different orders to produce counterbalancing: Order 1: 1, 2, 3, 4; Order 2: 2, 1, 4, 3; Order 3: 3, 4, 1, 2; Order 4: 4, 3, 2, 1.

Two different types of emotion rating questionnaire were created: the "emotion felt" questionnaire asked participants to judge the emotion they felt while listening to the music; the "emotion expressed" questionnaire asked participants to judge the emotion they thought was intended to be expressed by the music. (Participants completed only one of these questionnaires). Both questionnaires asked participants to circle one number, on a scale of 0 ("not at all") to 4 ("very much"), to indicate either the extent to which they thought each extract expressed, or they felt, each of nine emotions: happiness, exhilaration, tenderness, serenity, yearning, sadness, fear, anger, and frustration. These emotions differ slightly from those used in Experiment 1 in order to eliminate potentially ambiguous terms (e.g., "agitated-excitement" could indicate either positive or negative valence). However, the chosen emotion terms maintained an equal distribution across the four quadrants of the circumplex of emotions. Participants were also asked to indicate whether they had heard each excerpt before and whether it had any pre-existing emotional significance for them.

Procedure

Participants were tested individually. They were told that the experiment was investigating the effects of different states of alertness on making musical judgments and were fit-

TABLE 4
Musical Materials Used in Experiment 2

Piece	Music	Valence	Energy	Description
1	Haydn The Seven Last Words of Jesus Christ, Op. 51, 3rd mvt. (string quartet version)	Negative	Low	Minor mode; walking tempo; quiet dynamics; legato melodic line with regular, homophonic accompaniment
2	Haydn String Quartet, Op. 54, No. 1, 1st mvt.	Positive	High	Major mode; loud dynamics; fast tempo; melodic line with homophonic, chordal accompaniment; some staccato articulation
3	Haydn String Quartet in C Op. 76, No. 3, 4th mvt.	Negative	High	Minor mode; sudden contrasts of dynamics, texture and density
4	Haydn String Quartet Op. 76, No. 2, 2nd mvt.	Positive	Low	Major mode; slow, dancelike tempo; legato melodic line with plucked chordal accompaniment

ted with a heart rate monitor and a finger thermometer. Participants then completed the paper-and-pencil arousal and mood questionnaires and were randomly assigned to one of the three arousal manipulations. The ratio of male to female participants was similar across the three conditions: exercise (3 male and 13 female), delayed exercise (6 male and 10 female), and control (6 male and 10 female). Within each of these groups, participants were randomly assigned to one of two measurement conditions: emotion felt (8 male and 16 female) or emotion expressed (7 male and 17 female) (hereafter referred to as "mode"). After completing the questionnaires, participants engaged in one of three activities. Participants in the exercise condition rode the exercise bicycle for 2 min; participants in the delayed exercise condition rode the exercise bicycle for 2 min and then rested for 2-1/2 min; participants in the control condition completed a children's "spot the difference" paper-and-pencil puzzle for 2 min. The control was intended to keep participants alert but to keep their physiological arousal at each individual's baseline. Participants were then told they would hear four excerpts of classical music, each 40 s long, and that they should complete the appropriate part of the emotion questionnaire while listening to the music. Participants were able to pause the recording if they needed more time to complete any part of the questionnaire. After listening to the music and completing the emotion rating questionnaire, participants completed the mood and arousal questionnaires again and were debriefed. The experiment lasted approximately 25 min.

RESULTS

Preliminary ANOVAs revealed no significant effect of sex or order of presentation of materials on the emotion ratings at the specified alpha level of .05; therefore, these factors were eliminated from further analysis. To eliminate redundancy in subsequent analyses, principal components analysis (varimax rotation) was used on the ratings for each piece to reduce the set of nine measures (i.e., the nine emotion ratings) to four: one representing high energy and negative valence, a second representing low energy and negative valence, a third representing high energy and positive valence, and a fourth representing low energy and positive valence. Summary statistics from the four-factor solution are provided in Table 5. The solutions accounted for more than 70% of the variance in the original measures for all pieces. For Pieces 2, 3 and 4, three emotion scales loaded onto the high energy and negative valence factor (fear, anger, and frustration), and two scales each loaded onto the other three factors: low energy and negative valence (yearning and sadness), high energy and positive valence (exhilaration and happiness, although only happiness loaded onto this factor for Piece 3), and low energy and positive valence (tenderness and serenity: although only serenity loaded onto this factor for Piece 3). The loadings for Piece 1 were slightly different: fear and anger loaded onto the high-energy and negative valence factor, and yearning and frustration loaded onto the low-energy and negative-valence factor. In addition, sadness was negatively loaded onto the high-energy, positive-valence factor. The factor analysis revealed that the use of two dimensions (energy and valence) to analyze the results was appropriate, because these dimensions captured a high degree of the variance in participants' ratings of the excerpts. The particular emotion subscales implicated for each piece

Table 5

Four-Factor Solutions From the Principal Components Analysis of the Nine Emotion Rating Scales

Emotion	High Energy, Positive Valence				High Energy, Negative Valence				Low Energy, Positive Valence				Low Energy, Negative Valence			
Rating Scale	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**
Happiness	.81	.84		.69												-.43
Exhilaration	.61	.85	.91	.89												
Tenderness			.58						.91	.90					.44	
Serenity									.86	.84	.87	.84				
Yearning									.49			.72	.52	.86	.81	.85
Sadness	-.77							.46						.62	.70	.62
Fear					.84	.75	.73	.83								
Anger					.79	.91	.91	.90								
Frustration						.84	.88	.66					.96			

Note—The table lists the loadings for each measure on all factors by piece (P). Only loadings greater than .4 are shown.

also indicated that the pieces were differentiated in terms of their valence and energy as intended.

Reduction of the data from the nine emotion subscales to four sets of emotion rating scores for each piece was carried out by taking the mean of the relevant subscales as identified by the four factors in the principal components analysis. One set of subscores was then produced by averaging across pieces with the same intended valence, and another set was produced by averaging across pieces with the same intended energy level. This produced four rating scales (positive valence, negative valence, high energy, low energy) for each of the four types of piece used: the pieces with negative valence (Pieces 1 and 3), the pieces with positive valence (Pieces 2 and 4), the low energy pieces (Pieces 2 and 4) and the high energy pieces (Pieces 2 and 3). Mean emotion rating scores are shown in Tables 6 and 7. For each piece type (positive or negative valence, and high or low energy), a mixed factorial design analysis of variance was carried out. The design had two between-subject factors (arousal condition with three levels, and emotion mode with two levels), and one within-subject factor (either valence (positive and negative) or energy (high and low energy). Results for valence and energy are dealt with separately next.

Valence of the Music

Means for the ratings of the pieces in terms of the positive and negative aggregated emotion scales are shown in Table 6.

Pieces With Negative Valence (Pieces 1 and 3)

Negative emotions were rated higher than positive emotions, as expected given the intended negative valence of these pieces, $F(1, 42) = 10.66$, $p = .002$. There was no significant interaction between valence and arousal, although there was between mode and valence, $F(1, 42) = 11.52$, $p = .002$.

TABLE 6
Means (SD) for Emotional Valence Ratings for Positive- and Negative-Valence Pieces

Arousal		Pieces 1 & 3 (Negative Valence)				Pieces 2 & 4 (Positive Valence)			
Condition	Mode	Positive		Negative		Positive		Negative	
Exercise	Felt	1.41	(0.41)	1.17	(0.61)	1.77	(0.55)	0.95	(0.44)
	Expressed	1.38	(0.58)	1.93	(0.47)	2.09	(0.35)	1.10	(0.28)
Control	Felt	1.17	(0.84)	1.40	(0.63)	1.47	(0.32)	0.99	(0.38)
	Expressed	0.94	(0.32)	1.97	(0.39)	2.02	(0.41)	1.21	(0.29)
Delay	Felt	1.46	(0.41)	1.43	(0.65)	2.00	(0.30)	0.98	(0.48)
	Expressed	1.31	(0.64)	1.61	(0.30)	1.98	(0.44)	1.03	(0.28)

This interaction was explored by comparing the effect of emotion-mode on the reporting of positive- and negative-valence emotions separately. This revealed a significant contrast for the emotions with negative valence only ($p < .01$): participants reported a greater intensity of negative emotions expressed by the music ($M = 1.84$, $SD = 0.39$) than felt ($M = 1.3$, $SD = 0.63$).

Pieces With Positive Valence (Pieces 2 and 4)

As expected, positive emotions were rated higher than negative emotions, $F(1, 42) = 202.79$, $p < .0001$. In addition, there was a significant interaction between valence and arousal, $F(1, 42) = 3.13$, $p = .05$: there was a tendency for the two exercise groups to rate positive emotions higher and negative emotions lower than the control group, although pair-wise comparisons were not significant. There was no significant effect of emotion-mode on the ratings of pieces with positive valence.

Energy of the Music

Means for the ratings of emotional energy (arousal dimension) of the high- and low-energy pieces are given in Table 7.

Low-Energy Pieces (Pieces 1 and 4)

The intended energy level of Pieces 1 and 4 is confirmed by a significant main effect of energy on the emotion ratings, $F(1, 42) = 270.23$, $p < .0001$: pieces were rated higher on the low-energy emotions than the high-energy emotions. There was also a significant interaction between emotional energy and mode, $F(1, 42) = 6.0$, $p = .012$, but no interaction with arousal condition. The means suggest a tendency for low-energy emotions to be expressed more than they are felt, and for high-energy emotions to be felt

TABLE 7

Means (SDs) for Energy Emotion Ratings for Low- and High-Energy Pieces

Arousal		Pieces 1 & 4 (Low Energy)				Pieces 2 & 3 (High Energy)			
Condition	**Mode**	**Low**		**High**		**Low**		**High**	
Exercise	Felt	1.65	(0.62)	0.66	(0.30)	0.83	(0.41)	1.40	(0.44)
	Expressed	2.02	(0.45)	0.63	(0.32)	1.08	(0.46)	1.96	(0.36)
Control	Felt	1.50	(0.69)	0.68	(0.39)	1.02	(0.54)	1.27	(0.42)
	Expressed	1.88	(0.34)	0.49	(0.25)	.91	(0.31)	1.93	(0.14)
Delay	Felt	1.90	(0.51)	0.68	(0.33)	1.19	(0.48)	1.55	(0.41)
	Expressed	1.82	(0.55)	0.52	(0.27)	1.09	(0.43)	1.74	(0.23)

more than they are expressed. However, separate analyses of the effect of mode on ratings of high- and low-energy emotions reveal no significant differences.

High-Energy Pieces (Pieces 2 and 3)

The main effect of energy confirms the high energy character of Pieces 2 and 3: high-energy emotions receive higher ratings than low-energy emotions, $F(1,42) = 83.36$, $p < .0001$. There is no effect of arousal condition on the ratings, but there is an interaction between mode and energy, $F(1, 42) = 10.91$, $p = .002$. Separate analyses reveal a significant contrast for high-energy pieces only ($p < .0001$): high-energy emotions are expressed ($M = 1.88$, $SD = 0.27$) more than they are felt ($M = 1.41$, $SD = 0.42$).

In sum, there is a tendency for the two exercise groups to show increased ratings of positive emotions in relation to the control, for pieces with a positive valence. The negative valence of the piece appears to influence the intensity of emotion felt versus emotion expressed: when the piece had a negative valence, negative emotions were reported to be expressed by the music at a greater intensity than when they were felt by participants. Levels of induced arousal had no effect on ratings of the emotional energy of pieces. However, the energy level of the music appears to influence the intensity of emotion felt versus expressed: there is a tendency for those emotions congruent with the energy of the piece to be expressed more than they are felt.

As previously mentioned, possible causes of the differences in emotional experience associated with arousal manipulation and mode are, first, the effects of induced differences in physiological arousal, and second, changed mood state resulting from exercise. Analysis of these measures follows, and their implications for the emotion ratings are considered.

Physiological Arousal

Preliminary ANOVAs revealed no significant differences in heart rate or finger temperature according to the order of materials.

Heart Rate

Figure 2 shows the means for each of six measures of heart rate: one before (“HR1”) and one after the arousal manipulation (“HR2”), and one after rating each of the four pieces of music (“HR3-6”). An analysis of variance (with the six heart rate measurements as the within-subject repeated measure, and arousal and mode as the between-subject independent variables) confirms differences of heart rate between the six

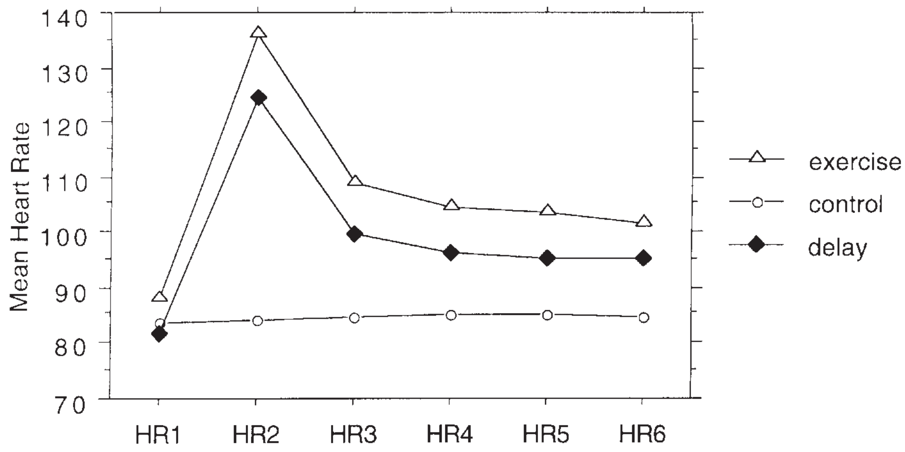

Fig. 2. Mean heart rate difference (beats per minute) as a function of arousal manipulations.

measurement points, $F(5, 38) = 21.06$, $p < .0001$, and an interaction of heart rate with arousal group, $F(10, 76) = 3.46$, $p < .0001$. There was no significant interaction with mode. Post-hoc comparisons reveal significant differences between the control and both the exercise group ($p < .0001$) and delay group ($p = .02$). This interaction was explored by using separate analyses of each of the six measurement points. This analysis reveals no significant differences between groups at the start of the experiment (HR1), but after the arousal manipulation, there are significant contrasts between the control and the exercise group (HR2, $p < .0001$) and the control and delayed exercise groups (HR2, $p < .0001$). The control and exercise groups have significantly different heart rates throughout the remaining measurement points (HR3, $p < .0001$; HR4, $p = .003$; HR5, $p = .002$; HR6, $p = .004$). The delayed exercise group has a significantly different heart rate from the control after the rating of the first piece only (HR 3, $p = .04$). These results indicate that the control group was differentiated from the exercise groups in terms of heart rate after the arousal manipulation, but that the two exercise groups were not differentiated from one another. It also suggests that from the time of rating the piece heard second, the heart rate of the delayed group was not reliably differentiated from that of the control.

Finger Temperature

Due to equipment malfunction, finger temperature data for 5 participants had to be discarded: data were recorded for 15 participants in the exercise condition, and 14 in each of the control and delayed exercise con-

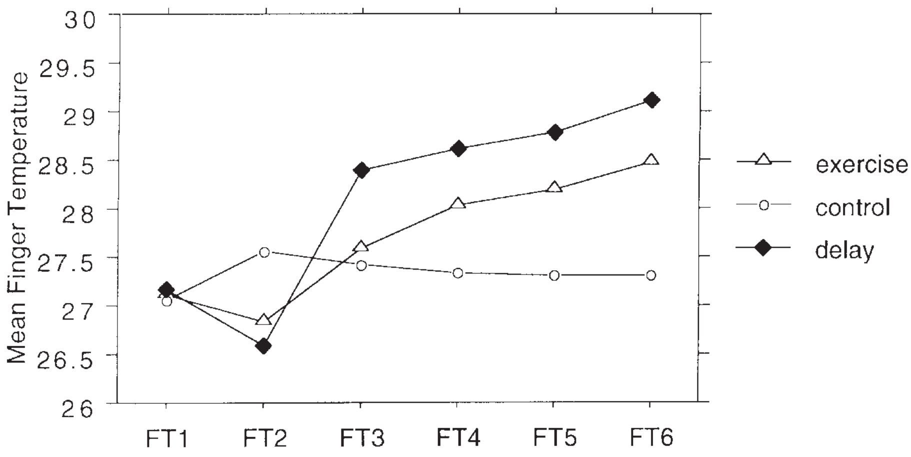

Fig. 3. Mean finger temperature (˚C) as a function of arousal manipulations.

ditions. Analysis of the six mean measurements of finger temperature revealed an increase in temperature across the experiment for the exercise groups (Figure 3). A repeated-measures ANOVA, with the six temperature measurements as the within-subject repeated measures, and arousal as the between-subject independent variable, revealed a significant difference between the six measurement points, $F(5, 36) = 7.43$, $p < .0001$, and between arousal manipulations, $F(10, 74) = 3.46$, $p < .01$. Participants in the delayed exercise condition showed a greater temperature rise than those in the exercise condition due to the latency associated with measures of finger temperature. Both exercise groups showed a tendency toward higher temperatures than the control group, but post-hoc analyses revealed no significant contrasts.

In summary, heart rate and finger temperature changes across the experiment suggest that the arousal manipulations were successful in producing differences between the physiological arousal of two exercise groups relative to a control group. The physiological measures do not indicate that exercise and delayed-exercise groups are reliably distinguished in terms of induced arousal.

Mood State

Preliminary ANOVAs confirmed that there were no pre-existing differences between the three groups of participants on any of the eight self-reported measures of arousal and mood (derived from the POMS questionnaire and affect grid administered at the start of the experiment). Further analysis of the data from the POMS questionnaire focused on whether mood differences result from participation in the different types of arousal induction. Mean mood disturbance scores before (M = 14.88, SD = 6.45) and after the experiment (M = 13.23, SD = 6.23) revealed a reduction in total mood disturbance across the experiment. A one factor, repeated-measures ANOVA (with the total mood disturbance scores before and after the test as the repeated measure, and arousal condition as the between-subjects factor), confirmed the reliability of this reduction in mood disturbance, $F(1, 45) = 4.47$, $p = .04$, but revealed no interaction with arousal manipulation. A more detailed analysis of each scale from the POMS questionnaire revealed a significant overall reduction in tension-anxiety, $F(1, 45) = 20.56$, $p < .0001$, depression-dejection, $F(1, 45) = 4.6$, $p = .04$, anger-hostility, $F(1, 45) = 9.16$, $p = .004$, and confusion-bewilderment, $F(1, 45) = 16.37$, $p = .0002$, but no significant reduction in fatigue-inertia or vigor-activity. Nor was there any interaction with arousal manipulation. In sum, participants reported an improved mood state over the course of the experiment that was not influenced by the arousal manipulation.

These results were confirmed by the ratings from the mood affect grid. Mean ratings on the mood affect grid revealed an increase of “pleasantness” (pretest M = 6.00, SD = 1.47; posttest M = 6.38, SD = 1.58) and an increase in “arousal” (pretest M = 4.85, SD = 1.62; posttest M = 5.33, SD = 1.8). A one-factor, repeated-measures ANOVA, with pretest and posttest mood disturbance scores as the within-subject dependent variable, and arousal condition as the between-subject factor, confirmed an increase in self-reported “arousal” after the experiment, $F(1, 45) = 4.99$, $p = .03$, but no effect of arousal manipulation. The difference between ratings of “pleasantness” before and after the experiment approached significance, $F(1, 45) = 3.58$, $p = .06$, although there was no interaction with arousal manipulation.

In sum, there was a general reduction in mood disturbance across the experiment and increased feelings of energy and pleasantness. The failure to find any differences in self-reported arousal between the exercise and delay groups is unexpected, as one might expect those who have been exercising to report more arousal and perhaps more fatigue. Failure to find significant differences between participants in the three conditions suggests that the differences in emotion ratings associated with the arousal manipulations cannot be explained as the effect of differences in mood state induced by the manipulations.

Predicting Emotion Ratings From Mood and Arousal

The preceding analyses indicate that the differences between the emotion ratings associated with the arousal manipulations are unlikely to be the result of mood differences, given the absence of mood-state differences as a function of arousal manipulation. However, to check for any association between mood state and emotion ratings, a series of linear regressions were carried out on the data, between the POMS total mood disturbance score at the end of the experiment and the ratings of each piece on each of the four aggregated emotion scales. Comparison was made with mood at the end of the experiment, because this was the measure taken after the arousal manipulation when any mood differences might have been produced. Ratings of emotion expressed and felt were analyzed together, given the lack of distinction between these two in relation to the effects of arousal just described.

These analyses revealed an association between mood and ratings of emotion in four cases. There was a significant positive association between total mood disturbance and positive ratings of Piece 2, which had a positive valence, $r(48) = .34$, $t = 2.46$, $p = .018$. The regression between mood disturbance and Piece 4, the other piece that had a positive valence, approached significance, $r(48) = .26$, $t = 1.86$, $p = .07$. However, this association is in the opposite direction to that hypothesized: the higher the mood disturbance, the higher the rating of positive emotions. Neither do the other significant associations support the hypothesis that improved mood state explains increased positive ratings of music that has positive valence: there is a significant positive association between mood disturbance and the ratings of Piece 2 in terms of both high-energy emotions, $r(48) = .35$, $t = 2.49$, $p = .016$, and low-energy emotions, $r(48) = .36$, $t = 2.64$, $p = .01$. In other words, the higher the mood disturbance, the higher the ratings of both kinds of energy. These associations do not form a consistent pattern and provide no clear evidence that differences in mood state account for the emotion ratings of the music.

Linear regressions were also carried out between the aggregated emotion ratings and ratings of mood, on the two scales derived from the affect grid. This revealed a small number of significant associations. Piece 3 (a negative, high-energy piece) showed a significant positive association between negative ratings and self-reported arousal, $r(48) = .41$, $t = 2.17$, $p = .036$, and a negative association between negative ratings and "pleasantness," $r(48) = -.41$, $t = -2.16$, $p = .036$. This suggests that feeling aroused and in a less pleasant mood is associated with increased ratings of negative emotions. Higher self-reports of arousal were also associated with increased ratings of high-energy emotions in relation to Piece 3, $r(48) = .35$, $t = 2.33$ $p = .02$. Thus, it appears that increased self-reports of arousal are associated with increased ratings of high-energy emotions, when the music is high in energy, and an increase in negative ratings when the piece is negative. The results of the mood affect grid provided only weak support for the hypothesis that differences in mood state can account for differences in the emotion ratings of music and suggest that self-perception of increased arousal is better able to account for increased emotion ratings when that arousal is congruent with the energy of the piece.

Aside from the effects of general mood improvement, the other possibility is that differences in emotion ratings are the result of increased physiological arousal. To test this idea, a series of simple linear regressions were performed between the emotion ratings for each piece (aggregated by valence and by energy) and heart rate and finger temperature at the corresponding point in time (taking into account order of presentation of materials). As before, ratings of emotion expressed and emotion felt were subjected to a single analysis.

There were no significant associations between finger temperature and any of the emotion ratings, nor were there any significant associations between heart rate and emotion ratings aggregated by valence. However, the regression between heart rate and emotional ratings aggregated by energy is significant in two cases: there is a positive association between heart rate and the high energy ratings for Piece 2, $r(48) = .4$, $t = 2.95$, $p = .005$, and for Piece 4, $r(48) = .33$, $t = 2.35$, $p = .023$. None of the regressions account for much of the overall variance of the scores. This is unsurprising given the individual variability inherent in physiological measures such as heart rate and finger temperature. In each case, increased physiological arousal, as measured by heart rate, is associated with an increase of the emotion ratings aggregated by energy. Pieces 2 and 4 are both positive in valence; therefore, it may be that physiological arousal intensifies emotional experience only for stimuli that are positive in valence. Taking these results together with those of the affect grid, it appears that arousal (both self-reported and physiologically measured) is associated with increased emotion ratings, and arousal seems to intensify the dominant response, particularly if the stimuli is positive in valence.

DISCUSSION

Experiment 2 found some evidence that arousal manipulation influences ratings of emotions felt, and thought to be expressed, while listening to music. Groups of participants who had exercised before making emotion judgments gave increased ratings of positive emotions in relation to a control group, when the music judged was positive in valence. Arousal manipulations did not affect ratings of the emotional energy of pieces. These results partially support the hypothesis that increased physiological arousal intensifies emotional experience with music. Although arousal manipulations did effect emotion judgments, increased physiological arousal seemed to increase only the dominant response, when that response was positive in valence. It did not increase ratings of negative emotions in relation to pieces negative in valence.

One explanation for the intensified emotional experience of pieces with positive valence is that exercising produces a general improvement in mood that causes intensification of positive emotions. However, no evidence for this was found: tests revealed no significant differences between the mood states of the exercise and control groups, and subsequent regressions revealed no consistent association between emotion ratings and mood state.

A second possibility is that increased physiological arousal is interpreted by listeners as an intensified emotional response to the music. Tests for an association between increased heart rate, temperature and emotion ratings provided some supporting evidence for a positive association between arousal and the intensity of the dominant response: increased heart rate was associated with increased ratings of high-energy emotions, when the piece was positive in valence. In addition, self-reports of arousal were associated with increased ratings of the dominant response: in particular, higher self-reported arousal was associated with higher ratings of high-energy emotions. These results suggest that participants were influenced by their body state in making emotional judgments of musical experience.

In addition, the results of Experiment 2 shed some light on the relationship between emotion expressed and emotion felt. The energy level of the music appears to influence the intensity of emotion felt versus that expressed: there is a tendency for those emotions congruent with the energy of the piece to be expressed more than they are felt. This may reflect a general tendency for a greater intensity of emotions expressed than felt. When the music was negative in valence, negative emotions were reported to be expressed by the music at a greater intensity than they were reported to be felt by participants. This pattern may be due to a greater unwillingness of participants to admit to feeling negative emotions during the experiment: it is more socially acceptable, for instance, to say that a piece of music expresses negative emotions than it is to say that you feel negative emotions. This may explain why no effect of arousal was found for the ratings of negative pieces of music.

The use of three different arousal manipulations allowed exploration of different states of arousal. In particular, the inclusion of a delay between the exercise and the rating task, in addition to an exercise task and a control task, allowed direct comparison with other studies using a similar paradigm. Evidence from other studies suggests that, where there is a delay between the exercise and rating task, arousal intensifies the dominant response, whereas when the exercise is immediately followed by the rating task there is no effect on emotion judgments. This was not found to be the case here: both exercise manipulations were associated with an increase in some of the emotion judgments.

The self-reports of arousal seem to contradict the physiological measurements of arousal: despite having elevated heart rates and temperature, participants who had exercised reported feeling no more aroused than did participants in the control group. A possible reason for this is that participants often think they have recovered from exercise before their physiological measures indicate they have (Cantor et al., 1975); therefore, this finding may reflect poor awareness of arousal on the part of participants rather than a lack of arousal. If correct, this result would suggest that there does not need to be conscious awareness of arousal for it to influence emotional experience. Additionally, it may be that the arousal caused by exercising is “cancelled out” in self-reports by the fatigue that results. One difficulty with using measures of physiological arousal is the high degree of individual variability to which such measures are subject, both in terms of how much change is caused by exercise for participants who have different levels of fitness, and what time course any physiological changes take after exercise has stopped. However, even in the face of this caveat, Experiment 2 provides some evidence that listeners are influenced by their body state when making judgments of emotional experience with music.

Conclusions

This research was intended to determine whether peripheral feedback influences emotional experience with music. Two separate experiments, using variants of the same paradigm, revealed that increased arousal influences listeners’ experiences of emotion. Experiment 1 revealed that increased physiological arousal intensified the dominant valence of emotions felt while listening to music, but not the arousal dimension of their emotional ratings. The results of Experiment 2 indicated an intensification of positive emotions felt and thought to be expressed by music when the music was positive in valence. The absence of any differences in mood state as a consequence of exercising indicates that these effects are not due to a general improvement in participants’ mood states. Furthermore, significant associations were found between emotion ratings and both self-reported and physiological measures of arousal. These results provide support for the hypothesis that increased physiological arousal intensifies emotional experience with music.

Whether arousal intensifies the dominant valence of the response (as suggested by Experiment 1), or intensifies positive emotions only for pieces that are positive in valence (Experiment 2) is unclear, because the two experiments provide conflicting results in relation to this issue. The results of Experiment 1, where arousal intensified the dominant response, are consistent with the results of similar studies using nonmusical target stimuli. Failure to find this effect in Experiment 2 may have been due to methodological differences. One possible reason for the lack of any effect for pieces with negative valence has already been discussed: participants reported lower levels of negative emotions felt than expressed in Experiment 2, which could be due to an unwillingness to admit to feeling negative emotions within an experimental setting that involved only the participant and the experimenter. In Experiment 1, participants were tested in groups and no such effect was found. If individual testing in Experiment 2 resulted in a lowering of ratings of negative emotions felt, then any effect of arousal on emotion ratings of pieces that had a negative valence might be subsumed within this larger effect. The failure to find a correspondingly strong influence on perceived emotional "energy" of the music suggests that listeners do not interpret their increased arousal as an intensification of the arousal dimension of emotional experience.

At first glance the results also seem to provide conflicting evidence regarding the effect of arousal on emotion felt or expressed: whereas the results of Experiment 1 suggest that arousal influences only emotion felt, no such distinction was found in Experiment 2. However, this difference seems to depend on whether these two judgments are made consecutively or by independent groups. If the same participants make both judgments, then emotion felt and expressed are distinguished from one another, and arousal seems to influence only emotion felt. If the judgments are made by independent groups, then emotion felt and expressed are not so reliably distinguished, and arousal seems to have the same effect on both. One point that should be noted is that the experimental situation necessarily represented a diminished range of situational factors (participants were drawn from a similar subject pool and participated in the experiment under the same controlled conditions), thus some of the situational variables that Gabrielsson has argued contribute to differences between emotion induction and perception were absent. In these circumstances, the similarity between induction and perception may be greater than might otherwise be expected. The lack of differentiation between emotion felt and expressed in Experiment 2 suggests that when asked only to make a single judgment, participants do not differentiate between emotion-modes as well as when they are asked to do both together.

It could be questioned whether participants are having an emotional response within the experimental setting at all. The paradigm requires listeners to evaluate emotion felt and/or expressed by the music in relation to four relatively short (40 s) extracts of music in succession, without any accompanying information (such as a narrative context). As might be expected within such a paradigm, both experiments elicited low emotion ratings overall. However, these ratings were still sufficient to show an effect of physiological arousal, the focus of the research. One way to increase the strength of emotional experience in future studies might be to use music from films, which would be a familiar genre to participants, and which is often explicitly designed with emotional experience in mind, or to adopt a design that involves a more ecologically valid setting.

Last, it is not clear that the electronic method of data collection was an improvement on the self-report method used in Experiment 1. Although the electronic method of data collection means that participants are unaware of their exact level of arousal, they are constantly reminded that their physiology is being measured by virtue of the fact that they are wearing pieces of equipment specifically designed to collect such information. Paradoxically, this may cause participants in Experiment 2 to be more aware of their body state throughout the listening task than participants in Experiment 1, who report their arousal level only at the start and end of the experiment.

Although this research provides evidence for undifferentiated arousal, differentiated arousal cannot be ruled out on the basis of this study. The methods of arousal used in these experiments (walking and cycling) were crude inducers designed to elicit various degrees of change in the level of arousal rather than to target specific physiological changes. However, it may be that the kind of arousal induced in this study is more congruent with certain kinds of emotions than others. For example, the particular physiological changes induced by vigorous exercise (high pulse and heart rate, faster breathing, heat) are changes that, it has been claimed, are associated with emotions that have a negative valence, namely, fear, anger, and sadness (Plutchik, 1994, p. 120). If people interpret the emotion they experience partly in terms of an assessment of their body state of arousal, then these particular physiological changes would produce interpretation in terms of these negative emotions. The results of this study suggest that arousal intensifies the dominant valence response, rather than only intensifying negative emotions. More controlled studies that create targeted arousal along the lines recently carried out with respiration (Philippot et al., 2002) could provide a means to investigate whether particular kinds of peripheral feedback can induce particular emotional experiences with music.

IMPLICATIONS FOR UNDERSTANDING EMOTION AND MUSIC

The results of this research confirm prevailing models of emotion, in which physiological arousal is one component of emotional experience, which as well as preparing the individual for action, can “feed back” and contribute to the intensity of the emotional feeling state. It suggests that listeners can use reflection on their body state (not necessarily conscious) as a clue to the emotion they are experiencing in relation to music. This has important implications for theories of emotion and music because it suggests that private self-perception, specifically perception of one's body state, can be one source of emotion experienced with music. When we experience emotional feeling states we also experience body sensations associated with those states. But, as this research shows, this phenomenon can also work in the opposite direction: body sensations from one source can be misattributed/transferred to another. In this case, the body sensations of arousal due to exercise are attributed or transferred to the music, and those sensations can intensify the emotion thought to be expressed by the music and/or the emotion felt in relation to the music.

Does this phenomenon ever occur in the real contexts within which listeners encounter music? It may be that the effect found here is an artifact of the reduced circumstances in which the emotion judgments were made. Perhaps when richer contexts are available to listeners, they do not use their body state to evaluate the emotion they feel. Further research is needed to determine the exact circumstances within which listeners are influenced by their body state. The significance of the findings presented here is that they suggest that listeners *can* use their body state as an input to their emotional experience with music. One implication of this finding would seem to be that the listening practices generally employed with classical music minimize the intensity of emotion felt while listening to music: concerts of Western classical music (the genre used in this study) usually require listeners to sit still and avoid overt displays of emotion. Conversely, genres that involve greater physical exertion (e.g., contemporary Western club or dance music, or music in evangelical worship where movement and overt display of emotion is encouraged) could intensify emotional experience. It may even mean that, for example, arriving physiologically aroused at a concert (because one is late and has had to run, for instance) may intensify emotional experience of the music. However, this would be a crude simplification of emotional experience: as emphasized earlier, body sensations do not operate in isolation and are only one component in a much more complex process. The significance of this research is that it provides evidence of the way in which visceral self-perception could influence emotional experience with music—and is one example of how extraneous cues contribute to an individual's emotional experience with music. Some theorists have suggested that music often lacks a definite emotional character and that listeners have to search the environment for clues as to the emotion they should feel or hear in response to a particular musical experience (Sloboda & Juslin, 2001). The findings from the research reported here suggest that one source of such "clues" is peripheral feedback.

References

Bartlett, D. L. (1996). Physiological responses to music and sound stimuli. In D. A. Hodges (Ed.), *Handbook of music and psychology* (2nd ed., pp. 343–385). San Antonio, TX: IMR Press.

Cacioppo, J. T., Berntson, G. G., & Klein, D. J. (1992). What is an emotion? The role of somatovisceral 'illusions.' *Review of Personality and Social Psychology, 14,* 68–98.

Cantor, J. R., & Zillman, D. (1973). The effect of affective state and emotional arousal on music appreciation. *Journal of General Psychology, 89,* 97–108.

Cantor, J. R., Zillman, D., & Bryant, J. (1975). Enhancement of experienced sexual arousal in response to erotic stimuli through misattribution of unrelated residual activation. *Journal of Personality and Social Psychology, 32,* 69–75.

Chwalisz, K., Diener, E., & Gallagher, D. (1988). Autonomic arousal feedback and emotional experience: Evidence from the spinal cord injured. *Journal of Personality and Social Psychology, 54,* 820–828.

Damasio, A. R. (1994). *Descartes' error: Emotion, reason and the human brain.* New York: G. P. Putnam.

Dutton, D. G., & Aron, A. P. (1974). Some evidence for heightened sexual attraction under conditions of high anxiety. *Journal of Personality and Social Psychology, 30,* 510–517.

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221,* 1208–1210.

Forster, J. (1998). The influence of motor perceptions on likeability judgements of attractive and unattractive portraits. *Zeitschrift für Experimentelle Psychologie, 45,* 167–182.

Frijda, N. H. (1986). *The emotions.* Cambridge: Cambridge University Press.

Gabrielsson, A. (2002). Emotion perceived or emotion felt: Same or different? *Musicae Scientiae, Special Issue "Current trends in the study of music and emotion," 2001–2002,* 123–147.

Harrold, G. *Complete relaxation.* Maidstone, Kent: Diviniti Publishing, 2000.

Haydn, *15 Famous String Quartets.* Kodály Quartet. Naxos, 1990.

Haydn, *Symphony no. 35 in B flat major and Symphony no. 39 in G minor.* L'Estro Armonio, dir. Derek Solomons, 1982.

Haydn, F. J. *The Seven Last Words of Christ.* Kodály Quartet. Naxos, 1989.

James, W. (1884). What is an emotion? *Mind, 19,* 188–205.

Konečni, V. J. (1975). The mediation of aggressive behavior: Arousal levels versus anger and cognitive labelling. *Journal of Personality and Social Psychology, 32,* 706–712.

Krumhansl, C. L. (1997). An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology, 51,* 336–352.

Larsen, R. J., Kasimati, S. M., & Frey, K. (1992). Facilitating the furrowed brow: An unobtrusive test of the facial feedback hypothesis applied to unpleasant affect. *Cognition and Emotion, 6,* 321–338.

Martin, L. L., Harlow, T. F., & Strack, F. (1992). The role of bodily sensations in the evaluation of social events. *Personality and Social Psychology Bulletin, 18,* 412–419.

McIntosh, D. N. (1996). Facial feedback hypotheses: evidence, implications, and directions. *Motivation and Emotion, 20,* 121–147.

McNair, D. M., Lorr, M., & Droppleman, L. F. (1992). *POMS: Profile of Mood States.* North Tonawanda, NY, & Toronto: Multi-Health Systems.

Mezzacappa, E. S., Katkin, E. S., & Palmer, S. N. (1999). Epinephrine, arousal, and emotion: A new look at two-factor theory. *Cognition and Emotion, 13,* 181–199.

Mozart,W. A. *Quintet G minor and quintet in C major.* Arthur Grumiaux Trio (with guests). Philips CD, 1991.

Nisbett, R. E., & Schachter, S. (1966). The cognitive manipulation of pain. *Journal of Experimental Social Psychology, 2,* 227–236.

Nyklicek, I., Thayer, J. F., & van Doornen, L. J. P. (1997). Cardiorespiratory differentia-

tion of musically-induced emotions. *Journal of Psychophysiology, 11*, 304–321.
Oatley, K., & Jenkins, J. M. (1996). *Understanding emotions.* Cambridge: Blackwells.
Philippot, P., Chapelle, G., & Blairy, S. (2002). Respiratory feedback in the generation of emotion. *Cognition and Emotion, 16*, 605–627.
Plutchik, R. (1994). *The psychology and biology of emotion.* New York: Harper Collins.
Priester, J. R., Cacioppo, J. T., & Petty, R. E. (1996). The influence of motor processes on attitudes toward novel versus familiar semantic stimuli. *Personality and Social Psychology Bulletin, 22*, 442–447.
Reisenzein, R. (1983). The Schachter theory of emotion: two decades later. *The Psychological Bulletin, 94*, 239–264.
Robbins, T. W. (1997). Arousal systems and attentional processes. *Biological Psychology, 45*, 57–71.
Russell, J. A. (1989). Measures of emotion. In R. Plutchik & H. Kellerman (Eds.), *The measurement of emotions* (Vol. 4, pp. 81–111). New York: Academic Press.
Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology, 57*, 493–502.
Schachter, S. (1964). The interaction of cognitive and physiological determinants of emotional state. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 1, pp. 49–79). New York: Academic Press.
Schachter, S., & Singer, J. (1962). Cognitive, social and physiological determinants of emotion state. *Psychological Review, 69*, 379–399.
Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion* (pp. 361–392). New York: Oxford University Press.
Sloboda, J. A., & Juslin, P. N. (2001). Psychological perspectives on music and emotion. In P. N. Juslin & J. A. Sloboda, *Emotion and music: Theory and research* (pp. 71–104). Oxford: Oxford University Press.
Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology, 64*, 211–220.
Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology, 54*, 768–777.
Wiens, S., Mezzacappa, E. S., & Katkin, E. S. (2000). Heartbeat detection and the experience of emotions. *Cognition and Emotion, 14*, 417–427.
Witvliet, C. van O, & Vrana, S. R. (1996). The emotional impact of instrumental music on affect ratings, facial EMG, autonomic measures, and the startle reflex: effects of valence and arousal. *Psychophysiology Supplement, 91.*
Witvliet, C. van O., Vrana, S. R., & Webb-Talmadge, N. (1998). In the mood: Emotion and facial expressions during and after instrumental music and during an emotional inhibition task. *Psychophysiology Supplement, 88.*
Zentner, M. R., Meylan, S., & Scherer, K. R. (2000). *Exploring 'musical emotions' across five genres of music.* Paper presented at the 6th International Conference of Society for Music Perception and Cognition, Keele, U.K.
Zillman, D. (1978). Attribution and misattribution of excitatory reactions. In J. H. Harvey, W. J. Ickes, & R. F. Kidd (Eds.), *New directions in attribution research* (Vol. 2, pp. 335–368). Hillsdale, NJ: Lawrence Erlbaum.
Zillman, D., Katcher, A. H., & Milavsky, B. (1972). Excitation transfer from physical exercise to subsequent aggressive behavior. *Journal of Experimental Social Psychology, 8*, 247–259.