Chapter 5
Music and Emotion

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5.1 Introduction to the Study of Music and Emotion

Music is the shorthand of emotion.

–Leo Tolstoy

Why waste money on psychotherapy when you can listen to the B Minor Mass?

–Michael Torke

These two quotations reflect common attitudes about music. Tolstoy's comment suggests that music *conveys* emotion, whereas Torke's question implies that music *influences* listeners' emotions. Section 5.2 of the present chapter includes a discussion of the various theoretical approaches that are used to explain affective responses to music. Few scholars dispute the claim that listeners recognize emotions in music. Some argue, however, that music does not elicit true emotions in the listener (e.g., Kivy 1980, 1990, 2001). For example, many years ago Meyer (1956) posited that affective responses to music consist of experiences of tension and relaxation (rather than actual emotions), which occur when listeners' expectancies about what will happen next in a piece of music are violated or fulfilled, respectively. This position has been challenged in recent years with findings from studies using behavioral, physiological, and neurological measures, all of which indicate that listeners respond affectively to music (e.g., Krumhansl 1997; Gagnon and Peretz 2003; Mitterschiffthaler et al. 2007; Witvliet and Vrana 2007). Nonetheless, the debate continues (e.g., Konečni 2008).

Even if one accepts that listeners respond emotionally to music, there are still disagreements about the nature of the response. Section 5.2 also includes an examination of issues that remain unresolved about whether emotional responses to music are

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(1) "real" emotions, (2) a separate class of "aesthetic" emotions, or (3) moods rather than emotions. A discussion of how to characterize and classify emotional responses to music is included. Categorical (or discrete) models of emotions, drawing from research on *basic emotions* (Ekman 1984, 1992), have been used in much of the past research. By contrast, dimensional (or continuous) models of emotion describe emotions in terms of various dimensions. Although the two approaches are not completely incompatible, the fit is not perfect. For example, the *circumplex model* (Russell 1980) uses two dimensions to describe emotions: *valence* (ranging from displeasure to pleasure) and *arousal* (level of activation). This approach works well for some specific emotions (e.g., *joy* has positive valence and high arousal; *sadness* has negative valence and low arousal), but others are undifferentiated on these dimensions. For example, *fear* and *anger* both have negative valence and high arousal.

Are certain musical characteristics such as tempo, mode, and loudness reliable indicators of a piece's associations with one or more emotions? Are some characteristics more consistent than others in being associated with emotions across listeners and musical styles? Are some emotions easier than other emotions to convey and induce with music? Do musical characteristics interact in their influence on the emotional status of a piece? Section 5.3 provides a review of evidence relevant to these sorts of questions.

Various ways to measure emotional responses to music are described and critiqued in Sect. 5.4. There are as many approaches to measurement of emotions as there are theories about what these are. Different models of emotion lend themselves to different measurement techniques. Categorical models make the use of distinct labels appropriate (e.g., happy, sad, etc.), whereas dimensional models are consistent with the use of rating scales (often for arousal and valence). Both of these methods rely primarily on self-report, which may be susceptible to response bias. Technological advances have provided more "objective" ways of measuring emotional responses (e.g., physiological responses, brain imaging), but these methods are relatively insensitive to emotional responses other than arousal and pleasantness/unpleasantness (or liking/disliking).

How are listeners' emotional responses to music similar to and different from their perceptions of the emotions conveyed by music? Differences in methods across studies make it difficult to arrive at general conclusions, or to resolve apparent discrepancies in findings that have been reported. Often, listeners are asked only about their own emotional experience (e.g., Hunter et al. 2008a), or what emotion they hear in the music (e.g., Gagnon and Peretz 2003). At other times, the locus of the emotion (i.e., felt or perceived) may be ambiguous. While emotional reactions are likely to parallel perceptions of emotions in many instances, at other times the two types of response may diverge. Section 5.5 provides a review of studies that explored links between perceiving and feeling emotions in musical contexts.

Section 5.6 addresses a specific, relatively intense emotional response to music: *chills*. First described by Goldstein (1980), chills are the "tingly" feelings that listeners sometimes experience. Chills are usually pleasurable experiences that can be accompanied by physiological reactions, such as piloerection (goosebumps).

Although the experiences are clearly emotional, it is unclear how they are evoked by music and how they fit within models of emotion. Section 5.6 explores what is known about the experience of chills (e.g., phenomenological, physiological, and neurological reactions) and reviews studies linking musical features to such experiences.

Section 5.7 comprises a discussion of one of the most basic affective responses to music: *liking*. Liking for music is reviewed as a function of consonance and dissonance, familiarity with the piece, and the emotion portrayed by the piece. Finally, Sect. 5.8 provides an overview of the chapter and highlights interesting questions that could be examined in future research.

5.2 What Are Musical Emotions?

Although scholars agree that music can *sound* happy or sad, there is contention over whether music truly evokes emotions. Even those who agree that music evokes emotions often disagree over the nature of those emotions and how they are induced. Are musically induced emotions the same as everyday emotions such as happiness, sadness, anger, and so on? Much of this debate centers on the definition of *emotion*. Outside the music literature, probably the most common position comes from *appraisal theory* (see Smith et al. 1993), which asserts that emotions result from cognitive appraisals of a target. For example, sadness is elicited by news of the death of a friend, which is appraised as beyond one's control and contrary to one's desires. The debate also depends on what "emotions" are considered to comprise. Most agree that emotions consist of a subjective feeling, but some expand the definition to include a combination of additional components, such as cognitive appraisal, physiological arousal, motor expression, and behavioral tendency (Scherer 2004). The present section details the various positions related to the presence and nature of emotional responses to music.

5.2.1 Emotivist and Cognitivist Positions

Music philosophers were among the first to debate the existence of music-induced emotions, with believers and nonbelievers referred to as *emotivists* and *cognitivists*, respectively. Kivy (1980, 1990, 2001), one of the main proponents of the cognitivist position, argues that happy- and sad-sounding musical pieces do not evoke true happiness and sadness in listeners. Rather, affective responses stem from listeners' evaluations of the music. He writes, "I experience unalloyed joy when I listen to sad music that is great music, utter boredom when it is sad music that is bad music" (Kivy 2001, p. 147). In line with appraisal theorists (e.g., Smith et al. 1993), Kivy argues that emotions require a cognitive appraisal of a target and that there is no target in music except the music itself. As a result, listeners simply feel positive or negative when they like or dislike the music, respectively. In other words, listeners refer to music as *happy* or *sad* because the music expresses happiness or sadness, not because the music makes them feel happy or sad.

By contrast, most emotivist theories suggest that music actually evokes or induces feelings in listeners (for a review, see Davies 2001). Various attempts have been made to deal with the difficulty of explaining emotional reactions to music in terms of cognitive appraisals. Some scholars deny that emotions necessarily involve appraisals (e.g., Maddel 2002), and argue that other mechanisms can give rise to musical emotions. For example, emotional responses to music may be a sympathetic response (Ridley 1995; Levinson 1996). A piece of music may invoke a hypothetical person expressing emotion; the listener consequently feels a similar emotion. In a related vein, Davies (2001) agrees that listeners' feelings may mirror those expressed by the music even though they are not targeted at the music. Rather, they are experienced *contagiously*, much like being around a sad person or a group of sad people can lead to feelings of sadness. Juslin and Västfjäll (2008) argue that cognitive appraisals are but one way emotions are induced, and they propose six other mechanisms that explain how musical pieces (and other stimuli) induce emotion: (1) brain stem reflexes (e.g., reactions to dissonance), (2) conditioning (i.e., a particular piece or genre is associated with a positive or negative emotion), (3) contagion (i.e., perceptions spread to feelings, as noted), (4) visual imagery (i.e., images evoked by music act as cues to an emotion), (5) episodic memory (i.e., a piece is associated with a particular event, which, in turn, is associated with an emotion), and (6) expectancies that are fulfilled or denied (from Meyer 1956).

Huron's (2006) ITPRA (Imagination-Tension-Prediction-Response-Appraisal) theory expands upon Meyer's (1956) work on the affective consequences of expectancies. Although the theory is formulated as a general theory of expectancy, Huron applies it specifically to music. He identifies five expectancy responses, two occurring before the onset of the event and three afterwards. The first is the *imagination response*, which is somewhat removed from the event and consists of the prediction of what will happen – and how the listener will feel – when and after the musical event occurs. By contrast, the *tension response* refers to listeners' mental and physiological preparation when the expected event is imminent. After the event has occurred, listeners receive some pleasure or displeasure from the accuracy of their prediction, which is the *prediction response*. Listeners also evaluate the pleasantness or unpleasantness of the outcome, which gives rise to *reaction response*. Thus, immediately following an event that was negative but nevertheless predicted, the listener may feel some mix of pleasure and displeasure. Finally, the *appraisal response* arises with the activation of conscious thought and involves a higher-level evaluation of the event and its consequences. The entire process can lead to specific affective responses. When expectancies are met, music listeners get a certain degree of pleasure, which is reinforced if the event is positive. Nonetheless, expectancies that are unfulfilled are not necessarily negative. If the event is appraised as positive overall, the result might be laughter, awe, or chills. These responses are related to the flight, freeze, and fight responses, which occur in response to negatively appraised events.

In a different view, Matravers (1998) accepts that emotions necessarily involve cognitive appraisals. Accordingly, he proposes that the affective experience of music is not one of emotions per se. Rather, musical affect consists solely of a feeling component – the subjectively felt component of an emotion without the associated cognition. This proposal blurs the distinction between emotions and *moods*, which are typically used to describe diffuse but relatively long-lasting feelings with no clear target (e.g., Morris 1992; Clore et al. 1994; Frijda 1994; Russell 2003; Schimmack and Crites, 2005). To further complicate matters, others argue that moods are dispositions towards certain kinds of cognitions (Frijda 1993; Siemer 2001). For example, when participants are asked to recall a sad or angry memory, the number of mood-congruent thoughts determines the degree to which the corresponding mood is experienced (Siemer 2005). When moods are measured after listening to happy-, sad-, or angry-sounding music (Siemer 2005), however, correlations between mood and thought processes could arise because the music initially evoked the mood, which then influenced participants' way of thinking. Moreover, the implication that sad music (or any music expressing negative emotions) induces sad feelings because it evokes sad thoughts is problematic. Why would listeners choose to hear sad-sounding music if it induces sad thoughts?

Regardless of whether music induces emotions or moods, there is much evidence against a strict cognitivist position. Physiological and neurological responses to music are similar to those that accompany emotional responding in general (e.g., Krumhansl 1997; Nyklíček et al. 1997; Mitterschiffthaler et al. 2007; Witvliet and Vrana 2007). In a recent study, however, physiological and self-report ratings were not completely synchronized during music listening (Grewe et al. 2007a). Because emotions are often considered to have physiological, psychological, and behavioral components (Scherer 2004), the authors interpreted the lack of synchronicity as evidence that music did not actually induce emotional responding. Nonetheless, these components are often out-of-sync in response to nonmusical events that elicit emotions (Niedenthal et al. 2006). In short, because music can elicit each component of emotion, it seems relatively safe to conclude that music induces some sort of emotional responding.

An alternative perspective (Scherer 2004; Zentner et al. 2008) argues that emotional reactions to music are common but that these differ from normal conceptions of emotion. For example, feelings of transcendence are a relatively common consequence of music listening, yet transcendence does not map readily into two-dimensional space defined by arousal and valence, and it is quite dissimilar from prototypical emotions used in the categorical approach. Thus, music is said to elicit a separate class of *aesthetic emotions* (see also Konečni 2008) that are distinct from everyday or *utilitarian emotions*. For aesthetic emotions, the feeling component is obvious but the behavioral and physiological components are often obscure. In one study that used retrospective self reports (Zentner et al. 2008), participants listed how frequently they perceive and feel a large number of affective terms in response to music. Principal components analysis revealed that common affective responses to music could be grouped into one of nine categories: *Wonder*, *Transcendence*, *Tenderness*, *Nostalgia*, *Peacefulness*, *Power*, *Joyful Activation*, *Tension*, and *Sadness*. Although there is some overlap between these terms and the terms used in categorical and dimensional models, these aesthetic emotions also differ substantially from everyday emotions.

Perhaps the strongest evidence for affective responding to music comes from the many studies that use music to induce moods (for review, see Västfjäll 2002). Presumably, the method would not be so common if it did not work. Self-reports confirm that listeners' moods are influenced subjectively by music listening, whereas measurable effects on cognition provide more objective evidence. One example, the so-called *Mozart effect* (Rauscher et al. 1993), refers to the finding that listening to music composed by Mozart improves performance on tests of spatial abilities. Follow-up studies reveal that similar enhancements are evident following exposure to other pleasant stimuli and on tests that measure nonspatial abilities, whereas lower levels of performance are observed after exposure to less appealing stimuli (Nantais and Schellenberg 1999; Ivanov and Geake 2003; Schellenberg and Hallam 2005). More importantly, the link between exposure to music and cognitive performance is mediated by the listener's mood and arousal level (Thompson et al. 2001; Husain et al. 2002; Schellenberg et al. 2007).

When all of the available evidence is considered, it is clear that music listening often leads to emotional responses that are more complex than simple liking and disliking. Nonetheless, music-induced affective responses may differ from common definitions of emotion, both in quality and because they are not directed at the source. Moreover, it is difficult to explain why people often choose to listen to sad-sounding music. Because negative emotions are usually associated with avoidance motivation (Davidson 1998), one would expect sad-sounding music to be avoided. The bottom line is that whether affective reactions to music should be called true "emotions" is largely a question of semantics. At the very least, the evidence demonstrates that music listening influences physiological and neurological indices of emotion, and listeners report feeling these emotions.

5.2.2 *The Structure of Emotions*

Despite the apparent categorical nature of emotions, some scholars argue that all emotions can be reduced to less specific core affect (e.g., pleasure and displeasure; Ortony and Turner 1990). Others (e.g., Russell 1980, 2003) suggest that affective experience can be explained largely using two continuous dimensions: arousal (high and low) and valence (positive and negative). These dimensions of the circumplex model are thought to be orthogonal, such that any emotion can be characterized by its coordinates in a two-dimensional space (see Fig. 5.1, left panel). To illustrate, happiness usually has positive valence and moderately high arousal, whereas sadness has negative valence and moderately low arousal. Support for this two-dimensional approach comes from the International Affective Picture System, a set of widely used visual stimuli that are used to represent and evoke emotions (Lang et al. 1997). The stimulus pictures are classified according to their arousal and valence. The bipolar valence dimension also helps to explain

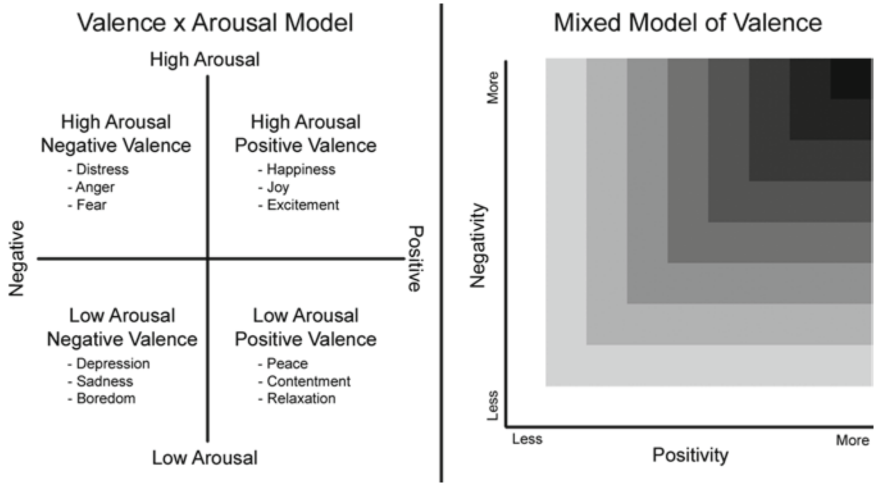

Fig. 5.1 Schematic illustrations of two models of emotion. The *left panel* shows a diagram of two-dimensional affective (valence X arousal) space – the circumplex model. Example emotions are noted in each quadrant. The *right panel* shows a model of mixed valence. Pure positive and negative responses lie along the axes in white. Darker shades of gray represent greater mixed feelings, which have shared positive and negative activation to varying degrees

affective influences on the *startle response*, the blinking reflex elicited by unexpected loud sounds (see Lang 1995). High arousal and positive valence lead to an attenuated response, whereas high arousal and negative valence lead to an exaggerated response. Fontaine et al. (2007) argue, however, that two dimensions are insufficient to categorize emotional responses completely. In a cross-cultural study, their participants were asked to differentiate 24 emotions. Responses were best described in terms of *four* rather than two dimensions: *evaluation-pleasantness*, *activation-arousal*, *potency-control*, and *unpredictability*. In short, differences in arousal and valence may fail to capture relevant distinctions among some emotions. For example, fear and stress are both negatively valenced and high on arousal but they are characterized by high and low unpredictability, respectively.

In music research, the two-dimensional model has been applied widely with considerable success (e.g., Krumhansl 1997; Schmidt and Trainor 2001; Thompson et al. 2001; Husain et al. 2002; Kreutz et al. 2008; Vieillard et al. 2008). In one study, multidimensional scaling was used to examine the underlying structure of emotional responses to music (Bigand et al. 2005). Listeners were asked to group pieces on the basis of their similarity in emotional meaning. The groupings revealed two main dimensions, arousal and valence, and a weaker third dimension related to kinetics. In an earlier study that also used multidimensional scaling (Wedin 1972), listeners rated musical excerpts on a number of different emotions. Again, the scaling solution revealed three dimensions: intensity–softness, pleasantness–unpleasantness, and solemnity–triviality. The first two dimensions corresponded closely to arousal and valence, respectively. Both of these studies provide some support for the two-dimensional approach, but they also imply that two dimensions may not be enough to explain completely the emotions expressed by music.

Moreover, although the dimensional approach has been used extensively as a framework for musical and nonmusical stimuli, mainstream emotion researchers have noted that these models are inadequate at explaining some common emotional responses, particularly those involving ambiguity or mixed feelings. Dimensional models assume that positive and negative valence lie on opposite ends of a bipolar dimension (Russell 1980; Fontaine et al. 2007). Thus, positive and negative emotions are mutually exclusive and cannot be felt simultaneously (Russell and Carroll 1999). By contrast, the *evaluative space model* (Cacioppo and Berntson 1994) suggests that positive and negative valence can be coactivated under some circumstances (see Fig. 5.1, right panel). This alternative conceptualization has received empirical support from behavioral studies (Diener and Iran-Nejad 1986; Larsen et al. 2001, 2004, 2009; Schimmack 2001; Hunter et al. 2008a). For example, in one study, participants performed a gambling task in which they could either win or lose either a small or a large amount (Larsen et al. 2004). When participants won or lost the larger amounts, they reported unambiguous positive and negative feelings, respectively. When they won or lost the smaller amounts, however, they reported feeling both positive *and* negative affect. In the case of winning the smaller amount, they appeared to feel positive that they had won, but negative that they did not win the larger amount. Conversely, when they lost the smaller amount, they felt negative about losing but positive that they did not lose even more. Happiness and sadness – putative opposites in valence – are also linked to neural substrates that are at least partially separable (Damasio et al. 2000). If valence were a single bipolar dimension, one would predict that happiness and sadness are subserved by degree of activation in a single substrate, or by two substrates that are mutually inhibitory.

Evidence of mixed feelings has also been found in response to music (Hunter et al. 2008a), a finding that is consistent with phenomenological experience and evaluations of what makes a musical piece interesting. In two experiments, participants listened to 30-s excerpts from musical recordings that had cues to happiness (fast tempo and major mode), sadness (slow tempo and minor mode), or to both happiness and sadness (fast tempo and minor mode, or slow tempo and major mode). In one experiment, participants rated their emotional responses on two separate unipolar scales: one for happiness and one for sadness, with both scales ranging from *not at all* to *extremely*. In a second experiment, they provided a single response on a two-dimensional grid, with one axis corresponding to happiness and the other to sadness (see also Larsen et al. 2009). In both experiments, participants reported greater levels of simultaneous happy *and* sad feelings when the tempo and mode cues were mixed compared to when they were consistent. Another interesting finding was that sad-sounding music elicited higher levels of mixed feelings compared to happy-sounding music.

Response patterns similar to those reported by Hunter et al. (2008a) were evident in a separate study that used more controlled stimuli: MIDI versions of Bach pieces that were manipulated with computer software to sound happy (fast and major), sad (slow and minor), or mixed (fast and minor, or slow and major; Hunter et al. 2010). Again, participants were more likely to respond ambiguously to music with mixed cues, and sad music elicited a larger degree of mixed feelings than happy music. Considered jointly, these studies demonstrate that music can elicit mixed feelings reliably and predictably, a finding that is precluded when happiness and sadness are measured with a single bipolar rating scale that ranges from *extremely sad* to *extremely happy*. Indeed, when listeners are asked to rate mixed feelings on a bipolar scale, they are compelled to either ignore the weaker response or to average their feelings, which leads to a relatively neutral rating that is insensitive to the positive *and* the negative aspects of their emotional state.

5.2.3 Summary

Section 5.2 was concerned with debates that extend beyond the music psychology literature. The question of which components should be included under the definition of "emotion" remains unresolved, and the choice of definition determines whether affective reactions to music can be considered "emotions." Some scholars include the subjective feeling only, whereas others include associated cognitions, and still others include physiological changes, motor changes, and behavioral tendencies. Although all of these components can be activated in response to music, they do not necessarily covary synchronously with each other. Moreover, the majority of affective reactions to music do not appear to be mediated cognitively in the same way that they are in response to many non-musical stimuli or events. For example, listening to Beethoven's Ninth Symphony or to The Rolling Stones' "Jumpin' Jack Flash" may cause strong positive feelings, yet these responses are not typically mediated by cognitive appraisals of Beethoven or The Rolling Stones, respectively. Thus, various alternatives have been proposed. Affective responses to music might consist of short-lasting moods, or they may be elicited through emotional contagion (i.e., perceived emotion in the music causes felt mood). Alternatively, music may elicit a separate class of aesthetic emotions that differ qualitatively from everyday emotions.

The second issue raised in this section concerned the use of the circumplex model as an explanatory framework for affective responses to music. Studies using nonmusical stimuli have provided evidence against the proposal that valence is a strictly bipolar dimension. Indeed, the use of bipolar ratings scales "can allow ambivalence to masquerade as neutrality by preventing respondents from reporting that they feel both good and bad" (Larsen et al. 2009, p. 454). In line with this view, studies using musical stimuli indicate that mixed feelings may be a relatively common and predictable result of music listening.

5.3 Emotions and Musical Characteristics

There have been many attempts to link emotions with specific aspects or dimensions of music, and to examine the consistency of these associations. Music varies on several dimensions (tempo, mode, loudness, pitch height, and so on) that are likely to influence emotional responding. In a classic series of studies

(Hevner 1935, 1936, 1937), listeners heard music that varied systematically along a number of these dimensions (e.g., mode, tempo, pitch). From a list of emotional adjectives, they choose the ones that best fit the music. Tempo and mode were the strongest determinants of perceived emotion in music. By asking listeners to choose emotions that "fit" the music, however, it is unclear whether their selections were based on their perception of emotion expressed by the music, or on their own feelings evoked by the music.

In other studies of musical correlates for different emotions, judgments of happiness and sadness tend to be more consistent than other emotions, such as fear and anger (Terwogt and Van Grinsven 1991; Gabrielsson and Juslin 1996; Krumhansl 1997), probably because of relatively straightforward associations with tempo and mode. Specifically, fast and slow tempos are associated with happiness and sadness, respectively, as are major and minor modes (for reviews see Gabrielsson and Juslin 2003; Juslin and Laukka 2004).

Far fewer studies have examined associations between affective responses and other musical dimensions, such as loudness, timbre, and pitch height. Gundlach (1935) reported that louder pieces were described as more animated, brilliant, uneasy, triumphant, and exalted, but less tranquil, mournful, melancholy, delicate, and sentimental. In a cross-cultural study (Balkwill et al. 2004), loudness was associated positively with perceptions of anger across Western, Japanese, and Hindustani musical styles, which suggests that loudness might be a universal cue to anger. Louder music is also predictive of higher levels of perceived activation and tension (Ilie and Thompson 2006). For female listeners, louder music may actually evoke negative feelings (Kellaris and Rice 1993). *Changes* in loudness are also important cues to emotion. Crescendos and decrescendos are associated with increases and decreases in arousal (Schubert 2004), respectively, whereas chills may be induced by crescendos (Panksepp 1995; Nagel et al. 2008).

Timbre appears to play a less central role in determining the emotional status of a piece of music. In a study of Western listeners' perceptions of emotions expressed by Hindustani music (Balkwill and Thompson 1999), flutes were associated with peacefulness and strings with anger. In a follow-up study that compared perceptions of music from different cultures (Balkwill et al. 2004), timbre played a relatively small part in affective judgments, but a flute (vs. string) timbre was associated with sadness in Western music. There is also some evidence that soft timbres (with attenuated high frequencies) are associated with tenderness and sadness, whereas sharp timbres (with emphasized high frequencies) are associated with anger (Juslin 1997). Other musical dimensions have been examined in relation to emotion but there are too few studies to make definitive statements. Some of these dimensions include pitch height, harmonic and rhythmic complexity, specific intervals, and orchestral range (Gundlach 1935; Hevner 1935, 1936; Ilie and Thompson 2006). Previous reviews (Gabrielsson and Juslin 2003; Juslin and Laukka 2004) provide more detailed descriptions of links between musical characteristics and perceived emotion in music.

As noted, some emotions expressed by music may be interpreted correctly across cultures. Western listeners can correctly interpret joy, sadness, and anger expressed by Indian ragas (Balkwill and Thompson 1999), whereas Japanese listeners can correctly identify these emotions expressed by Western and Hindustani music (Balkwill et al. 2004). Fritz et al. (2009) examined the perception of emotions expressed in Western music among Mafa listeners who lived in a culturally isolated region of Cameroon. A forced-choice task confirmed that these listeners could identify happiness, sadness, and fear expressed in the music at above-chance levels. These findings suggest that some affective associations with musical characteristics are present cross-culturally if not universally.

In a meta-analysis of music-performance studies, Juslin and Laukka (2003) concluded that listeners perform better than chance at interpreting happiness, sadness, anger, fear, and tenderness in music, as they do at interpreting prosodic cues in speech. They also found that anger and sadness are typically identified better than the other three emotions. One possible explanation for the discrepancy between this conclusion and the one above (re: happiness and sadness) comes from the fact that Juslin and Laukka focused on studies that used melodies as stimuli (i.e., monophonic music, such as a single voice or a trombone). Each melody was typically performed by a musician in multiple ways, with each performance designed to express a different target emotion. In other words, emotions other than happiness and sadness may be expressed and decoded successfully when the musician's specific goal is to convey a single emotion in a brief melody.

Different studies have manipulated musical characteristics in different ways. Some researchers contrasted real recordings that varied in a systematic manner (e.g., Hunter et al. 2008a), whereas others created pieces that varied along a single dimension (e.g., Gabrielsson and Juslin 1996). Such methodological differences could lead to inconsistent findings across different studies. In an attempt to facilitate comparisons across laboratories, Vieillard et al. (2008) derived a set of musical excerpts (like Eckman's faces; Ekman and Friesen 1976), with each excerpt associated primarily with one of four emotions: happiness, sadness, fear, or peacefulness. Peacefulness (not a basic emotion) was included to cover each quadrant of arousal and valence space defined by the circumplex model (Russell 1980). The happy-sounding excerpts (high arousal and positive valence) were in major mode with a fast tempo, the fearful excerpts (high arousal, negative valence) were in minor mode with some dissonance and irregular rhythms, the peaceful excerpts (low arousal, positive valence) were major with an intermediate tempo, and the sad excerpts (low arousal, negative valence) were slow and minor. Adult listeners confirmed that each excerpt was associated with its corresponding emotion. Accuracy was higher for the happy-sounding than for the other excerpts, however, and listeners sometimes misidentified peaceful-sounding excerpts as sad or happy. To derive a smaller number of more unambiguous stimuli that could be used with children, Hunter et al. (2008b) reduced the stimulus set to the five excerpts from each emotion category that were identified most reliably by adults. Compared to older listeners, younger children had more difficulty identifying sad- or peaceful-sounding excerpts correctly, but adult-like accuracy was reached by 11 years of age. The development of emotional responses to music is considered in greater detail by Trainor and Corrigal, Chap. 4.

One relatively underexplored area concerns ways in which musical characteristics *interact* in their influence on emotional responding. Such interactions are liable to be complex and at least somewhat idiosyncratic, varying from piece to piece and from listener to listener. For example, in one study, rhythm and pitch changes interacted in their influence on listeners' judgments of the emotions conveyed by melodies, and such interactions varied across stimuli even for the same emotion (Schellenberg et al. 2000).

5.3.1 Summary

The available evidence indicates that happiness and sadness are readily associated with musical characteristics such as tempo and mode, and that such associations may be evident across musical cultures. Other basic emotions such as fear and peacefulness may be perceived reliably when the stimuli are designed specifically to portray one of these emotions. Although affective associations of both tempo and mode are fairly well established, effects of other musical characteristics are poorly understood, as are the ways in which characteristics of music interact in determining the emotional status of a piece. Efforts to create standardized affective musical pieces (such as those created by Vieillard et al. 2008) may help to make results more consistent across future studies.

5.4 Measuring Emotional Reponses to Music

5.4.1 Self-Reports

Most studies have used one of three methods to measure emotional responses to music. Perhaps the most common method is to ask listeners to rate the extent to which they perceive or feel a particular emotion, such as happiness (e.g., Gagnon and Peretz, 2003; Hunter et al. 2008a). Another method is to present listeners with a list of possible emotions and ask them to indicate which one (or ones) they hear (e.g., Gundlach 1935). A third approach is to require participants to rate pieces on a number of dimensions (often arousal and valence; e.g., Schmidt and Trainor 2001; Vieillard et al. 2008). Less common but more sophisticated approaches have used continuous response scales (e.g., Grewe et al. 2007a) that measure second-by-second changes in one or more dimensions of affective responding. These kinds of techniques allow specific musical events to be correlated with simultaneous changes in reported affect (Schubert 2001). In a relatively novel approach, Juslin et al. (2008) used experience sampling to demonstrate the relative frequency of various emotions in musical and non-musical contexts over long time spans. Participants were supplied with electronic devices that prompted them seven times a day to respond to a questionnaire.

All of the above methods represent different types of *self report*, which may lead to concerns of response bias and to doubts about the validity of the responses. Fortunately, people tend to be very attuned to how they are feeling (i.e., to the subjective component of their emotional responses). For example, self-reports are used to verify that mood-induction procedures are successful. The induced moods, in turn, have differential consequences for a variety of other behaviors (e.g., Husain et al. 2002; Alter and Forgas 2007; Grant et al. 2007). Self reports of participants' emotional state also correlate with *other reports* (i.e., responses provided by friends or informants; Watson and Clark 1991; Lucas et al. 1996), and they predict real-world outcomes such as suicide and longevity (Lyubomirsky et al. 2005). Indeed, the available evidence provides support for Gabrielsson's (2002, p. 128) conclusion that self reports are "the best and most natural method to study emotional responses to music."

5.4.2 Physiological Measures

Several researchers have attempted to measure emotional responding to music physiologically (Krumhansl 1997; Nyklíček et al. 1997; Rickard 2004; Sammler et al. 2007; Khalfa et al. 2008). Krumhansl's (1997) participants listened to music while 12 indices of physiological activity were measured. These included seven measures relating to blood flow (e.g., cardiac inter-beat-interval), three related to respiration (e.g., respiration depth), as well as skin conductance and finger temperature. The musical stimuli consisted of six excerpts that sounded happy, sad, and scary, with two excerpts representing each of the three emotions. Similarly, Nyklíček et al. (1997) measured a number of cardiac and respiratory variables while participants listened to music excerpts from one of four categories, which represented four quadrants of emotion space defined by arousal and valence (i.e., happy, agitated, sad, and serene). Both studies found differences between high- and low-arousal emotions but few differences between emotions with positive or negative valence. Although Krumhansl reported differences between responses to happy- and sad-sounding music, because happiness and sadness differ in both valence and arousal, it is difficult to determine the cause. Indeed, Nyklíček et al. reported that differences in valence accounted for only 10% of the variance in their physiological measures.

Other researchers have also found differences between responses to happy- and sad-sounding pieces on some measures (diastolic blood pressure, skin conductance, finger temperature, and zygomatic activity), but again, because these emotions differ on both valence and arousal the findings could be attributed to differences in arousal, not valence (Khalfa et al. 2008; Lundqvist et al. 2009). Moreover, reliable changes in skin-conduction responses that are evident in response to unexpected musical events are likely to be a consequence of increases in arousal (Koelsch et al. 2008b). Thus far, then, physiological measures are good at measuring differences in levels of arousal that occur in response to music listening, yet they are relatively insensitive at discriminating responses that differ in valence. One exception involves musical stimuli that are manipulated electronically to sound pleasant (consonant) or extremely unpleasant (highly dissonant). In this instance, unpleasant stimuli lead to decreases in heart rate (Sammler et al. 2007).

One physiological measure that holds some promise is facial electromyography (EMG). EMG measurements of zygomatic (cheek) and corrugator (brow) facial muscles are associated with processing positive and negative events, respectively (Schwartz et al. 1980; Tassinary et al. 1989; Lang 1995). Witvliet and Vrana (2007) measured muscle activity while participants listened to music that was selected to fit in one of the four quadrants of the arousal and valence space. They reported greater zygomatic activity in response to pieces that elicited high arousal and positive valence, whereas corrugator activity was exaggerated in response to pieces with negative valence, regardless of arousal. Thus, corrugator activity might serve as a measure of valence. Unfortunately, *liking* ratings were lower for negatively valenced pieces, which makes it unclear whether the observed corrugator effect was a result of the negative emotion of the piece, or the fact that listeners did not like it. Indeed, although EMG is often considered to be a measure of valence, many of the relevant studies used stimuli (e.g., negative pictures; Lang 1995) that evoke both negative emotions and unpleasant evaluations. This issue is particularly relevant for music, which can evoke or express a negative emotion (e.g., sadness) yet the listener may still find the particular piece to be pleasant or beautiful.

Other researchers found few differences in corrugator responses to happy- and sad-sounding pieces, but zygomatic activity was greater for happy-sounding pieces (Khalfa et al. 2008; Lundqvist et al. 2009). In short, although the findings are equivocal about corrugator activity, increases in zygomatic activity are evident in response to happy-sounding (high arousal and positive valence) pieces. Nonetheless, fearful stimuli also increase zygomatic activity (Schwartz et al. 1980; Stemmler et al. 2001; Pauls and Stemmler 2003), which rules out a simple valence explanation of such activity.

5.4.3 Measures of Brain Activation

Several studies have used measures of brain activity to examine emotional responses to music. One approach has been to measure asymmetry in frontal electroencephalographic (EEG) activity. Greater activity in the left-frontal region is often assumed to be associated with positive affect, whereas greater activity in the right region is associated with negative affect (Davidson 1998). In line with this view, Schmidt and Trainor (2001) found greater left- and right-hemisphere activity during listening to music with positive and negative valence, respectively. Other results indicate, however, that frontal asymmetry actually measures motivational direction (i.e., approach and avoidance tendencies) rather than valence. For example, anger – a negatively valenced *approach* emotion – elicits left frontal activity (Harmon-Jones and Allen 1998; Harmon-Jones and Sigelman 2001). Others studies have reported that

(1) liked music evokes left frontal activation, whereas disliked music evokes right but slightly more bilateral activation (Altenmüller et al. 2002), (2) pleasant sounding (consonant) music evokes greater midline activity compared to unpleasant sounding (dissonant) music (Sammler et al. 2007), and (3) EEG activity varies in response to expressive and unexpressive musical performances (Koelsch et al. 2008b).

Neuroimaging approaches have had some success as measures of emotional responding (for a review, see Peretz 2010) but they too are not without problems. Several studies compared responses to pleasant and unpleasant music, but very few compared responses to music that expresses more specific emotions, such as happiness or sadness. In one exception, Green et al. (2008) used functional magnetic resonance imaging (fMRI) to compare brain activity among participants listening to novel melodies composed with major or minor scales. A pilot study confirmed that the major melodies sounded happier than the minor melodies, even though the two sets were equated for tempo. The anterior cingulate, the left parahippocampal gyrus, and the left medial frontal cortex were more active while participants listened to minor than to major melodies. The behavioral task in the scanner involved making liking judgments for each melody, however, so it is unclear whether participants actually felt happiness or sadness in response to the melodies. Moreover, although liking judgments did not differ significantly for the two sets of melodies, the observed difference between sets (i.e., minor melodies liked slightly more, $p < 0.1$) would have been significant with a slightly larger sample. Hence, differential brain-activation patterns may have stemmed from differences in liking, differences in perceived happiness and sadness, and/or differences in felt happiness and sadness.

In another study, Mitterschiffthaler et al. (2007) used fMRI recordings while listeners heard happy-, sad-, and neutral-sounding excerpts from familiar orchestral pieces (e.g., *The Blue Danube* by Johann Strauss). After each piece, participants rated whether their emotional state became happier or sadder while listening to the piece. The researchers made no attempt to measure or equate liking for the pieces, however, and the results were quite different from those of Green et al. (2008). Compared to the neutral pieces, the happy-sounding pieces elicited more activity in the parahippocampal gyrus, anterior cingulate, and ventral and dorsal striatum. For sad-sounding music, greater activity was evident in the hippocampus/amygdala region. These are many of the same regions that were implicated in studies comparing pleasant and unpleasant stimuli, which highlights the importance of equating pieces in terms of pleasantness or liking. At present, conflicting findings and the use of different behavioral tasks (e.g., liking or happy/sad ratings) and stimuli (e.g., novel melodies or familiar orchestral pieces) preclude unequivocal interpretations of the results from neuroimaging studies that measured brain-activation patterns in response to happy- and sad-sounding music.

Neuroimaging techniques are more successful, however, at distinguishing between positive (e.g., liking, pleasantness; Blood and Zatorre 2001) and negative (e.g., disliking, unpleasantness; Blood et al. 1999) responding. For example, Koelsch et al. (2006) used fMRI to record brain activity while their participants listened to pleasant (consonant) and unpleasant (dissonant) music. Pleasant and unpleasant music activated regions related to positive and negative affect processing, respectively (e.g., the ventral striatum and the parahippocampal gyrus). These activation patterns were similar to those reported previously (Blood et al. 1999).

In addition, activity in the amygdala appears to be a marker of pleasantness. That is, reduced activity occurs in response to pleasant sounding music, whereas activity increases in response to unpleasant music (Blood and Zatorre 2001; Brown et al. 2004), even in response to a single unexpected and unpleasant sounding chord (Koelsch et al. 2008a). Brown et al. (2004) observed activation throughout the brain during music listening, but the control condition involved no listening experience – participants simply rested in the scanner. Thus, observed activation patterns may not have been specific to music or to affective responding. One method (i.e., cyto-architectonically defined probabilistic maps) used in conjunction with fMRI allows for higher resolution images, which reveal that *both* pleasant (consonant) and unpleasant (dissonant) musical stimuli lead to enhanced activity in separate areas of the amygdala (Ball et al. 2007).

5.4.4 Patients with Brain Damage

Studies of patients with brain damage are also informative about regions that subserve the perception of specific emotions. Gosselin et al. (2005, 2007) studied the effect of temporal lobe lesions and amygdala damage on the recognition of happy, sad, peaceful, and scary emotions expressed in music. Amygdala damage is known to be associated with specific impairments in the recognition of threat signals, especially from faces (Adolphs et al. 2005). In one case study (Gosselin et al. 2007), a patient with specific bilateral amygdala lesions showed deficits in recognizing scary and sad emotions in music. Thus, the amygdala seems essential for the perception of threat from scary-sounding music, although it may also be important for sadness, which would be consistent with Mitterschiffthaler et al. (2007)'s finding of amygdala activity while listening to sad-sounding music. In another study, lesions in the temporal lobe were associated with impairments in the recognition of scary and, to a lesser extent, peaceful emotions expressed musically (Gosselin et al. 2005). It is unclear to what extent these deficits extend to *felt* emotions.

5.4.5 Summary

This section focused on four categories of measurement, each with its own strengths and weaknesses. Behavioral measures (such as scale ratings and continuous response scales) rely typically on self report yet they are reliable and valid. They also benefit from ease of interpretation, at least for subjective feelings, and they are by far the least expensive method. Physiological measures (e.g., heart rate, blood pressure) are reliable at differentiating pieces that elicit varying levels of arousal, but not valence. Facial EMG might be an exception, although further studies using well-controlled stimuli are necessary. Neurological measures have been used successfully for differentiating responses to stimuli that differ in pleasantness, but there are no studies that examined specific emotional responses (e.g., happiness and sadness) while controlling for stimulus differences in liking or pleasantness. Lastly, research with patients suffering from brain damage has highlighted the importance of the amygdala in recognizing certain emotions (e.g., fear) in music. More studies are needed to determine whether amygdala activity extends to felt emotions, and whether other types of neurological damage impair emotional responding to music.

5.5 Perceived and Felt Emotions: Similarities and Differences

If we accept that listeners perceive emotions conveyed by music *and* respond emotionally to music, a logical question arises: how are these perceptions and feelings similar and different? In one questionnaire survey, most respondents (≈70%) reported that when they perceive an emotion expressed musically, they often feel the same emotion (Juslin and Laukka 2004). In many studies, however, it is unclear whether listeners responded according to how the music sounds or how it makes them feel. For example, in Hevner's studies (1936, 1937), listeners were asked to choose which emotion best "fit" the music. Many other studies used similarly ambiguous response formats (e.g., Gundlach 1935; Cunningham and Sterling 1988; Kastner and Crowder 1990; Terwogt and Van Grinsven 1991). When response formats are unclear, participants may respond according to their perception of emotion expressed in the music, or to the emotion they feel in response to the music. These two constructs do not necessarily vary in tandem (see Gabrielsson 2002). For example, listeners may have no emotional response to sad-sounding music when they are in a happy mood, yet they might still recognize that a piece sounds sad. Similarly, a piece that is obviously happy-sounding may elicit negative feelings if it is associated with a negative event that happened in the past (e.g., the breakup of a relationship).

To determine the extent to which feelings differ from perceptions, it is necessary to measure both kinds of responses. A small number of studies have done this, but the results tend to be inconclusive for various reasons. In one study, listeners heard short pieces created electronically using MIDI (Vieillard et al. 2008, Experiment 1). Some listeners rated their felt emotion; others rated the emotion they perceived. Ratings were highly correlated across pieces, but feeling ratings tended to be higher than perceptions of emotion, which seems counter-intuitive. Indeed, because the pieces were unfamiliar and relatively unexpressive, one would expect actual emotional responding to be weaker than perceptions. The problem may have stemmed from asking listeners to rate either feelings *or* perceptions, when the question of interest is whether these ratings covary within listeners. Zentner et al. (2008) also examined feelings and perceptions, but they did so by asking participants to rate the general frequency with which they feel or perceive particular emotions when listening to their favorite music. Perceptions were more common than feelings for most emotions, but this finding does not tell us whether they correlate in terms of magnitude.

Kallinen and Ravaja (2006) used 1-min musical excerpts to compare felt and perceived emotions. Listeners made 16 ratings related to their feelings as well as 16 ratings related to the emotions they perceived. Feeling and perception ratings were correlated, but perceptions tended to be stronger than feelings on ratings of arousal and activation, whereas the reverse was true for ratings of pleasantness. It is interesting to note that some pieces expressing negative emotions were rated as eliciting pleasant feelings. One problem with this study is the total number of ratings that listeners were required to make. Indeed, by the time respondents made their 32nd rating, their memory for how the piece sounded and how it made them feel may have faded. Other studies have provided converging evidence that perceptions tend to be stronger than actual feelings when both responses are measured identically (Schubert 2007a, b; Evans and Schubert 2008). Because listeners rated a small number of pieces (from 2 to 5) in each instance, however, considerations of how the magnitude of feeling and perception responses co-vary within individual listeners were precluded. In one study, feeling responses were more variable across listeners than perceiving judgments, presumably because the listeners were familiar with the stimuli (pieces from the Romantic repertoire), which may have evoked personal associations that were specific to individual listeners (Schubert 2007b).

In an attempt to address some of these methodological issues, Hunter et al. (2010) asked listeners to rate only their felt and perceived happiness and sadness in response to 32 musical stimuli. The stimuli were 30-s MIDI versions of Bach preludes that were manipulated to vary in tempo and mode. As with Kallinen and Ravaja, the perception and feeling ratings were correlated positively but not perfectly (see also Evans and Schubert 2008), and perceptions were stronger than feelings for both happy and sad ratings, as one would expect. Mediation analyses revealed that feelings were mediated by perceptions, but that the reverse was not true. In other words, when listeners responded emotionally to music, they also tended to be aware of how the music sounded. By contrast, in some instances listeners perceived emotions expressed musically without actually feeling anything.

5.5.1 Summary

Links between feeling and perceiving musical emotions have been understudied. Current evidence suggests that feeling and perceiving responses are correlated positively but imperfectly, and that perceptions are typically stronger than feelings. Further research in this area may clarify the mechanisms through which music evokes emotions (Juslin and Västfjäll 2008). For example, the emotional contagion hypothesis suggests that the emotion perceived in music should tend to evoke the same or a similar emotion in the listener, although not necessarily at the same intensity.

5.6 Chills

Goldstein (1980) was the first to study empirically the phenomenon of chills (or *thrills*) in response to music. He described chills as a tingling sensation resulting from a strong emotional experience. Questionnaires given to three groups of participants (university employees, medical students, and music students) indicated that about half of the population had experienced music-related chills. Chills were also reported to be fairly frequent, at least among music students, 60% of whom said they had felt them in the past week. These estimates vary, however, depending on the sample and the questions asked. Sloboda (1991) found that 90% of his participants, mostly professional and amateur musicians, reported feeling chills within the past 5 years. In another study, 86% of students enrolled in an introductory psychology class reported having the experience with some regularity (Panksepp 1995). Experiencing chills may also depend on certain personality factors. Indeed, one item on a widely used *Big Five* personality inventory (Costa and McCrae 1992) asks respondents whether they feel aesthetic chills. Across cultures and languages, this particular item is one of the most reliable predictors of the dimension of personality called *openness to experience* (McCrae 2007).

5.6.1 What Are Chills?

Goldstein (1980) reported that chills were felt most commonly in the back of the neck and upper spine, yet more than one-quarter (28%) of his respondents reported similar sensations in their legs. Chills also varied from being very brief, isolated experiences, to spreading sensations of longer duration. In one study, musical passages that elicited chills also led to increases in skin conductance response (SCR), and, in some cases, piloerection, but not to changes in skin temperature or heart rate (Craig 2005). In another study, the association between chills and increases in SCR was evident only when listeners heard emotionally powerful music; relaxing music, arousing (but not emotional) music, and watching an emotionally powerful film scene did not have the same effect (Rickard 2004).

In a positron emission tomography (PET) study, Blood and Zatorre (2001) examined brain activity while participants were experiencing music-induced chills. Using participant-selected music (with another participant's selection as a control stimulus), they found activation patterns similar to those involved in receiving rewards (i.e., greater activity in ventral striatum and dorsomedial midbrain, reduced activity in the amygdala and ventromedial prefrontal cortex). In other words, chill-inducing music appears to be something like auditory cocaine. As in other imaging studies, the authors did not consider specific emotions in their analysis. The findings might have been even stronger had the authors used different control stimuli, because there is some evidence that one listener's chill-inducing music may also induce chills in other listeners (Panksepp 1995). Perhaps a more appropriate control would have been a second piece selected by participants that did not induce chills but was liked equally.

Self-report and brain data both imply that chills result from or occur in tandem with strong experiences of pleasure. In line with this view, some listeners report fewer chills after taking an opiate antagonist (Goldstein 1980). Nonetheless, another view holds that chills represent a measure of negative affect. For example, chills can be more common among females when they listen to sad-sounding pieces (Panksepp 1995), and among both males and females when they listen to slow-tempo music (Guhn et al. 2007). Chills also occur in response to aggressive film scenes (Geen and Rakosky 1973), erotic stimuli (Hamrick 1974), and fear imagery (Vrana 1995). In other words, chills may stem from heightened states of emotional activation rather than any specific emotion. Rickard (2004) noted that SCR – one of the most reliable physiological correlates of chills – is one of the most sensitive measures of strong affect (Andreassi 2000).

In line with this view, Huron (2006) suggested that chills are related to the fight response that sometimes arises when animals (including humans) are faced with a threatening stimulus. Both responses involve piloerection. Cold temperatures also elicit this response, which provides a means of keeping the body warm. Because piloerection makes animals appear larger, it may be an adaptive response that occurs in situations when animals need to appear to be threatening, such as when they are surprised by a potentially dangerous stimulus. If the stimulus is subsequently appraised as nonthreatening, the piloerection response may be accompanied by pleasure, similarly to the way in which other surprising events may induce pleasure.

5.6.2 How Are Chills Elicited by Music?

Music appears to be the most common stimulus that induces chills. For example, almost all of the participants (96%) in Goldstein's (1980) study endorsed music as a chill-inducing stimulus, although dramatic scenes (92%) and aesthetic beauty (86%) were also very common. By contrast, parades (26%) were a response option that relatively few participants selected. The association between music and chills appears to rely at least partly on familiarity. Indeed, most studies have asked participants to choose their own stimuli, namely familiar pieces that reliably induce chills (e.g., Goldstein 1980; Sloboda 1991; Blood and Zatorre 2001; Rickard 2004; Grewe et al. 2007b). Nonetheless, certain pieces seem to be relatively effective at eliciting chills across participants, such as Pink Floyd's "Post-war Dream" (Panksepp 1995) and Mozart's *Tuba Mirum* (Grewe et al. 2007b). It is impossible to rule out familiarity, however, in explaining responses to these songs. The same recording (Air Supply's 1983 hit single: "Making Love Out of Nothing at All") was found to be effective at eliciting chills in one instance but not in another. Presumably, the song was more familiar to Americans in the 1990s (Panksepp 1995) than it was to Germans more than a decade later (Grewe et al. 2007b).

Are there musical characteristics that evoke chills with some consistency? In one report, chills occurred most commonly in response to new or unprepared harmonies and to sudden dynamic or textural changes (Sloboda 1991), which is consistent with Huron's (2006) account of chills that occur in response to unexpected but ultimately non-threatening events. In other reports, chills tended to occur when the music was slower, when the lead instrument changed, and when there was an increase in loudness (Grewe et al. 2007b; Guhn et al. 2007). The association between crescendos and chills was also reported by Panksepp (1995), although it may be evident only at certain frequencies (920–4400 Hz; Nagel et al. 2008).

5.6.3 Summary

The phenomenon of chills in response to music is complex. To date, it is clear that chills are relatively common in response to music, and that they are often a pleasurable experience associated with increases in arousal and SCR. Although chills can be evoked by unexpected changes in musical characteristics, responses seem to vary across listeners and pieces. In line with this view, one model of chills considers characteristics of the piece as well as the listener's personality and familiarity with the musical style (Grewe et al. 2007b). It remains unknown why chills arise primarily from exposure to music and other aesthetic stimuli. Experiences of pleasantness and emotional arousal may play a role, as may more complex, ambiguous feelings that music and other art forms evoke (Scherer 2004; Zentner et al. 2008), such as feelings of sadness (Panksepp 1995) that may be combined with experiences of pleasure (Hunter et al. 2008a) and neural activation of reward circuitry (Blood and Zatorre 2001).

5.7 Liking for Music

Those who argue that emotions such as happiness and sadness are not directly elicited by music (Kivy 1980; Konečni 2005; Konečni et al. 2007) tend to focus instead on the aesthetics of music. Konečni (2005, 2008) suggests that affective experience to music should be discussed in terms of a "trinity" that includes chills, being moved, and aesthetic awe, whereas Kivy (1980) believes that affective experiences in response to music consist only of enjoyment (or lack thereof). Regardless of the particular perspective, it is clear that listeners *like* some musical pieces more than others, and that any individual piece may be liked by some listeners but not by others. But what drives preferences for some pieces over others? There are bound to be many influential factors, and a majority of these may be contextual or personal and relatively difficult to document systematically.

One recent finding points to a *contrast effect* based on the listening context: hearing a particularly good or bad musical stimulus influences evaluations of a subsequent stimulus in the opposite direction (Parker et al. 2008). Other research finds evidence that liking for music tends to be higher when listeners respond emotionally to it, and when their actual feelings parallel the emotion they perceive (Schubert 2007a; Evans and Schubert 2008). These findings are consistent with the view that people listen to music because of the way it makes them feel. Three other factors – each with multiple pieces of supporting evidence – are discussed below: consonance and dissonance, familiarity, and liking for sad-sounding music. The focus is on liking for novel pieces of music regardless of genre. Preferences for specific genres of music vary as a function of individual differences in lifestyle, social, and personality factors that are beyond the scope of the present chapter (North and Hargreaves 2007a, b, c; Rentfrow and Gosling 2003, 2006).

5.7.1 Consonance and Dissonance

Many music preferences may be person-specific, yet there are some preferences for features of music that appear to be widespread, and some factors that universally affect music preferences. At a very basic level is the preference for consonance over dissonance. Degree of dissonance is correlated with brain activity in regions associated with processing negative stimuli (e.g., the parahippocampal gyrus; Blood et al. 1999) and with physiological responses such as heart rate (Sammler et al. 2007). Moreover, a preference for consonance over dissonance is evident behaviorally in very young infants (Zentner and Kagan 1996, 1998; Trainor and Heinmiller 1998; Trainor et al. 2002; Trainor and Corrigal, Chap. 4). Indeed, because even 2-month olds exhibit a preference for consonance over dissonance (Trainor et al. 2002), this preference appears to be either innate or learned very early in life. In line with this view, the preference is evident cross-culturally. For example, the culturally isolated Mafa tribe from Cameroon dislike both Mafa and Western pieces when the pieces are manipulated to sound dissonant (Fritz et al. 2009). The preference for consonance may, however, be unique to humans. Other primates (i.e., tamarin monkeys) do not show a similar preference (McDermott and Hauser 2004). Future research could examine how and why a preference for consonance evolved among humans.

5.7.2 Familiarity

Familiarity is well established as a factor that influences preference for a stimulus. Zajonc (1968) was the first to demonstrate that simple exposure is sufficient to manipulate degree of liking, even when participants have no explicit memory for the stimulus. This *mere exposure* effect has been replicated many times (Bornstein 1989). It has also been documented in response to music (e.g., Mull 1957; Peretz et al. 1998). Although the effect is consistent with anecdotal evidence that music becomes popular as it is played more often on the radio (Jakobovits 1966), the mere exposure effect cannot explain *disliking* for music that is overplayed, for which there is an equal amount of anecdotal evidence. Many attempts to document this inverted-U shaped function of increases followed by decreases in liking have met with only partial success (e.g., Zajonc et al. 1972).

Szpunar et al. (2004) examined effects of number of exposures on liking for music while varying both the complexity of the stimuli (from random sequences of pure tones to excerpts from orchestral recordings) and whether the exposure involved focused or incidental listening. Figure 5.2 illustrates liking ratings as a function of number of exposures, stimulus complexity, and listening condition. For pure-tone sequences, liking did not vary as a function of exposure for listeners who were required to focus on the stimuli during the exposure phase, presumably because the stimuli were aesthetically impoverished. For listeners who heard the same stimuli incidentally (i.e., in the background), however, liking increased monotonically as a function of exposure, even though listeners had no explicit memory for stimuli they had heard as many as 64 times. For this group, response patterns were a complete replication of the mere exposure effect. The same linear increase in liking as a function of

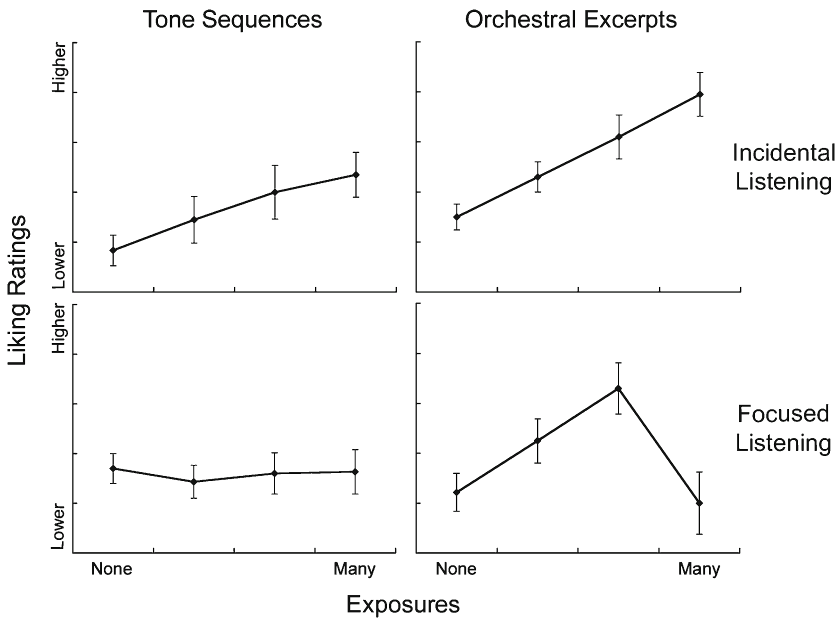

Fig. 5.2 The effect of exposure on liking as a function of number of exposures, the type of exposure, and stimulus complexity (Data are from Szpunar et al. 2004)

exposure was evident for focused listeners tested with complex stimuli (real music), except that these listeners also remembered the excerpts. Finally, the inverted-U shaped function was evident only with focused attention and more complex stimuli. For these listeners, liking and memory increased for pieces they heard twice compared to novel pieces (i.e., a baseline measure), and for pieces heard eight times compared to those heard twice. Liking for pieces heard 32 times returned to baseline levels, when memory was at ceiling.

Two main theoretical frameworks are used to account for effects of exposure on liking. The *two-factor model*, first proposed by Berlyne (1970) and developed further by Stang (1974), posits that an inverted-U shaped function is the result of the *arousal potential* of a stimulus, which should be neither too great nor too small. Unfamiliar stimuli are potential threats, which makes their arousal potential too great. With increasing familiarity and exposure to the stimulus that does not have adverse consequence, its arousal potential decreases to an optimal level and, as a result, liking for the stimulus increases. This first (increasing) part of the curve is related to Zajonc's (1968) explanation of the mere exposure effect: humans have an initial disposition to distrust an unfamiliar stimulus, but with exposure that is not harmful they begin to trust and therefore like it. The two-factor model also notes that after many exposures, boredom or fatigue sets in as the arousal potential of the stimulus decreases to less than optimal levels. This second factor accounts for decreases in liking for over-familiar songs.

Another explanation is Bornstein's (1992; Bornstein and D'Agostino 1994) *perceptual fluency/attribution model*. It suggests that previous exposure to a stimulus can result in a context-free representation of that stimulus, which increases processing fluency (i.e., speed and efficiency of processing) for subsequent exposures to the same stimulus. When the perceiver has no explicit memory for the stimulus, this fluency can be misattributed as a positive disposition towards the stimulus. An updated but similar model holds that fluency itself is pleasurable (Reber et al. 2004), which helps to explain preferences for prototypical and symmetric stimuli as well as preferences for familiar stimuli. Any factor that increases fluency should also increase liking. In both models, fluency is pleasurable when it is unexpected. Presumably, after a small number of exposures the perceiver may have the pleasant experience of unexpected fluency yet no explicit memory for the stimulus. With a greater number of exposures, the stimulus becomes familiar such that processing fluency is expected and no longer pleasurable. In short, both models suggest that when an individual is aware of the cause of fluency or expects fluency, liking should decrease. In other words, once the stimulus is remembered explicitly, participants should start to dislike it. In many instances, however, listeners both remember and like musical stimuli (Szpunar et al. 2004; Schellenberg et al. 2008). Similar findings are evident in other domains, such as when participants consciously remember and like visual stimuli (e.g., polygons or photographs of faces; Newell and Shanks 2007).

The available data on exposures, liking, and memory for music indicate that which model is appropriate depends on stimulus complexity and the listening experience. Indeed, a complete account of the data appears to require a hybrid of the two-factor and perceptual fluency/attributional models.

5.7.3 Liking for Sad-Sounding Music

One of the most intriguing yet under-researched questions concerns sad-sounding music: why listeners like it and why it even exists. If sad-sounding music elicits sad emotions or moods, and if sadness is an unpleasant state, then why would anyone produce it or listen to it? According to most theories of emotions, including appraisal theory (Smith et al. 1993) and the circumplex model (Russell 1980), listeners should not like sad music. Indeed, participants in experiments typically prefer happy- over sad-sounding music, or they judge sad-sounding music to be unpleasant (Thompson et al. 2001; Hunter et al. 2008a; Vieillard et al. 2008). There is also evidence that listening to sad-sounding music activates a right-sided frontal asymmetry in EEG activity (Schmidt and Trainor 2001), which is a marker of avoidance motivation.

Studies of mixed feelings, which ask listeners to rate happy and sad feelings separately on two unipolar scales (Hunter et al. 2008a, 2010) indicate that listeners are actually ambivalent toward sad-sounding music. Although they report feeling sad, they also report some happy feelings as well. By contrast, happy-sounding music elicits only happy feelings. Sad-sounding music also leads to ambiguous responses when listeners are asked to make ratings of pleasantness and liking. Mixed feelings cannot fully explain listening to sad-sounding music, however, because when given the choice between a stimulus that elicits just happiness and one that elicits both happiness and sadness, an individual should prefer the former.

Schellenberg et al. (2008) examined the effect of repeated exposures on liking for happy- and sad-sounding music. The conditions were similar to those used by Szpunar et al. (2004). Listeners rated their liking for novel pieces as well as for pieces heard 2, 8, and 32 times previously. The initial exposures occurred during focused or incidental listening. For focused listeners, the typical preference for happy music was evident (i.e., liking ratings were significantly higher for happy music). For incidental listeners, however, happy and sad pieces were liked equally (see Fig. 5.3, upper panel). Because the incidental listeners completed a demanding and lengthy distractor task during the exposure phase, the sad-sounding music they heard later might have had a pleasant calming effect. Alternatively (or in conjunction), the demanding and lengthy task may have put listeners in a negative mood. In other words, the appeal of sad-sounding music might increase when listeners are in a negative mood.

The latter hypothesis was tested directly in a follow-up study (Hunter and Schellenberg 2008). The authors compared liking ratings for happy- and sad-sounding music after happy, sad, and neutral mood inductions. To induce a mood, participants viewed a set of pictures. They then wrote a short paragraph about their emotional response to one of the pictures. Responses included emotional memories, issues participants felt strongly about, or just a description of the picture (if no emotion was evoked). As one would expect, the typical preference for happy- over sad-sounding music was evident after happy and neutral mood inductions. When a sad mood was induced, however, happy- and sad-sounding pieces were liked

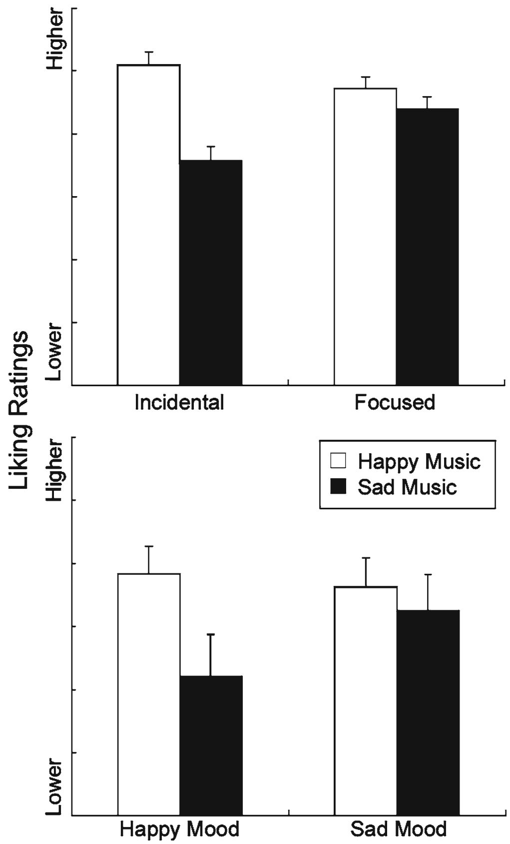

Fig. 5.3 Liking for happy-and-sad-sounding music as a function of the type of previous exposure (*upper panel*, data from Schellenberg et al. 2008) and listener's mood (*lower panel*, data from Hunter and Schellenberg 2008)

equally (Fig. 5.3, lower panel). Because levels of liking for happy-sounding music were virtually identical after happy and sad mood inductions, it is safe to conclude that sad moods increased the appeal of sad-sounding music. Sad-sounding music may also have a cathartic effect by helping listeners to get in touch with their sad feelings, thereby allowing these feelings to dissipate.

5.7.4 Summary

This section discussed a number of influences on liking for music. Consonance appears to have a fairly basic influence on liking. It is typically preferred to dissonance regardless of age and familiarity with Western musical traditions. Moreover, such a preference may be uniquely human. Familiarity is another basic influence on liking. Although initial exposures to music typically increase liking, over-familiarity often leads to disliking. The association between exposures and liking varies, however, as a function of stimulus complexity and the listening experience. Finally, listeners tend to prefer happy- over sad-sounding sad music, yet they often choose to listen to sad-sounding music. The appeal of sad-sounding music appears to increase when listeners are fatigued or sad.

5.8 Conclusions and Future Directions

Several themes emerge from this review of research on links between music and emotion. One is the still unanswered question of the nature of affective reactions to music: whether they consist of true emotions, moods, aesthetic emotions, or liking responses. Musical emotions appear to differ from everyday emotions, at least as defined by appraisal theory. Emotional reactions to music (with a few exceptions, e.g., anger because a particularly disliked song is playing) are not the same as those to everyday events because the stimulus (music) is not goal-relevant and does not elicit the usual cognitive appraisals. Nevertheless, there may be other routes for activating emotions through music (Juslin and Västfjäll 2008). Another possibility is that affective responses to music are short-lived moods rather than emotions, which are similar to those evoked by nonmusical stimuli. Affective responses to music could also represent a separate class of emotions that consists primarily of the subjective feeling and may be specific to aesthetic stimuli (Scherer 2004; Zentner et al. 2008).

Thus, if we accept that listeners respond affectively to music, we have three possible explanations: (1) listeners respond emotionally but without cognitive appraisals, (2) music evokes temporary changes in mood, and (3) music evokes a special class of aesthetic emotions. These three explanations for affective reactions to music are not mutually exclusive. Aesthetic emotions may be one particular type of mood or emotion and it is not obvious how these alternatives could be distinguished empirically. The extent to which moods, emotions, or aesthetic emotions are elicited could, however, depend on the listener, the piece, and the context. Future research on individual differences and the effect of the context on the nature of affective reactions to music may lead to insights that could help to resolve theoretical debates, which are currently deadlocked.

Another issue is the ubiquity of the use of the circumplex model in research on music and emotion and the need to consider alternatives in some instances. Recent evidence suggests that this two-dimensional model is not appropriate for every context. More specifically, emotional responses may vary along dimensions other than valence and arousal (Fontaine et al. 2007). Further studies could focus on validating these additional two dimensions with musical stimuli. Moreover, findings of mixed feelings (i.e., coactivated positive and negative affect) in response to music (Hunter et al. 2008a, 2010) and nonmusical stimuli (e.g., Larsen et al. 2004) suggest that valence is better conceptualized as two dimensions rather than one. If a particular research question is concerned only with certain emotions, however, or if the method is unlikely to evoke feelings of ambiguity, then the circumplex model may provide a parsimonious explanation of response patterns. When the question involves different emotions that lie in the same quadrant of the circumplex, or when emotional coactivation and mixed feelings are likely to arise (e.g., when examining responses to sad-sounding music), alternatives to this model should be considered. Measuring positive and negative valence separately simply requires the use of two rating scales rather than one, or, alternatively, a two-dimensional response grid (Larsen et al. 2009). If reliable neural or physiological correlates of positive and negative affect were to be identified at some point in the future, one prediction is that they would be coactivated when listeners experience mixed feelings in response to music.

Although the affective correlates of tempo and mode are well established, research to date on other musical dimensions is inconsistent and suffers from a diversity of methods and stimuli. A second problem is that these dimensions are often considered in isolation of one another. One avenue for future studies would be to consider in more detail how these dimensions interact (Schellenberg et al. 2000). For example, is the effect of loudness on emotional responding independent of whether the piece has a fast or slow tempo? If not, for which emotions are interactions evident? Further use of continuous response measures (Schubert 2001; Grewe et al. 2007a) could also advance our understanding of the links between musical characteristics and emotional responding, which may change from moment to moment while listening to a single piece.

It is also important to separate effects of liking and pleasantness from more specific emotional responses such as happiness and sadness. This problem is particularly chronic for studies that use physiological and neurological measures of responding to music. Obviously, the most solid findings arise when multiple methods of measurement lead to the same conclusions. To date, behavioral methods (self reports) have been remarkably effective at finding consistency for some affective responses to music. For example, fast music in a major key is rated as happy, in terms of the listener's perceptions and their feelings and by different populations across time and contexts. The reliability of self reports as a measure of emotional responding is supported further by evidence from mood studies, comparisons of self and other reports, and real-world predictive validity (e.g., Lucas et al. 1996; Husain et al. 2002; Lyubomirsky et al. 2005).

Unfortunately, psychologists' infatuation with physiological and neuroimaging techniques has come at a cost, both literally, in terms of the funding required, and figuratively, in terms of equivocal findings that differ from one study to the next. Thus far, physiological methods have difficulty distinguishing responses that differ in valence, whereas neuroimaging techniques identify emotional positivity (i.e., approaching, liking, pleasantness) versus negativity (i.e., avoiding, disliking, unpleasantness) with a modicum of consistency, yet they remain insensitive to distinctions between more specific emotions, such as happiness and sadness. Clear conclusions about differences in neurological responding to happy-sounding (e.g., major key) and sad-sounding (e.g., minor key) musical pieces require equating the pieces for liking and pleasantness. Evidence of consistent differences in physiological and neurological activity when listening to happy- and sad-sounding (but equally pleasing) music would provide additional support for claims that affective reactions to music are not merely aesthetic evaluations (Konečni 2008) or liking responses (Kivy 1980).

Careful distinction between measuring felt and perceived emotions is also crucial to a complete understanding of associations between music and emotion. Researchers need to be clear about which variable is the one of interest. As some studies have shown (Kallinen and Ravaja 2006; Schubert 2007a, b; Evans and Schubert 2008; Zentner et al. 2008; Hunter et al. 2010), feelings do not necessarily vary in tandem with perceptions. Further studies could seek to elucidate conditions under which they diverge. Again, some of these conditions are likely to be idiosyncratic (e.g., an individual's emotional associations with a particular song), whereas others might be documented relatively easily in a laboratory setting (e.g., by manipulating listeners' moods).

A separate issue about which much is still unknown concerns chills, which are the strongest feelings induced by music. Researchers have been able to describe the phenomenological nature of chills and to measure physiological and brain responses, but attempts to link chills to musical events have been less successful. Chills appear to be elicited by changes in musical structure, but the nature of the change varies across studies. One possible next step would be to test models of chills that take into account the person, the stimulus, and the context (Grewe et al. 2007b). Further research could also seek to examine chills in response to stimuli other than music, in order to determine similarities and differences in chill responses across domains. A better understanding of the adaptive relevance of the chill response would also be most welcome.

Liking is perhaps better understood and more predictable than other emotional responses to music. Outstanding issues include a more complete understanding of individual differences in liking for music as a function of exposure, and how, for example, preexisting music preferences for some genres might accelerate or delay the increases and decreases in liking that have been documented. Moreover, much remains to be discovered about liking for sad-sounding music. Preliminary findings suggest that listeners warm up to sad-sounding music when they are fatigued or in sad mood (Hunter and Schellenberg 2008; Schellenberg et al. 2008). Future research could explore further the links between the listeners' emotional state and liking for sad-sounding music, and the possible role of sad-sounding music in catharsis and mood repair. Finally, although manipulations have been identified that *equate* liking for happy- and sad-sound music, it would be informative to document instances when listeners actually *prefer* sad- over happy-sounding music.

Other issues not dealt with in this chapter also bear consideration. Many scholars have suggested evolutionary explanations for the role of music in human life that are affect-related, including emotional communication (Juslin 2001), synchronicity and social cohesion (Brown 2000), and attracting a mate (Darwin 1871; Miller 2000). One possibility is that aesthetic emotional responses are linked to natural and sexual selection. It is also important to consider listeners and musical genres from different cultures. The most useful models of affective responses to music should be applicable across different musical traditions and different groups of listeners.

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