Juslin, P.N. & Sloboda, J.A. (ed.) (2001) *Music and emotion: theory and research.* Oxford ; New York : Oxford University Press.

CHAPTER 16

EMOTIONAL EFFECTS OF MUSIC: PRODUCTION RULES

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It is an ancient, and very pervasive, idea that music *expresses* emotion. Apart from the copious literature to this effect contributed by composers, musicologists, and philosophers, there is also solid empirical evidence from psychological research, reviewed in chapters of this book (e.g. Gabrielsson & Lindström, this volume; Juslin, this volume), that listeners often agree rather strongly about what type of emotion is expressed in a particular piece. It is also a pervasive belief that music can, at times, actually *produce* emotion in listeners. The distinction between perception and production is related to the distinction between cognitivism and emotivism proposed by philosophers in their analysis of emotion in music (e.g. Kivy 1989). Whereas 'emotivists' hold that music elicits real emotional responses in listeners, 'cognitivists' argue that music simply expresses or represents emotions. Our view is that it would be premature to prejudge the issue and that both positions may be perfectly appropriate depending on a number of factors outlined below. Our purpose in this chapter is to provide a formalization of the processes whereby music produces emotional effects in the listener that go beyond the cognitive inference of what the music can be said to express. In addition, we review the pertinent evidence to date and suggest ways in which future research might investigate these processes in a systematic fashion. We state at the outset that our discussion and the review of the available evidence are largely based on Western classical music, thereby restricting the generalizability of our claims to other kinds of music and other cultures.

Our attempt at a formalization of emotional effects of music will consist in defining the affective changes that music is supposed to produce in the listener and to identify the determinants of the listening situation (features such as the musical structure of the piece listened to, the interpretation by the performer, relevant state and trait characteristics of the listener, and the respective context). An important issue for discussion will be the relative weighting of the different determinants and the type of their interaction in producing the affective outcome. We follow the senior author's attempt to define the emotional meaning of music in analogy to Bühler's Organon model of language, postulating composition, expression, perception, and production *rules* to model the different facets of emotional meaning (Scherer, 2000*d*). In this context, the term *rule* is used to denote a certain regularity or lawfulness of the effects discussed that can be expressed in concrete predictions or hypotheses. It is not excluded that these rules can be integrated into attempts at computational modelling of the underlying mechanisms (in fact, we consider this a highly desirable option), but we do not feel that the current state of the art provides the necessary precision in specifying the model parameters and the input and output variables that would be required to pursue this aim. Thus, the term *rules* and the pseudo-mathematical formulas to formalize them suggested below are used in a purely descriptive sense in this chapter.

A formalization of the process by which music generates emotion requires, first of all, a definition of what exactly is to serve as the *output variable*, that is, the type of emotional or affective state that is supposed to be produced by music. This is necessary since much of the confusion in the literature is due to a lack of conceptual clarity concerning the hypothetical constructs involved. Scherer (2000*a*) has suggested a design feature delimitation of various affective phenomena, reproduced in an adapted form in Table 16.1. In view of the lack of agreement in the field, we have not attempted to identify the characteristics of *aesthetic emotions*, particularly relevant to music, either as a separate category or as a subcategory of the types proposed. This is a task that remains to be accomplished in future work. We will consistently apply the distinctions suggested in Table 16.1 in this chapter, both in classifying the literature to be reviewed (which at times requires one to speculate what an author meant or what a study measured) and in formalizing mechanisms and discovery procedures. In particular, we will try to distinguish affective preferences, moods, and emotion episodes, all of which might be produced by music. Clearly, any attempt to demonstrate that these different types of states are induced by music requires that the defining characteristics of the respective state are operationalized and measured.

The next step is to operationalize the *input variables*; that is, to specify in greater detail which aspects of listening to a piece of music are involved in the inference and/or induction of emotion (for a more detailed example of such an analytical approach, see Dowling & Harwood 1986). We will distinguish structural, performance, listener, and context features, presuming that these features can, individually or in combination, produce the different affective states described above.

Structural features

We subdivide structural features of music—that is, all those qualities of a composer's score that a good performer needs to respect—into segmental and suprasegmental types. *Segmental features* consist of the acoustic characteristics of the building blocks of musical structure: individual sounds or tones as produced by the singing voice or specific musical instruments. In some ways one may presume that such individual sounds correspond to the isolated affect vocalizations that may lie at the source of speech and music. The use of 'Ah' and 'ahimé' in baroque operas illustrates what has been called the domestication of 'brute' affect vocalizations (Kainz 1962; Wundt 1900; for a review of this literature, see Scherer 1994). The closest equivalent in instrumental music is the individual tone, interval, or chord. The acoustic structure of such individual tone segments, corresponding to phones in speech, is described by duration, energy (amplitude), pitch (fundamental frequency), and timbre or harmonic structure (spectral composition) of the complex wave, as well as the energy and pitch envelopes and microchanges in timbre over the duration of the sound. In sound or tone sequences, this acoustic information can be aggregated, yielding measures of central tendencies (mean, median) that, in relatively homogeneous sequences, can be described as the

Table 16.1 Design feature delimitation of different affective states (adapted from Scherer (2000*a*))

Design feature / **Type of affective state:** brief definition *(examples)*	Intensity	Duration	Synchronization	Event focus	Appraisal elicitation	Rapidity of change	Behavioral impact
Preferences: evaluative judgments of stimuli in the sense of liking or disliking, or preferring or not over another stimulus (*like, dislike, positive, negative*)	L	M	VL	VH	H	VL	M
Emotions: relatively brief episodes of synchronized response of all or most organismic subsystems in response to the evaluation of an external or internal event as being of major significance (*angry, sad, joyful, fearful, ashamed, proud, elated, desperate*)	H	L	VH	VH	VH	VH	VH
Mood: diffuse affect state, most pronounced as change in subjective feeling, of low intensity but relatively long duration, often without apparent cause (*cheerful, gloomy, irritable, listless, depressed, buoyant*)	M	H	L	L	L	H	H
Interpersonal stances: affective stance taken toward another person in a specific interaction, colouring the interpersonal exchange in that situation (*distant, cold, warm, supportive, contemptuous*)	M	M	L	H	L	VH	H
Attitudes: relatively enduring, affectively coloured beliefs and predispositions towards objects or persons (*liking, loving, hating, valuing, desiring*)	M	H	VL	VL	L	L	L
Personality traits: emotionally laden, stable personality dispositions and behavior tendencies, typical for a person (*nervous, anxious, reckless, morose, hostile, envious, jealous*)	L	VH	VL	VL	VL	VL	L

VL = very low, L = low, M = medium, H = high, VH = very high.

dominant acoustic structure of the sound sequence. This process of aggregation is straightforward for some acoustic variables (e.g. pitch) and rather difficult for others (e.g. timbre). However, even in the more difficult cases approximations can be found (e.g. a rough aggregate measure of dominant timbre might be the mean proportion of the energy above 1 kHz).

Segmental effects on emotion inference or induction are expected to be relatively stable and universal, with the exception of random error, over all types of listeners and performance conditions. Generally, such effects are mediated by evolutionarily evolved iconic signalling characteristics, based on physiological changes in affect vocalization and relatively independent of individual or cultural differences (cf. also Rosar 1994).

Suprasegmental features consist of systematic configurational changes in sound sequences over time, such as intonation and amplitude contours in speech. In music, comparable features are melody, tempo, rhythm, harmony, and other aspects of musical structure and form. While iconic coding also plays an important role (e.g. with respect to tempo, rising/falling contours), suprasegmental features seem to carry emotional information primarily through *symbolic coding*, as based on a process of historically evolved, sociocultural conventionalization (see Kappas *et al.* 1991; Scherer 1988; Sloboda 1992).

Performance features

These refer to the way in which a piece of music is executed by performer(s). Both the stable *identity* (physical appearance, expression, reputation) and *ability* (technical and interpretative skills) of the performer, as well as transient performance-related variables referred to here as *performance state* (interpretation, concentration, motivation, mood, stage presence, audience contact, etc.), may have a major impact on the perception and induction of emotion. The effects of performance features can be based on both iconic and symbolic coding.

Listener features

Listener features are based on the individual and sociocultural identity of the listener and on the symbolic coding convention prevalent in a particular culture or subculture. They can consist of interpretation rules (e.g. musical systems) that are shared in a group or culture, or of inference dispositions based on personality, prior experiences, and musical talent. These factors can be summarized into *musical expertise*, including cultural expectations about musical meaning, and *stable dispositions* unrelated to music, such as personality or perceptual habits. In addition, transient listener states such as motivational state, concentration, or mood may also affect emotional inference from music (cf. Cantor & Zillmann 1973). In the case of listener features, we suggest a third type of meaning-conferring coding—*associative coding*—in addition to the established semiotic distinction between iconic and symbolic coding. By this we mean the fact that segmental, suprasegmental, and performance cues can be associated with emotional content in an individual's memory due to learned associations and conditioning.

Contextual features

These refer to certain aspects of the performance and/or listening situation. Thus, the *location* of a performance and/or a listening situation may be a concert hall, church, open-air site, car, or recording studio. The dominant material surrounding the listener/performer may be wood, glass, stone, metal, or cement. In addition to the location, the particular *event* may be a wedding, a funeral, a ball, or the celebration of an outstanding achievement. The music may be transmitted through loud-speakers, headphones, or without any technical support. The music may be heard without interruption or it may be disturbed by the sirenes of an ambulance or the coughing of a concert visitor. We submit that all these features can have an influence on the acoustics, the ambiance of the location, or the behaviour of the audience, which in turn may lead to different emotional effects due to objective features of the situation or subjective perceptions of the listeners.

16.1 Production rules

16.1.1 Predictions

We suggest that an emotion that is actually experienced by a listener while listening to music is determined by a multiplicative function consisting of several factors:

Experienced emotion = Structural features × Performance features × Listener features × Contextual features,
where
Structural features = W_1 (Segmental features) × W_2 (Suprasegmental features),
Performance features = W_3 (Performer skills) × W_4 (Performer state),
Listener features = W_5 (Musical expertise) × W_6 (Stable dispositions) × W_7 (Current motivational / mood state),
and
Contextual features = W_7 (Location) × W_8 (Event).

We postulate multiplicative rather than additive functions because it is unlikely that any of the constituent factors in and of themselves, in the absence of other factors, can lead to marked, reliable emotional effects. Furthermore, it seems intuitively reasonable to assume that some listener features (e.g. musical expertise) will strongly interact (in the statistical sense of conveying special strength or significance) with specific structural or performance features. Finally, we submit that the different factors carry different weight. In fact, the order in which the variables are listed above follows the results of a study in which experienced listeners, many of them experts, were asked to rate the extent to which each of the major factors listed above was perceived to influence musical emotion induction (Scherer *et al*., in press). Clearly, more exploratory studies are needed before more subtle predictions can be made and tested.

After this initial formalization of the output and the input variables involved in emotional responses to music, and the formulation of certain predictions, we now turn to what we call *routes*, that is, particular mechanisms whereby emotion may be generated by music. We distinguish: (a) *central routes* (i.e. implicating the central nervous system (CNS) in emotion generation); and (b) *peripheral routes* (based on direct effects on the peripheral, i.e. the somatic and autonomic, nervous systems (SNS and ANS) with ensuing proprioceptive feedback to central areas). In Sections 16.1.2 and 16.1.3 below, we will briefly describe these different routes and some of the underlying mechanisms. Section 16.1.4 describes the evidence to date.

16.1.2 Central route production

Appraisal

A parsimonious premise is that musical stimuli provoke emotions in a similar fashion to any other emotion-eliciting event. Thus, the mechanisms described by emotion psychologists may be also applicable to the study of emotion induction via music. There is an emerging consensus that emotion elicitation and differentiation is best understood by assuming a process of event evaluation, or appraisal, that models the way in which an individual assesses the personal significance of an event for its well-being on a number of criteria and dimensions. This process of evaluation is demonstrated in the upper portion of Fig. 16.1: an object or event is evaluated by a specific person, with respect to a number of criteria or dimensions concerning the implications of the event for needs, goals, or values of the individual and his or her ability to cope with the consequences of the event. The result of this appraisal process is an emotion, which is then expressed or externalized in physiological symptoms and, particularly, in motor expressive movements in the face, body, and voice. In this theoretical tradition, the type of ensuing emotion and the patterning of the physiological and expressive responses are seen as dependent on the specific profile of appraisal results on the pertinent criteria (see Scherer 1999; Scherer *et al*., 2001; for alternative models of emotion differentiation, see Scherer 2000*a*). This appraisal process may occur in a rudimentary, automatic fashion at lower levels of the CNS (mostly the limbic system), especially for evolutionarily 'prepared' stimuli, or in a more elaborated and more effortful process involving the cortical association regions of the CNS as well as the lower centres (see Leventhal & Scherer 1987; Teasdale 1999; van Reekum & Scherer 1998).

The automatic, lower-level appraisal route to emotion elicitation has been well described by Öhman and his colleagues (Öhman 1988) who have suggested that a number of stimuli (e.g. snakes and spiders) can be processed by the lower centres of the brain in an extremely short period of time, outside of awareness, without any apparent

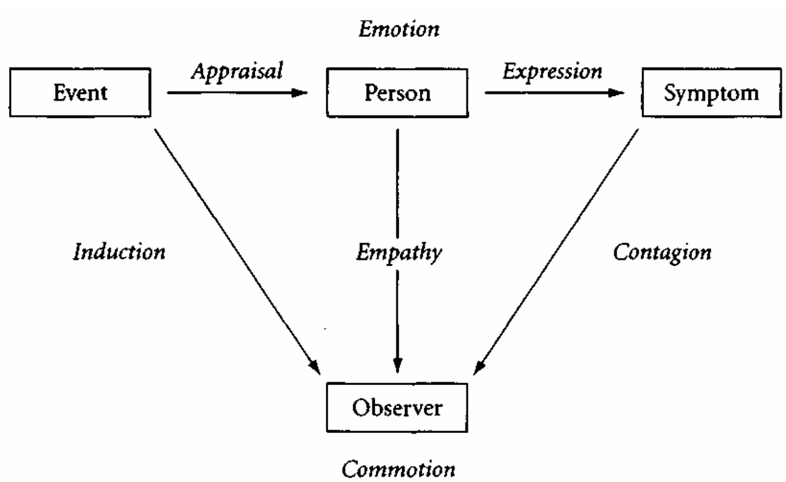

Figure 16.1 Model of 'normal' emotion induction via appraisal (upper part) and mediated 'commotion' due to empathy or other mechanisms of emotional communication (lower part) (based on Scherer, 1998).

implication of cortical association areas. This research group has demonstrated that facial expressions of fear may have the same effect (Dimberg 1988). While empirical evidence for humans is lacking, one can assume that vocal expressions of emotions comparable to alarm calls in primates (see Jürgens 1988) maybe similarly 'prepared' stimuli with respect to immediate, low-level meaning assignment. In consequence, musical stimuli sharing the acoustic characteristics of such fear vocalizations (sudden onset, high pitch, wide range, strong energy in the high frequency range) may be appraised by evolutionarily primitive but extremely powerful detection systems and may provoke, like pictures of spiders or facial expressions of fear, physiological defence responses (see Öhman 1988).

Similar low-level detection mechanisms can be demonstrated for the appraisal criteria of suddenness/novelty and intrinsic pleasantness (e.g. Scherer 1984, 1988). While the results of such rudimentary evaluation processes may not be emotions in the fully-fledged sense, as defined in Table 16.1, they may nevertheless produce positive valence reactions with respect to preferences or other types of affective phenomena short of fully-fledged emotions. There is some evidence that musical sounds can generate strong suddenness/novelty and, in particular, intrinsic pleasantness evaluations.

For example, Zentner and Kagan (1996, 1998) examined the hypothesis of an innate preferential bias favouring consonance over dissonance by exposing 4-month-old infants to consonant and dissonant versions of two melodies. Consonance and dissonance were created by composing the dissonant version in parallel minor seconds, the consonant version in parallel thirds using only two (synthetic) voices (for details regarding the stimuli, see Zentner & Kagan 1998). It was found that infants looked significantly longer at the source of sound and were less motorically active to consonant compared with dissonant versions of each melody. Further, fretting and turning away from the music source occurred more frequently during the dissonant than the consonant versions. Because no relation was found between infants' previous exposure to music (as assessed by questionnaire) and their behaviour in the experiment, the authors suggested that the human infant might possess a biological preparedness that makes consonance more attractive than dissonance. This tentative conclusion is not only consistent with perceptual work on infants' responses to consonant and dissonant intervals (e.g. Schellenberg & Trehub 1996), it is also supported by animal work which demonstrated a preference of consonant over dissonant chords in albino rats (Borchgrevink 1975).

It should be noted that similar automatic evaluation processes can occur for auditory stimuli that are not themselves evolutionarily prepared but that have been conditioned to such stimuli. Thus, LeDoux (1996) has convincingly shown that sounds conditioned to electrical shocks are processed by direct projections from the thalamus to the amygdala in rats (eliciting preparatory neuroendocrine and peripheral responses), before more extensive processing via the auditory cortex and the association areas occur. Similarly, pieces of music that have been consistently associated with evolutionarily prepared (or other powerful, unconditioned stimuli) can be evaluated at very low levels of the brain and evoke emotional responding.

One interesting issue that, so far, has not been much explored in the psychology of emotion, is that, either as a part of intrinsic valence detection or as a separate mechanism, there may be automatic evaluation of aesthetic qualities. Thus, it cannot be excluded that there are some universal criteria of beauty that are evaluated automatically on the basis of visual and auditory stimulation and give rise to an affective response (see Etcoff, 1999). This is certainly the case for the schematic level of appraisal where learned aesthetic preference may play a powerful role.

The capacity of musical stimuli to elicit emotion via processes of higher-level appraisal are virtually unlimited. The appraisal criteria or dimensions suggested by appraisal theorists in particular concern the goal conduciveness/obstructiveness of an event, the individual's potential to cope with the consequences, as well as socionormative and self-ideal norms or standards, (for a summary, see Scherer 1999). Very simply put, appraisal theory predicts that if I have to listen to music that I tend to abhor and that in addition disturbs my concentration on an important task at hand (obstructiveness with respect to desires and goals), I will experience anger or aggravation if I believe it is possible to get the music to stop eventually, and desperation or resignation if I feel powerless.

It can reasonably be argued that music plays only a secondary role in this example, easily exchangeable with any other disturbing stimulus. Future work in this area will need to pay much greater attention to motivational constructs that are specific to music. Why do people listen to music? Why do they go to concerts? Why are some pieces chosen over others? These are the kinds of motivational urges that need to be taken into account when assessing goal conduciveness or obstruction in appraisal processes antecedent to emotions produced by music. More detailed discussions of this point can be found in the chapters by Sloboda and O'Neill, DeNora, and Gabrielsson (this volume).

The evaluation of the compatibility of a stimulus event with external standards (norms, cultural values) and internal standards (personal values) as part of emotion antecedent appraisal is highly relevant for emotion elicitation via music. There seem to be prescriptions specific to culture and/or historical periods as to what is aesthetically pleasing or beautiful and what is to be rejected as a violation of 'good taste' (e.g. Farnsworth 1969; Kenyon 1991; see also Lynxwiler & Gay 2000, for an interesting recent example). Throughout musical history, the social norm or standards criterion has been involved in powerful emotional reactions towards 'modern' music, which was seen as violating established standards of morality and decency. The well-known scandal provoked by the première of Igor Strawinsky's dissonant and polyrhythmic *Sacre du Printemps* or by the première of Edgar Varèse's surreal *Deserts*, both in Paris, are just two particularly drastic examples of strong emotional reactions to the perceived disregard of established standards.

Appraisal processes, then, are one possible route by which emotion may be generated by music. Before turning to other potential mechanisms of emotion production, let us mention certain limitations with this explanatory approach. First of all, the appraisal dimensions pertinent to an evaluation of music may only be in part the same as the dimensions implicated in the generation of everyday emotion. In fact, it has often been claimed by theorists that music does not seem to present stimulus antecedents that are usually implicated in emotion appraisal (e.g. Budd 1985; see also Davies, this volume; Sloboda & Juslin, this volume). Methodologically, examination of this route faces particular challenges, one of which is the microanalysis of specific appraisal processes that continuously precede emotional changes in *real time.* Appropriate methods for such sophisticated analyses do not exist and have yet to be invented.

Memory

Another central route that is well established as a mechanism of emotion induction is imagination or recall from memory. In these cases, a strong emotional reaction that an individual has experienced in the past resurges in memory, spontaneously or triggered by a specific cue, or is evoked due to an experimental instruction to vividly imagine the event. It has been suggested that expressive and physiological reaction patterns to emotion-inducing events are stored in memory together with the experiential content (Lang 1979; Lang *et al.* 1980). In consequence, it is often claimed that recall of past emotional experiences from memory and imagination can evoke similar emotional reactions as in the original experience. The empirical evidence for such memory-induced resurgence of expressive and physiological reactions is still scarce (but see Contrada *et al.* 1991; Dalton 1998; Tarrant *et al.* 1994) except for clinical evidence from the area of post-traumatic stress disorder (Pitman *et al.* 1999; van der Kolk 1997).

Music, like odours, seems to be a very powerful cue in bringing emotional experiences from memory back into awareness. This is not surprising, for two reasons: first, music is quite a pervasive element of social life and accompanies many highly significant events in an individual's life—religious ceremonies, marriage, burial rites, dancing, and other festivities, etc. Thus, there are many associations between musical elements and emotionally charged memories. Second, music, like odours, may be treated at lower levels of the brain that are particularly resistant to modifications by later input, contrary to cortically based episodic memory (e.g. LeDoux 1992).

Empathy

In the two routes described above, emotion elicitation was based either on the occurrence or the remembering of an event of major significance to the individual. However, emotions are sometimes elicited by just *observing* another person being affected by an event that is very important to him or her but not necessarily to us. Examples are pity with someone afflicted by malfortune or shared joy with someone who has succeeded beyond expectation. The lower part of Fig. 16.1 illustrates three possible origins of such 'commotion' (for further detail, see Scherer 1998). The arrow to the left marks a 'normal' case of emotion *induction* via appraisal: we evaluate the event that has produced the emotion in the person we observe and evaluate it in a similar fashion, with similar results. Even if we are not directly affected by the consequences of the event (e.g. an unreasonable action by a third person), we may evaluate the injustice or unreasonableness in exactly the same fashion as the person that is directly concerned and react equally with anger or irritation (possibly without knowing the reaction of the person concerned). The middle arrow illustrates the mechanism of *empathy.* Here the assumption is that we directly identify with the person concerned and feel 'with' her or him. The process of empathy requires sympathy—were we to dislike the person in question, we might actually feel the opposite emotion (e.g. joy over our enemy's anger). Finally, the right arrow illustrates a mechanism often called *emotional contagion.* Here, the essential feature is the observation of the motor expressions of the person concerned, possibly without any knowledge of the event that caused the reaction. The assumption is that the sheer observation of strong motor expressions can produce similar muscular innervations in ourselves. This process, generally called 'motor mimicry' (Eisenberg & Strayer 1987), has been at the centre of a theory of emotional inference suggested by the German philosopher and psychologist, Lipps (1909). He argued that understanding the emotions of others occurs through *Einfühlung* (empathy), which is based on our mimicking, at least in a rudimentary fashion, the expressive patterns we see in the other (in other words, a contagion, at least of the expressive movement).

Why are these mechanisms of interest to the issues at hand? The link becomes clear when we try to extend the model in Fig. 16.1 to the situation of mass media communication such as film or TV. Assume that you are watching a character in a movie who is experiencing a very sad event, like the loss of a lover. In this case, there is no objective event, only the idea of an event that is the imaginary cause of the actor's acted feelings and the consequent expression manifestations. Assuming that the motor mimicry effect underlying contagion does not require an authentic experience, we presume that the viewer may still reproduce some of the features of the observed expression, albeit in a very weak and rudimentary fashion. In addition, it is not impossible that one will feel empathy, even though we know the emotion of the actor to be prescribed by the script. How else can we explain the tears shed in movie theatres? And, finally, we may even evaluate the imaginary event and be affected by this virtual appraisal. The adaptation of the emotion model to theatre or mass media-generated emotions is shown in Fig. 16.2 (for further detail, see Scherer 1998).

One can argue that listening to expressive music is very close to this example. Rather than an actor playing out a script, we have a musician performing a musical score. We may expect that the expressive movements in the music will lead to some kind of contagion, for example, a certain rhythm producing synchronized movements of the body. This mechanism will be described in greater detail below, because

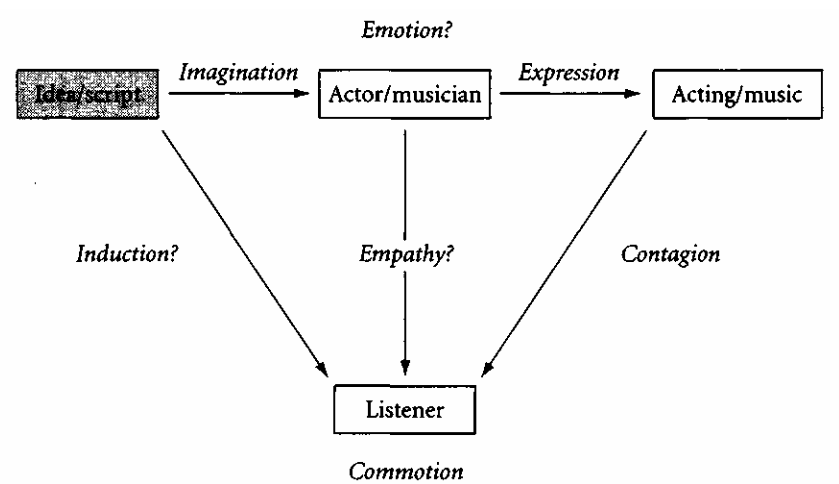

Figure 16.2 Adaptation of the commotion model in Fig. 16.1 to the case of listening to emotionally expressive musical performances, based on the suggestions concerning emotion communication in the mass media in Scherer (1998). Grey shading indicates the potentially virtual nature of ideas/scripts.

it may occur on a peripheral rather than a central level. However, there may also be a kind of empathy with the emotion presumed to be felt by the performer that may be construed in our imagination through an underlying 'idea' that is seen as responsible for the emotional state that is expressed (for example, the longing of the composer for his homeland, as in Dvoràk's 'New World Symphony'). Thus, emotion might be induced by the identification with a performer seen as living through an emotional experience produced by an underlying idea. We expect that such a process of musical empathy will be more likely in the case of listening to an admired performer (a listener feature, for example, an attitude) who is performing in a highly emotional manner (performance features such as skill, interpretation, and affective state). Finally, one might wonder whether, even in the absence of such performance cues, the 'underlying idea' might induce an emotional state on the basis of the evaluation of the musical structure of the piece alone. While these hypotheses are highly speculative, they do have the merit of bringing the investigation of the emotional effects of music theoretically closer to other kinds of live or mediated performances (theatre, movies, TV) that are generally considered to have the potential for emotion induction in the viewer, thereby providing opportunities for theoretical and empirical cross-fertilization.

16.1.3 Peripheral route production

Proprioceptive feedback

This route, while much less established than those described above, provides an interesting alternative, especially for some types of music. It is based on the idea that the emotion system consists of integrated components and that the system as a whole can be activated by manipulating the patterning of one of its components. For example, in a series of studies, Ekman and Levenson have provided some evidence that it may be possible to induce physiological and experiential emotion reactions by asking an individual to produce the facial patterning that is characteristic of certain emotions (without the person being aware of this purpose; see Ekman *et al.* 1983). While these findings are often contested, explaining the effects by a variety of experimental artefacts (e.g. Boiten *et al.* 1994), Ekman, Levenson, and their collaborators have systematically replied to these criticisms by adding further controls in replication experiments (P. Ekman, personal communication). The general idea is also consistent with proprioceptive feedback theories (e.g. facial feedback; see McIntosh 1996) that claim, in their strong form, that subjective feeling can be produced, or in their weak form, enhanced or intensified, by increased or uninhibited motor expression.

Thus, if music could be assumed to systematically influence one of the emotion components, peripheral mechanisms might be invoked to explain a spread to other emotion components, thus in fact producing emotion states that did not exist before. One potential candidate for such influence is rhythm. We all know the contagious effect strong musical rhythm has, at least on susceptible individuals who find it difficult not to move their heads or their legs in unison with the rhythm (e.g. in the case of dance rhythms, marches, or techno beat). Recent evidence suggests that such coupling of internal rhythms to external drivers, as originally described by Byers (1976), might be present at a very early age (Rochat & Striano 1999). If there is, indeed, a fundamental tendency for synchronization of internal biophysiological oscillators to external auditory rhythms, such coupling may provide a promising explanatory venue for the emotion-inducing effects of music. For example, given the close relationship of respiration and cardiovascular function, a change of respiration through musical rhythm may have an impact on a variety of neurophysiological systems (Boiten *et al.* 1994), in many ways similar to emotion-induced physiological changes.

Facilitating the expression of pre-existing emotions

So far, we have discussed the production of emotions where there were none before. Another potential effect of listening to emotionally arousing music can be the weakening or the elimination of control or regulation efforts. Due to sociocultural display and feeling rules, or because of strategic considerations, emotional reactions are often highly controlled or regulated, both with respect to motor expression and subjective feeling (Ekman 1984; Goffman 1959, 1971; Hochschild 1983; Scherer 2000*b*). One interesting effect of music, so far reported more often in an anecdotal fashion than empirically established, seems to be a loosening of such control or regulation effects. Movie-goers often report that, while watching a moving film, when the music started they could no longer hold back their tears. This effect may be partly due to similar contagion effects as described in the section above: when a pre-existing tendency toward specific motor expressions and physiological reactions is reinforced by external stimulation, it may be much harder to keep affect under control.

This remark on facilitating mechanisms concludes our overview of some of the mechanisms that may underlie the production of emotion through music. It should be noted, however, that we do not suggest that these mechanisms function in an exclusive manner. Rather, we assume that, generally, all of these mechanisms are operative jointly but having, depending on the circumstances, more or less of an impact on the emotional state produced. Thus, the peripheral route via rhythm entertainment may be particularly powerful for certain types of musical structures (lullabies, waltzes, or marches) and for particular occasions (a ballroom setting or a carnival march). In contrast, the central route, both via appraisal, associative memory, and empathy effects may be dominant in cases where one listens to well-known music in a reflexive mood, as in a concert setting.

16.1.4 Evidence

While there is massive evidence that listeners consistently *attribute* specific emotions to certain types of music, it is much more difficult to find convincing evidence that music can indeed *produce* emotion through one of the mechanisms described above. This task is rendered all the more difficult by the problem of deciding on a valid criterion for the *presence* of a certain emotion. As shown below, most studies have used a verbal report criterion, that is, listeners reporting that they are actually experiencing a certain emotion or affective feeling state as a consequence of listening to a particular piece of music. However, the danger of experimental artefacts, demand characteristics, social desirability, and many other problems besetting verbal report make one wonder whether verbal report can really be considered the gold standard as a criterion for genuine emotional experience (see below).

Ideally, the criterion to be used should be linked to the psychological definition of emotion as a hypothetical construct, that is, the operationalization, accessible to empirical measurement, as to the necessary and sufficient conditions to diagnose the presence, including beginning and end, of an emotional episode. So far, there is no consensus on such an operational definition in the literature. However, there is increasing convergence on the notion that emotions need to be seen as multicomponential phenomena (Scherer 2000*a*), involving at least the components of physiological arousal, motor expressive behaviour, subjective feeling, and possibly also a motivational component in the form of action tendencies and a cognitive component consisting of emotion-constituent appraisal and reappraisal (of external and internal events, including the emotional reaction itself). In addition, there is widespread agreement on the need to conceive of emotions as constantly changing processes, or episodes, rather than steady states. Thus, Scherer (1984, 1993, 2000*c*, 2001), proposing a *component-process model of emotion*, has suggested that researchers should use the criterion of coupling or synchronization of the different emotion components as evidence that an individual *has* a certain emotion at a particular point in time (see Table 16.1). Using this strict criterion, the claim that music induces emotion would have to be instantiated by studies showing that listening to a piece of music reliably leads (at least for a clearly specified group of listeners and under specified context conditions) to a synchronization of cognitive, physiological, motor-expressive, motivational (in the sense of evoked action tendencies), and experiential (subjective feeling) processes.

Although a few musical mood induction studies have incorporated multiple measures of affect (e.g. Albersnagel 1988; Kenealy 1988; Pignatiello *et al.* 1989; see also below), it may take a while until a study that measures at least three of the different components and determines their synchronization, is designed, excecuted, and published. In consequence, we will review the available evidence on the basis of individual components, providing an inventory of empirical findings separately for each of the components.

Cognitive changes

The philosophical literature across the ages has credited music with multiple effects on the mind, especially the power to provoke specific images or ideas that were, in turn, assumed to produce some of the emotional effects (for recent overviews of the philosophical literature, see Budd 1985; Davies 1994). Similarly, music is often supposed to affect judgment and evaluation. Unfortunately, few of these presumed effects have been empirically validated, demonstrating significant, experimentally induced effects for appropriately operationalized variables. The most frequently examined effects of music on cognitive performance have focused on memory.

For example, Martin and Metha (1997) examined the effects of musical mood induction on recall of childhood memories and found that music had an impact on the total number of memories recalled in the happy condition, but that there was no significant effect of sad music on eliciting sad memory recall. Balch *et al.* (1999) demonstrated mood-dependent memory effects following mood induction through music (i.e. the facilitation of remembering events one has memorized under the effect of a certain emotion when a similar emotion is elicited) (Blaney 1986; Forgas 1991). Their results suggest that it seems to be mostly the valence dimension of the emotional state that triggers the effect.

In one of the few experimental studies on the effect of music on judgmental processes, Bouhuys *et al.* (1995) showed that participants who felt depressed after listening to sad music perceived more rejection/sadness in faces with ambiguous emotional expressions and less invitation/happiness in faces with clear, unambiguous expressions. Some pertinent work may also be found in the studies on the effect of music on consumer attitudes and behaviour (Hargreaves & North 1997; see also Brown & Mankowski 1993, which is discussed below under 'subjective experience').

Physiological arousal

The idea that music can influence the ANS (also called the peripheral or vegetative nervous system) both in an arousing and a calming fashion is a very old one, going back at least as far as Greek philosophy (Bartlett 1996). Similarly, in many contemporary, popular treatments of this issue, the power of music to affect our autonomic nervous system and even the immune functions of our body are evoked. Thus, Ornstein and Sobel (1989) suggest that music evokes a calmness that may decrease blood pressure and reduce stress, and that it may help control hormones that suppress the immune system.

As to the empirical study of this idea, the French composer Grétry (1741-1813) is credited with the first reported attempt to measure cardiovascular effects of singing by counting the pulse rate by placing a finger on an artery (Diserens 1923, cited in Bartlett 1996). Serious study of the notion that music affects the ANS started as soon as the first instruments for physiological measurement became available and has continued unabatedly for the last 120 years, the period reviewed by Bartlett (1996). In general, researchers were concerned with the arousing or stimulating versus calming or sedating effects of music. Bartlett concludes that in the majority of studies (estimated at 61 per cent), an effect of music on different ANS parameters, corresponding to the prior hypothesis (e.g. increased heart rate and muscle tension for arousing music vs. decreased heart rate, decreased muscle tension, increased skin temperature, increased skin conductance for calming music) was found. There were, however, important differences between physiological variables: while the cardiovascular predictions were confirmed in only 39 per cent of the studies, skin temperature predictions were confirmed in almost all studies.

The large majority of studies reviewed by Bartlett (1996) focused on the issue of arousal versus relaxation as emotional effects of music. Given the period of time in which most of these studies were conducted, this is congruent with the dominant view of emotion during the heydays of behaviourism in psychology. This view defined the emotions as states of the organism characterized by different degrees of psychophysiological arousal or activation (Duffy 1941).

More recently, following the work of Tomkins (1962, 1963, 1984), and particularly his followers Ekman (1984, 1992) and Izard (1971, 1994), the Darwinian notion of a limited number of 'basic' or 'fundamental' emotions serving adaptational purposes (which has been postulated by philosophers since the dawn of time) reasserted itself (see Sloboda & Juslin, this volume, for further discussion). If the induction of emotion via music is seen from this theoretical angle, the issue becomes to demonstrate which of the basic emotions are elicited by a specific piece of music, as judged from the physiological response pattern observed. This question is consistent with the idea prevalent in musical circles ever since the baroque *Affectenlehre* (Mattheson 1739), claiming that music can express specific emotions, a position violently attacked by Hanslick (1854). One could presume that if music can express discrete emotions, it might also be able to generate or induce these same emotions (see 'production rules' above). The evidence required to prove such induction is the production, via music, of the specific patterns of physiological reactions that are postulated for the basic emotions by theorists in that tradition (Levenson 1992) and that have been demonstrated, more or less convincingly, in studies using film stimuli, imagination, or other induction techniques (Ekman *et al.* 1983; but see also Cacioppo *et al.* 1993; Stemmler 1996).

In an exploratory study, Krumhansl (1997) attempted to examine this prediction. She presented 38 Berkeley students with six excerpts from pieces of classical music that are generally expected to induce specific emotional states (and which were consensually rated, by another group of judges, to express the emotions of sadness, fear, happiness, or tension). Eleven physiological parameters, the large majority tapping respiration and cardiovascular functioning, were measured while subjects were listening to the music excerpts (average duration 3 minutes). The results supported the general prediction that music does indeed affect the ANS: during the listening periods, many of the physiological parameters had values significantly different from those during the pretrial (resting) period. Furthermore, Krumhansl was able to show statistically significant differences between the music samples (chosen to express the three emotions, sadness, fear, and happiness) in the extent to which they seemed to influence specific parameters (e.g. sadness excerpts producing large changes in heart rate, blood pressure, skin conductance, and temperature; fear excerpts producing large changes in pulse transit time and amplitude; and happy excerpts producing large changes in respiratory patterns). The author found that these changes were rather well correlated with subjectively reported experiences when analysed on the level of dynamic change over time, but not for the averaged physiological parameters and an overall judgment of emotion for a piece.

However, with respect to the central piece of evidence, the matching of the emotion-specific physiological response patterns, the results were far less encouraging. While, in some cases, the changes for a particular parameter went in a similar direction as the theoretically postulated ones, it would be difficult to argue that complete physiological response patterns, prototypical for 'discrete' or 'basic' emotions, were found. In any case, this would be a tall order, given that even psychologically highly sophisticated induction techniques, designed to produce specific emotions, so far have not yielded the kind of specificity in physiological response patterning that is expected by discrete emotion theorists (see Cacioppo *et al.* 1993; Stemmler 1996).

In a well-designed and highly controlled study using very naturalistic inductions of anger (harassment by experimenter) and fear (dangerous equipment failure), Stemmler and his collaborators (2001) were able to find systematic differences between anger and fear that can be directly linked to the differential action tendencies (i.e. fight and flight; see Frijda 1986; Scherer 1984) for these two emotions. The authors conclude that significant differences can only be expected on the basis of functional demands on behaviour and express some doubt as to the existence of highly specific patterns for many different emotions.

In another music induction study, Nyklicek *et al.* (1997) presented 26 undergraduates with 12 classical music excerpts (of 120-220 seconds' duration), with three excerpts each having been found to reliably express emotional states described as happy, serene, sad, or agitated. Physiological measurement again focused on cardiorespiratory variables. Rather than try to match theoretically defined patterns for discrete emotions, the authors employed multidimensional discriminant analysis to examine whether the reactions to the excerpts with different affective tones could be reliably distinguished on the basis of the physiological patterns. The discriminant analysis classified the reactions to the four types of excerpts with an accuracy of 46.5 per cent, the first discrimination function being largely determined by respiration parameters (reflecting an arousal or activation dimension), and the second dimension being determined by dynamic aspects of the cardiovascular processes (interbeat interval and left ventricular ejection time). While the first dimension was directly linked to subjectively perceived arousal, the second is more difficult to describe with respect to subjective meaning of the emotion space (it did not directly represent the valence dimension of subjective experience). The authors interpret their findings as evidence for both a discrete emotion and a dimensional model, arguing that the lower-order discrete emotions may be discriminated in a space formed by higher-order dimensions. This is reminiscent of the claims made by all dimensional models, starting with Wundt (1974). However, it should be noted that emotion theorists proposing dimensional models generally focus on the subjective feeling rather than the physiological or expressive components of emotion (see Scherer 2000*a*).

In a recent series of studies, Witvliet and Vrana (1996; Witvliet *et al.* 1998) looked at the effect of music on autonomic measures of skin conductance and heart rate, as well as on the somatic parameters of electromyographic change scores for the zygomatic, corrugator, and orbicularis oris muscles in the face. The music excerpts had been preselected with respect to their scores on the valence and arousal dimensions. In line with the earlier literature reviewed by Bartlett (1996), their results showed clear arousal effects on the autonomic measures with increased levels of skin conductance and heart rate, as well as increased tension of the orbicularis oculi muscle, during listening to excerpts judged as high on the activity dimension. In addition, they were among the first to show *valence* effects for music, particularly for the somatic measures. As predicted by discrete emotion and appraisal theorists (Ekman 1992; Scherer 1986, 1992), there was increased corrugator activity (used in frowning) while listening to music with negative valence and increased zygomatic activity (used in smiling) for music with positive valence (especially when combined with high arousal). This is consistent with the results of a more recent study (Lundqvist *et al.* 2000), in which facial electromyography, autonomic activity, and emotional experience were measured while subjects listened to happy and sad music. The happy music elicited larger zygomaticus activity, larger skin conductance, lower finger temperature, more (self-reported) happiness and less sadness compared with the sad music.

Limitations of the studies reviewed above include the lack of sensitivity to the dynamic unfolding of the effects of music over time (often with very rapid changes) and the lack of attention to the determining role of musical structure. Indeed, much of this research only examined physiological reactions integrated over a relatively long time interval. Furthermore, often no expert analyses of the structural features (musical score) were done to examine, or at least derive hypotheses about, what exactly in the music might have been responsible for the reported physiological phenomena.

A pioneering study by Vaitl *et al.* (1993) took both of these aspects into account. In a field study carried out in the festival theatre of Bayreuth in the summers of 1987 and 1988, 27 listeners were psychophysiologically examined while listening to a number of Wagner operas, from *Tannhäuser* to *Parsifal.* However, only data produced by three subjects in response to the leitmotivs during *The Mastersingers of Nuremberg* were analysed in depth. Electrodermal responses, respiratory activity, and ratings of emotional arousal were continuously recorded and analysed during the leitmotivs. It was shown that physiological responses differed markedly with respect to the leitmotivs and their musical features (e.g. melody, rhythm, continuation). An important additional finding was the interindividually variable, but overall weak, correspondence between emotional arousal ratings and physiological responses. Although this case study has obvious limitations, it is a good model to follow for future studies, combining dynamic measurement, on line, of physiological changes and feelings of emotional arousal within a live performance and linking the observed values to particular features of musical structure.

Motor expressive behaviour and action tendencies

From ancient times, there has been an assumption that movement is a key component, if not the underlying mechanism, of emotional reactions to music. This position is, for example, articulated by Aristotle as follows

> Why is sound the only sensation that excites the feelings? Even melody without words has feeling. But this is not the case for color or smell or taste . . . But we feel the motion which follows sound . . . These motions stimulate action, and this action is a sign of feeling (cited in Helmholtz 1954, p. 251).

Among modern philosophers, it is, in particular, Edmund Gurney and Carroll Pratt who gave a central place to movement in their theories of emotional effects of music (Gurney 1880, Pratt 1931).

The fact that much of modern-day music listening occurs under ritualized conditions in the concert hall, under more relaxed conditions in one's living room or car, or via earphones while pursuing all kinds of activities, masks the fact that throughout history much music was composed with very specific action tendencies in mind—getting people to sing and dance, march and fight, or work and play together. Composers of dance music and marches attempt to entice listeners to produce the appropriate rhythmic movements, and many people actually report that they cannot sit still and have trouble suppressing rhythmic body sway and other movements when hearing some bars of a Strauss waltz. On the other hand, lullabies evolved because of their presumed ability to put children to sleep, thus leading to the opposite effect of inhibition of motor arousal (Trehub & Schellenberg 1995).

One would expect, then, to find mechanisms that can produce motor expression and action tendencies via the peripheral production route described above. In one of the few attempts at theoretical foundation, Todd (1992) suggests that expressive sounds may induce a percept of self-motion in the listener via the central vestibular system. The argument is that expression based on elementary mechanics may sound natural because the vestibular system evolved to deal with similar kinds of motions (i.e. gravity and linear and rotational acceleration). As mentioned above, Byers (1976) reviewed potential mechanisms for rhythm induction. Clynes (1977) also argued for pervasive emotion-specific dynamic motor patterns.

Unfortunately, hard empirical, especially experimental, evidence for the production of motor patterns and action tendencies by music is rare (but for some attempts, see Fraisse *et al.* 1953; Harrer & Harrer 1977). Kneutgen (1964) discussed the biological significance of rhythm synchronization in different species and emphasized the role of music in driving biological rhythms. In an interesting pilot study (Kneutgen 1970), an Argentinian lullaby was played to four listeners in sessions lasting from 30 minutes to 2 hours (almost every day for a period of 3 months). It was found that the lullaby had the effect of markedly decreasing heart rate. In addition, the breathing rhythm became synchronized with the rhythm of the music. Interestingly, no such effects were found in a control group exposed to jazz music.

DeVries (1991) used Clynes' (1977) *sentograph* to measure affective motor responses to music and reported that the pressure patterns shown for 11 brief musical excerpts were similar across subjects and seem correlated with the expressive content of the music. However, so far convergent evidence from methodologically sophisticated studies on the validity of the sentograph are missing, and also the theoretical assumptions underlying its use seem rather elusive (but for studies in this area, see Carmean 1980; Gorman & Grain 1974; Nettlebeck *et al.* 1989; Trussoni *et al.* 1988).

Generally, there have been very few controlled studies using measures other than verbal report, on the induction of dynamic motor behaviour or specific action tendencies by music. The same is true for motor expression in the voice and face. In one of the very few studies looking at the facilitation of vocalization by music, Pujol (1994) varied the instrumentation (flute vs. bells) in two types of melodies (pentatonic vs. major) and studied the effects on physiological (respiration and pulse rate) and behavioural responses (eye movement, facial expression, vocalizations, and motor movement) of 15 profoundly handicapped persons. The music (particularly the major flute melody) stimulated the production of vocalizations, an effect which decreased over time.

Given the assumption that the face is 'the primary theatre' of the emotions (Ekman 1992; Tomkins 1984), one would expect to find much evidence for the facilitation of facial expression via music. Again, appropriate studies are rare. However, as reviewed above, Witvliet and Vrana (1996) reported evidence that different kinds of music differentially stimulate the innervation of the zygomatic muscle or corrugator muscles (see also Lundquist *et al.* 2000).

Studies on the effects of music on the tendency to perform certain actions (e.g. prosocial or aggressive acts) tend to be rare. In an experiment by Fried and Berkowitz (1979), different groups heard 7-minute-long musical selections that were either soothing, stimulating, or aversive in nature, while a fourth group was not exposed to any music. Those who heard the soothing music were most apt to show altruistic behaviour immediately afterwards (volunteering for another study). Mood ratings indicated that the soothing and stimulating music created somewhat different positive moods, while the aversive music tended to arouse negative feelings.

Subjective experience (*self-report of feeling*)

Among the methods used to study emotion induction through music, the self-report of feeling has been the most widely used approach. However, most studies having examined emotion *production* via self-report were not carried out within the area of music psychology, where the main emphasis has been on the perception of emotion in music. Assessments of emotion production via self-report is typically found in *mood induction* studies. The aim of such studies is often to examine the effects of different affect states, moods, and emotions on cognitive and evaluative processes, memory, behaviour, and physiology. Such 'instrumental' use of music as a means of emotion or mood manipulation has rapidly increased in recent years, placing music among the most widely used techniques for mood induction in psychology (for a review of mood induction studies, see Westermann *et al.* 1996).

There are two ways to examine the success of a given mood induction. One is indirect, relying on significant effects of the mood conditions on the dependent variables of interest. However, in addition, a self-report of mood or emotion is often used as a so-called manipulation check for the success of the mood induction. Typically, after the mood manipulation, the subject is given a self-report measure of mood. The results are then compared across mood conditions and significant differences among the conditions are interpreted as evidence for the success of the mood induction. Some of the most frequently used self-report instruments to assess emotion or mood production via music include: the multiple affect adjective check list (MAACL(-R-)) (Zuckerman & Lybin 1985); the Nowlis mood adjective checklist (Maslach 1979); the visual analogue scales (VAS) (Bond & Lader 1974); and the brief mood introspection scale (BMIS) (Mayer & Gaschke 1988).

The use of self-report measures as evidence for emotion production has both advantages and disadvantages. It remains the only method that allows access to the subjective emotional experience. Therefore, it should not be replaced by any other measure. However, the data collected in this way are sensitive to the following potential biases and artefacts that need to be carefully considered before conclusions are drawn. Firstly, demand characteristics can be responsible for the mood effects found. Secondly, listeners may confuse the emotions expressed in the music with what they actually feel unless they are specifically requested to distinguish between the two emotion modalities, as has been the case in our recent studies (Zentner *et al.* 2000).

To be taken as indicators of mood effects of music, then, self-report measures have to be validated against other criteria, or they have to be experimentally controlled. Following the latter avenue, Kenealy (1988) has compared self-reported mood effects in two conditions; one in which demand characteristics were intentionally created and one in which the effect of demand characteristics was minimized. She found no effects of demand characteristic on self-reported mood effects, concluding that the 'music procedure is relatively free from demand characteristics' (Kenealy 1988, p. 46). However, one could argue that the so-called 'no demand' condition was in reality also affected by demand characteristics. Subjects were left alone in a room by the experimenter who left on the pretext of having something urgent to attend to. Then, happy or sad music (depending on the condition) was played for 8 minutes. The subject, knowing they were in a psychological experiment and suddenly hearing music, might well have guessed the purpose of the experiment even without explicit demands and even without admitting it after the experiment. Such difficulties in the interpretation of the results notwithstanding, Kenealy's research is important in suggesting possible strategies for controlling demand effects.

The second criticism, confusion of perception and induction, is particularly relevant to studies in which subjects are explicitly instructed to report what they feel in response to the music. Kivy (1989) has argued that listeners make a fundamental attribution error in that they *habitually* take the expressive properties of the music for what they feel. This position is not new. In fact, it has already been summarized by Meyer (1956, p. 8) as follows: 'it may well be that when a listener reports that he felt this or that emotion, he is describing the emotion which he believes the passage is supposed to indicate, not anything which he himself has experienced'.

To our knowledge there is little, if any, empirical evidence to back up this claim. For this reason, we recently conducted a study in which participants were instructed to describe both what they *felt* and what they *perceived* in response to different genres of music. We found that the type of instruction (felt vs. perceived) changed the results quite dramatically (Zentner *et al.* 2000). Overall, the majority of emotions were reported much less frequently when the participants were instructed to focus on the *production* rather than the *perception* of emotion. This does, of course, not suggest that particular emotions are never felt in response to music, as Kivy would have it. (As a matter of fact, for particular emotions the reverse was true—they appeared to be more readily felt than perceived.) However, it indicates that the distinction between perception and production of emotion is empirically valid and that it is essential to take this distinction into account when instructing people to report their emotional responses to music. The studies by Kenealy (1988) and preliminary evidence from our group show that, although verbal reports of moods and emotions have their limitations, there still is much to be done to improve their quality.

In addition to asking listeners directly about their emotional reactions, there is also the possibility of assessing the feeling state without asking subjects directly about their emotional experience. Little use has been made of this possibility in the present area. In a recent review of mood effects on judgments and social cognitions, Forgas (in press) discusses several paradigms that could also be easily applied to the study of music and emotion. In some of these paradigms, subjects are asked to rate something other than affect or mood, for example certain individual dispositions related to attitudes, personality, or self-esteem. In a typical study (Brown & Mankowski 1993), a musical mood induction was used to induce positive, negative, or neutral affect. Afterwards, listeners evaluated *their* specific qualities and characteristics (How smart are you? How kind are you?). It was found that subjects rated themselves more favourably after listening to happy compared with sad music (see also Bouhuys *et al.* (1995), which is discussed above under 'cognitive changes'). Interestingly, this effect was stronger for subjects with low self-esteem, suggesting greater sensitivity to mood manipulation for this particular group.

In sum, because access to the subjective emotional experience of a listener is logically impossible without verbal report, optimization and extension of these methods is indicated. Perhaps, in the future, various brain-imaging techniques can be used as additional indicators of subjective feeling state (cf. Peretz, this volume). At present, verbal report remains the only means to assess this important component of emotional experience. Therefore, it is surprising that there has not been more effort made to systematically develop a vocabulary suited to describe what listeners feel in response to music. This is even more striking if we consider the doubts, expressed by several theorists, that emotional responses to music may not resemble everyday life or basic emotions, such as anger, fear, joy, sadness, shame, and disgust. Thus, Lippmann (1953, p. 569) suggested: 'Musical feelings have their own character: they are not the feelings we know and roughly name in our experience outside of music ... Thus music may be an emotional experience, and still not represent emotional contexts belonging to other areas of life, for the emotions it formulates are not identical with those accompanying extra-musical experience, nor does the one kind necessarily remind us of the other'.

As is often the case in this domain, there is little empirical evidence to confirm or invalidate this conjecture. Few efforts have so far been made to examine whether the basic emotion categories derived from emotion psychology are theoretically sensible, empirically valid, or musically plausible for describing the emotional experience induced by music. The few systematic attempts at creating a taxonomy of 'musical emotions' (e.g. Hevner 1936; Rigg 1964; Wedin 1972; see also Gabrielsson & Lindström, this volume) were entirely focused on perceived, not aroused, emotions. As has been pointed out by Sloboda (1992, p. 36), 'The relevance of these studies to emotional experience, however, is not proven. It is possible to make character judgements on the basis of conventional characteristics without experiencing any emotion whatsoever'. Moreover, these attempts lacked rigour, as has been pointed out recently by Gabrielsson (1998, p. 2): 'Procedures followed for this purpose are not always explicitly described and are rarely, if ever, based on some theory, rather on the researcher's own experiences and ideas and material used by earlier researchers'. Clearly, then, adopting a systematic approach for deriving a taxonomy of musical emotions while focusing on the aroused, not the perceived, emotions, is an important task for future research in this area.

Such work requires a theoretical background that does not prejudge the issue, as is the case with emotion theories that either, like discrete emotion theories, start from the assumption of a limited number of basic or fundamental emotions or that, like dimensional theories, focus exclusively on the valence and arousal dimensions of emotional feeling (see Scherer 2000*a*). Unfortunately, neither of these make any provision for emotion processes that may be specific to music. Scherer (1984) has suggested that there may be as many different emotions as there are differentiated outcomes of appraisal processes, rejecting the very limited taxonomy that is imposed by the semantic structure of the 'basic emotion' vocabulary in a specific language. Thus, componential process approaches (Scherer 2001) are perhaps better suited to provide the theoretical underpinnings for research on the specific emotions produced by different types of music. It should be recalled that this does not mean that conscious appraisal implying all criteria is necessarily involved in emotion elicitation via music (see above). It may be necessary to discard the standard, 'fundamental' emotion terms altogether and to focus more strongly on terms for more subtle, music-specific emotions (such as longing, tenderness, awe, activation, solemnity) that seem to describe the effects of music more readily than anger, sadness, or fear (Zentner *et al.* 2000).

16.2 Perspectives for future research

The review of the research evidence presented above has suggested that we are far from being able to provide a clear answer to the question of how music can actually *produce* emotional states. Apart from a general lack of sufficient research evidence, particularly with respect to non-verbal measures of affect, it is difficult to avoid the impression that this research domain suffers from lack of theoretical rigour. This is a bad omen for future research, since it is to be feared that additional, isolated research efforts with little or no theoretical underpinnings are more likely to add to the current confusion than to the insight to which the researchers aspire. We believe that much of the problem is due to the lack of differentiation between the different types of affective processes as described in Table 16.1. Clearly, confusion is hard to avoid when researchers apply different criteria for the evidence they require to infer the presence of the successful induction of an affective process via music. Therefore, it would be advisable for researchers to specify more carefully what kind of affective process they attempt to induce through the presentation of musical stimuli.

We suggest the adoption of the distinctions proposed in Table 16.1 for further work in this area. In what follows, we will attempt to specify in greater detail what criteria, both verbal and non-verbal, might be chosen to infer the presence of the respective process. Since it seems unrealistic to assume that music can produce any of the long-term affect dispositions in rows 4-6 of Table 16.1, only the short-term processes in rows 1-3 are discussed. Because there is no established consensus for either the classification proposed or the criteria suggested, the recommendations made below will have to be judged on the basis of their plausibility.

Preferences, defined as evaluative judgments of stimuli in the sense of liking or disliking, or preferring or not over another stimulus, are the simplest form of affect manifestations and some theoreticians may deny that they have an affective as well as a cognitive basis. However, because they are treated as emotional phenomena by some theorists (Zajonc 1980; Zajonc & Markus 1984) and because they are directly linked to valence which is seen by many theorists (especially the dimensional theorists) as an essential component of emotion (see Scherer 2000*a*), it seems mandatory to include them here. The verbal criterion for the existence and strength of induced preferences is the verbal claim by a person to like or dislike a certain piece of music with a certain intensity or certainty, or, in a comparative context, to like a piece of music more than (or prefer it over) another piece. One can also ask listeners to sort pieces of music in ascending fashion for greater liking or arrange them on a bipolar scale from extreme disliking to extreme liking.

On the non-verbal level, preferences can be assessed rather precisely by observing choice behaviour, that is, the choice of listening to one type of music rather than another, the length of listening behaviour, and other behavioural measures. Another non-verbal measure of liking is facial expression, measured either through observer coding of visible behaviour (Ekman 1992) or facial electromyography measurement (Cacioppo *et al.* 1993). The presence and strength of musculus zygomaticus innervation (smiling) can be taken as an indicator of degree of liking, and of musculus corrugator innervation (frowning) as a sign of degree of dislike. On the level of physiological measurement, Lang and his collaborators have suggested that the startle probe (e.g. Lang *et al.* 1990) can be used as a measure of valence (positive or negative feeling state). It should be noted that these behavioural changes are expected to be stimulus-driven, that is, they should only be present in the anticipation, presence, and possibly immediate aftermath of the stimulus, in this case, the music presentation. In contrast, the cognitive judgment, and verbal expression, of liking should be permanently accessible once a stimulus is identified and remembered.

Music seems to elicit preferences almost automatically, as the work on low-level automatic appraisal, reviewed in Section 16.1.2, suggests. Even if there is no comprehensive empirical evidence at present, there is little music that people find completely neutral and for which they are impartial as to whether to listen or not, if given a choice. Judging from informal evidence, most individuals seem to have little trouble in rating the degree of preference or liking (or disliking) on standard scales. However, it seems that there are powerful differences with respect to liking and disliking (e.g. Behne 1997). This seems quite natural since music that nobody likes is unlikely to survive (although detractors of modern music often claim that this is listened to for reasons other than liking). Thus, research on the induction of preference or liking may only be of interest in a differential context.

Contrary to preferences, *moods* are generally not elicited by concrete stimulus events at a particular point in time. Rather, they are defined as diffuse affect states, most pronounced as a change in subjective feeling, of low intensity but relatively long duration, often without apparent cause and thus persisting across encounters with multiple stimulus events. Because the labels for moods and emotions are often similar, care has to be taken to clearly distinguish the two in the instructions by specifying the long-term, non-event-related character of mood states (e.g. scales of good or bad mood, touchy vs. serene mood, etc.). Similarly, behavioural indices have to remain present over a lengthier period of time and not be related to an immediately preceding stimulus. This obviously rules out behavioural choice measures because these are automatically stimulus-driven. However, enduring evidence for morose versus serene facial expression, or prosocial versus aggressive acts, might serve as behavioural indicators.

Music may well be able to produce mood effects. At least this is what the music industry suggests, in particular for positive moods, by selling selections of music destined to produce relaxation or to generally improve one's mood (Bruner 1990; for concrete marketed examples see the mood-inducing compilations by Conifer Classics 1997 and Sony 1995). Similarly, claims for the effectiveness of music therapy are based on the assumption that the effect outlasts the presentation of the music (cf. Bunt & Pavlicevic, this volume). In contrast, music designed to incite customers to buy something or to calm aggression at football games, may rely on co-presence for its effect. There are only a few studies that have addressed the issue by carefully selecting valid *mood* criteria as defined above. Future research in this area, using appropriate measures, seems of prime importance, given the important implications for applied settings.

Can music induce *emotions* in the strict sense of Table 16.1, that is, defined as relatively brief episodes of synchronized responses of all or more organismic subsystems in response to the evaluation of an external or internal event as being of major significance? According to the senior author's theory, this implies that the emotion process is directly produced by an appraisal of the musical event and that the response pattern generated is specific to the event. While it may last beyond the presence of the event, in the case of certain emotions even for relatively long periods (e.g. Frijda *et al.* 1991; Scherer & Wallbott 1994), it is generally expected to be of shorter duration and of higher intensity than moods. Thus, contrary to preferences, valence cues should be accompanied by the presence of arousal indicators in the ANS. While these might also be present for mood, they should be more intense and less stable than in the case of mood. Furthermore, emotion processes should entail motivational changes and preparation of adaptive action in the form of modes of action readiness or action tendencies (Frijda 1986; Scherer 1984).

As mentioned above, Scherer (1984, 1993) suggested that the most salient criterion of the presence of an *emotion* process (in the strict sense defined in Table 16.1) is a high degree of coupling or synchronization of all organismic subsystems, including cognition, during the emotion episode. In order to answer the question of whether music induces emotion in this strict sense, all pertinent indicators in the respective organismic subsystems need to be measured and the degree of their synchronization assessed. So far, none of the studies in this area has attempted to do this, and it is not to be denied that it is a formidable undertaking. Yet, if one agrees to define emotions in this narrow or strict sense, it will be necessary to engage in comprehensive verbal and non-verbal measurement and powerful mathematical modelling of coupling or synchronization.

It is rather probable, of course, that one will not be able to find as intense and highly synchronized response patterns as found in the case of violent rage leading to fighting, for example. Ellsworth (1994) has pointed out that music is quite a special emotion-inducing stimulus in that it is difficult to specify the underlying concerns or goals that tend to be the motor of emotion (cf. Sloboda & Juslin, this volume). One could add, that it is also difficult to see which modes of action readiness or action tendencies that, according to Frijda (1986), define the quality of emotions, can be evoked by music. The exceptions are action tendencies like singing or dancing that are quite regularly provoked by certain types of music. However, it is likely that these action tendencies are provoked by peripheral entrainment, as described above, rather than by centrally controlled motivational changes as is generally the case in the provocation of adaptive action tendencies in 'real' emotions.

We believe that progress in the area will be difficult as long as researchers remain committed to the assumption that real intense emotions must be traditional basic emotions, such as fear or anger, for which one can identify relatively straightforward action tendencies such as fight or flight. Progress is more likely to occur if we are prepared to identify emotion episodes where all of the components shown in Table 16.1 are in fact synchronized *without* there being a concrete action tendency or a traditional, readily accessible verbal label. In order to study these phenomena, we need to free ourselves from the tendency of wanting to assign traditional categorial labels to emotion processes. Take, as an interesting example, the feelings that are rather vaguely described as 'being touched' or 'being moved' for which there is not even a substantive in some languages such as English and French (but there is *Rührung* in German). Examples are the tears shed during sentimental movies in the cinema or the flash of warmth experienced when hearing about a good deed. It would seem that such experiences are what music often produces. One is 'moved' by music (accompanied by symptoms such as moist eyes, chills, thrills, or gooseflesh) without there being a readily accessible label to describe what one is feeling or why. Of course, this does not mean that the lack of suitable verbal labels (or the inability of normal people to discriminate different states) absolves scientists from making the necessary differentiation, falling back to simple arousal models. On the contrary, the task is to develop both suitable non-verbal and verbal indicators that allow one to identify music-induced states that may not correspond to the traditional categories described in emotion textbooks. Finally, and taking this reflection a step further, we have also to be open to the possibility that, in certain instances, responses to music may not fit the states presented in Table 16.1 and may be of a thoroughly non-affective nature.

16.3 Conclusion

The suggestions for more principled research efforts in this area, studying several components of emotion, require substantial research investments and competencies in several areas of measurement. It may be unrealistic to expect that such research efforts will emerge in the near future. Yet, even if one is unable to launch such a sophisticated research programme, one still needs to define the theoretical suppositions in greater detail if the work in this area is to achieve a status that permits systematic comparison, replication, and eventually accumulation of findings. Following the specification of the theoretical model to be tested, the appropriate measures would need to be obtained, particularly in the non-verbal domain. This chapter provides an entire spectrum of possibilities for multimodal measurement approaches, encouraging research that does not only rely on standard self-report inventories with their well-known limitations (e.g. Nisbett & Wilson 1977; Scherer & Ceschi 2000). Thus, in future research, the criterion for successful induction should be multimodal, for example verbal report complemented by non-verbal measures such as physiological responses and expressive behaviour. Some of these measures are particularly well suited for this purpose since they provide a continuous, variable signal and are in large parts resistant to conscious regulation.

What are the requirements for measurement for proponents of different theoretical approaches, as outlined above? Researchers adopting dimensional theories would need to specify the expected values for valence and activity for the emotions to be studied and include physiological and expressive indicators in addition to verbal report measurement. Proponents of discrete emotion theories would need to clearly specify the expected emotion-specific response patterns for the emotions studied and include all pertinent variables in their measurement operations. In addition, with respect to the statistical analysis it would seem necessary to use pattern-matching procedures (e.g. profile analyses) rather than simple comparisons for differences (e.g. univariate *F*-tests) between various emotions. Finally, appraisal theorists, in addition to sharpening the predictions for the outcomes to be expected for different appraisal results and the measurement of the respective variables (Johnstone *et al.,* 2001; Pecchinenda 2001), need to indicate how appraisals can be determined in the case of music. Obviously, this requires a much greater research effort than obtaining verbal reports, and one might claim that the suggestions made in this chapter are unrealistic. Yet, similar approaches can already be found in several research domains in the affective sciences and we believe that this tendency will continue.

In brief, we have suggested that by linking research on the emotional expressiveness of music more directly to the progress in the affective sciences generally (see Davidson *et al.*, in press), it may be possible to design empirical studies that are likely to yield results that can be interpreted against a background of theoretical predictions as compared with multiplying studies that have been designed on an *ad hoc* basis and that are difficult to integrate into a coherent body of literature.[1]

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1The preparation of this chapter was facilitated by Grant No. 1114-049680.96 entitled 'Introduction of emotional states through music' by the Swiss National Research fund to Marcel Zentner and Klaus Scherer. The theoretical suggestions linked to perception and production rules were first presented by Klaus Scherer in the context of a keynote speech 'Music and emotional meaning: Perception and production rules' at the Sixth Conference of the International Society for Music Perception and Cognition, 5-10 August 2000, at Keele University, UK. The authors acknowledge important suggestions by a group of anonymous reviewers.

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