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Psychology of Music 1996; 24; 68
DOI: 10.1177/0305735696241007

Psychology of Music,
1996, **24,** 68–91

Emotional Expression in Music Performance: Between the Performer's Intention and the Listener's Experience

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Abstract

Nine professional musicians were instructed to perform short melodies using various instruments – the violin, electric guitar, flute, and singing voice – so as to communicate specific emotional characters to listeners. The performances were first validated by having listeners rating the emotional expression and then analysed with regard to their physical characteristics, *e.g.* tempo, dynamics, timing, and spectrum. The main findings were that (*a*) the performer's expressive intention had a marked effect on all analysed variables; (*b*) the performers showed many similarities as well as individual differences in emotion encoding; (*c*) listeners were generally successful in decoding the intended expression; and (*d*) some emotional characters seemed easier to communicate than others. The reported results imply that we are unlikely to find performance rules independent of instrument, musical style, performer, or listener.

The fact that music can be used as an effective means for expression and communication is often acknowledged. Yet this is one of the least understood aspects of music, at least as far as scientific explanation goes. The communication chain from the originator of the music to the recipient contains a number of intervening elements, different in different situations. As regards most art music, it includes the composer, the score, the performer(s), the sounding music, and the listener. In improvisation the role of the composer and performer merge and there is usually no score. In electroacoustic music the composer may directly store the piece on tape or compact disc, leaving the performer aside. The number of elements between the originator and the recipient – the sender and the receiver in communication theory terms (Shannon and Weaver, 1949) – thus varies. To our knowledge, there is practically no valid empirical research on musical communication including all elements sketched above. To conduct such research would be demanding, indeed. In this paper we concentrate on the communication chain from the performer to the listener, specifically on the expression and communication of emotions.

Music may express as well as arouse emotions in different ways (Dowling and Harwood, 1986); by being associated with a certain situation, by generating deviations from expectations (Meyer, 1956; Berlyne, 1971; Gaver and Mandler, 1987), or by mirroring the structure of emotions (Langer, 1953; 1957). These categories should, of course, not be taken to be mutually exclusive; any given musical event may involve more than one of these possibilities. However, it is the last-mentioned principle that is focused upon in this paper.

There are several studies on perceived emotional expression in music, mainly in Western tonal music (Brown, 1981; Gundlach, 1932; Hevner, 1935; Rigg, 1964; Schoen and Gatewood, 1927; Wedin, 1969; 1972). These studies aimed at finding suitable descriptors of emotional expressions and relating them to various musical elements. A typical procedure was to collect a large number of pieces of music, assumed to reflect a wide spectrum of emotions, and to have listeners judge them by means of adjective checklists or the like. Another approach was to study emotion attribution experimentally by systematically changing various properties of short pieces of music (Hevner, 1936) or short tone sequences (Scherer and Oshinsky, 1977). Rigg (1964) provided a convenient summary of the results. "Serious" and "solemn" music was said to be slow, low-pitched, and avoid irregular rhythms and dissonant harmonies. "Sad" music is likewise slow and low-pitched, further apt to be in a minor mode, and to contain dissonance. "Happy" music is fast, high-pitched, in major mode, and contains little dissonance. "Exciting" music is fast, loud, and apt to contain dissonance. These investigations show that listeners find it quite natural to attach general emotional labels to pieces of music, and that there is reasonable agreement as to the broad characterisations of emotional expression in music (Dowling and Harwood, 1986).

However, there was no study of different *performances* in these investigations. The musical elements mentioned were such as are usually indicated in the score, whereas variables in the microstructure of music performance were not considered. Measurements of performance have revealed extreme complexity and variation of music performance when considered in relation to the musical score; for a review, see Gabrielsson (in press). There are numerous "deviations" in timing, dynamics, and intonation from what seems prescribed in the score. These deviations are often different for different types of music, instruments, and individual performers. There are a lot of implicit rules associated with different musical genres, which are taught and learned in actual practice. Moreover, notation conventions vary between genres and epochs. And even if the same score is used, performers differ considerably in their representation and performance of it. The attempts to formulate general rules for music performance solely on the basis of designations in the musical score (Clarke, 1988; Sundberg, Friberg and Frydén, 1991) have therefore met with limited success. Kendall and Carterette (1990) found considerable variability among performers even in a very short musical excerpt, and concluded that their data failed to support "something as strict and invariant as *the* musical grammar, performer grammar, or listener grammar" (p. 160).

All this highlights the necessity of studying the performer's representation of the music and how the intentions following from that affect the performance. To complete the performer–listener communication chain we must also study the listener's experience of the music, to see whether the performer's intentions are grasped by the listener; if performer and listener share a common code. Rather than look for lawful relations between the score and the performance, one should search for them in the relations between the performer's intentions, the variables in the sounding music, and the listener's experience. This was suggested already by Harold Seashore (1937) in a summary of his extensive studies of artistic singing: "The psychophysical relations between the performer and the listener must be worked out; the data presented here will contribute to such studies and will depend for their final interpretation on such studies" (p. 118). Regarding structural characteristics, some reports approximate this goal, for instance, the studies of performed and perceived meter by Sloboda (1983; 1985a) and Edlund (1985), and of dynamic variations in performance by Nakamura (1987).

However, although empirical research on music performance has now been conducted for about 100 years (Gabrielsson, in press), there is practically no study on emotional expression in performance. Music performance has mainly been discussed and studied with regard to how it reflects the musical structure (Clarke, 1988; Sloboda, 1985b). Clarke (1989), for instance, noted that "it is an assumption of most performance research that expression is primarily used to convey musical structure to listeners" (p. 3). However, the importance of motional and emotional aspects in this context has been a repeated theme in the senior author's writings (Gabrielsson, 1973; 1985; 1986; 1987; 1988; 1993; 1995).

Interestingly, along with a recent resurge of interest in emotional phenomena in general, there has also been an increase of interest in emotional aspects related to music performance. This has partly grown out of nagging concerns that the one-sided emphasis on structural aspects somehow does not capture the essence of musical activity. Thus, for example, Shaffer (1992) notes that "listeners tend to hear moods and emotions expressed in music, performers feel that they are conveying these moods and emotions, and composers may conceive of these moods and emotions as part of the musical intention" (p. 264).

Kendall and Carterette (1990) had five musicians perform the beginning of "Thy hand, Belinda" from Purcell's *Dido and Aeneas* with "appropriate expression", "exaggerated expression", and "without expression". On the whole these expressive intentions were grasped by the listeners. The two expressive performances were played slower, used more amplitude vibrato and more variation in timing than the performance without expression. Davidson (1993) used "point-light technique" for video recording of musicians' movements when performing music "deadpan", "projected", and "exaggerated". The three performance manners could be identified in the video recordings with the sound eliminated. In both studies "expression" is used as a fairly general concept of which there is simply more or less, without discussing *what* is actually "expressed". In a study by Senju and Ohgushi (1987) the violinist Senju played ten different versions of the beginning of Mendelsohn's *Violin Concerto* with various expressive intentions, such as "deep", "sophisticated", "bright", "beautiful", and "dreamy". There was very limited correspondence between the player's intentions and the listener's impressions, perhaps due to the rather diffuse meaning of these labels. Behrens and Green (1993) had eight musicians – two violinists, two vocalists, two trumpet players, and two timpanists – perform 30-second improvisations to express one of three emotions: "sad", "angry", and "scared". Listeners identified "sad" improvisations best when they were performed with the violin and the voice, "angry" improvisations when performed on timpani, and for "scared" the identification was best with the performances on violin. The two last-mentioned studies used more specific emotion labels. However, there were no measurements of the performances and thus no information about what means the musicians used to bring about the intended expression.

We recently initiated a research project to more systematically combine studies on music performance with studies on emotional expression and communication. In particular, we study which means musicians use in their performance to express various emotional characters and try to determine the extent to which musicians and listeners have a common expressive code. An experimental approach is used in which performers are asked to play or sing short pieces of music so as to express various emotions. The performances are validated by having listeners rate them on various adjective scales. Valid performances are analysed to see what means the musicians used to bring about the desired emotional expression. We strive to include music and musicians representing different styles; also to include a variety of instruments, since instruments differ with regard to what means are available for emotional expression; and listeners with varying musical backgrounds.

As mentioned above, our main interest lies in the relationship between the structure of music and emotions. Langer (1953; 1957) postulated the existence of a general *isomorphism* between the structure of music and the structure of feelings; "music is a tonal analogue of emotive life" (1953, p. 27). The theory has been extensively discussed (*cf.* Åhlberg, 1994), but since her descriptions of the formal similarities between human feelings and music are fairly general and practically without concrete musical examples, the theory has not generated any empirical research. Furthermore, scientific knowledge concerning the structure of experienced feelings is not well developed, so we are thus confined to study the structure of feelings as reflected in their overt expression, such as bodily, facial, and vocal behaviours.

Clynes (1977) postulated that each basic emotion is associated with a characteristic brain pattern and that it can be expressed with the same dynamic form in different output modalities, such as "gestures, tone of voice, facial expression, a dance step, musical phrase, etc." (Clynes, 1977, p. 18) or, in experimental settings, by pressing a button on a so-called sentograph. We should thus be able to find musical parallels to emotional expression in other modalities. For instance, on the basis of the existing literature on vocal affect expression (Scherer, 1986; 1991) and our general experience of body language, we may hypothesise that the expression of "happiness" would involve fast tempo, relatively high sound level and pitch level, rapid tone onsets, "airy" articulation and bright timbre, whereas the expression of "sadness" would be characterised by slow tempo, lower sound and pitch level, slower onsets, legato articulation and subdued timbre. These and similar predictions concerning other emotions are reminiscent of the results on emotional expression in music summarised by Rigg (1964; see Introduction).

A further development of ideas on music and emotion was presented by Juslin (1995a), who suggested the systematic application of a *functionalist perspective* to the study of emotional communication in music performance. This involves the integration of ideas and concepts from evolutionary oriented emotion psychology and non-verbal communication with Brunswik's (1956) probabilistic functionalism, including a modified version of his well-known lens model (see also Scherer, 1982). Two hypotheses derived from the functionalist approach are that (*a*) basic emotions (such as "happiness", "sadness", "anger", or "fear"; see Ekman, 1992; Plutchik, 1994) should be easier to communicate – because of their phylogenetic history and intrinsic relation to expression – than other emotional characters in non-verbal communication (including music performance), and (*b*) females should be more skilled than males in decoding emotional expression in music performance, in analogy with the gender differences found in other areas of non-verbal communication, such as facial expression and vocal affect expression (*cf.* Brody and Hall, 1993). The theoretical underpinnings of our research are more fully discussed elsewhere; see Gabrielsson (1995) for comments on Clynes's and Langer's theories, and Juslin (1995a) for a discussion on the functionalist approach.

Beside the above hypotheses and results from earlier research on emotion in music we also rely on our own practical experience of music performance in the selection of questions and methods. The results of our initial studies (Gabrielsson, 1994; 1995; Gabrielsson and Lindström, in press; Juslin 1995a) agree with earlier results regarding tempo and sound level but also present several new findings on how timing, articulation, dynamics, tone onsets and vibrato are used to achieve an emotional expression in music performance. These phenomena are further investigated in this report using other musical material, instruments, performers, and listeners.

Methods

Two studies are described in this paper. Study I featured three performers with different instruments – the flute, violin, and singing voice – and Study II six performers playing the same instrument – the electric guitar.

Subjects

Study I: Three male professional musicians (teachers at a college of music), aged 40–50 years. Study II: Six professional male guitar players, aged 25–45 years. All performers played their own instruments and were paid for their (anonymous) participation.

Musical material

To facilitate recording and measurements, the musical material is in the present stage of our investigations limited to short monophonic pieces. They should represent different musical styles and varying emotional characters but also be possible to perform with other characters. Study I comprised the well-known signature tune of the Eurovision television programs, taken from *Te Deum* by Charpentier (Melody A), a Swedish folk melody (Melody B) used in earlier performance studies (Bengtsson and Gabrielsson, 1980; Gabrielsson, Bengtsson and Gabrielsson, 1983), as well as a melody (Melody C) composed for this study. Study II employed the well-known negro spiritual *Nobody Knows* (Melody D). The structure of all melodies is obvious from the notations (Figure 1). However, the notation of *Nobody Knows* should be considered as an approximate transcription of a tune that belongs to oral tradition.

Procedure

Performance recording and measurements

The performer was instructed to play the given melody so as to render the performance with different emotional expressions, namely “happy”, “sad”, “angry”, “fearful”, “tender”, “solemn”, as well as “no expression”. Furthermore, he was asked to play the melody as he thought it ought to be performed. He was asked to imagine that he was trying to communicate the prescribed emotional characters to a potential listener. He had to keep the pitches in the melody but was otherwise free to vary whatever variables he wanted – such as tempo, timing, dynamics, articulation, phrasing, vibrato, attack, and timbre – in order to bring about the intended emotional expression. Each version was to be played twice as similarly as possible. The performer was allowed to practice beforehand and to go on until he was satisfied with his performance of the respective version (usually 2–3 attempts were enough). The pieces should be played by heart if possible (and this was

FIG. 1
Notation of melodies A (Eurovision signature tune), B (Swedish folk melody), C (newly composed) and D (*Nobody Knows*).

usually the case); if not, the notation was provided. All performers accepted the task with great interest and provided several comments during the procedure and in an interview afterwards.

The performances in Study I (melodies A, B and C) were made in a professional music studio, and those of Study II (melody D) in a laboratory room with acceptable acoustics. The tape recordings of the performances were stored in computer memory, using 22 or 50 kHz sampling frequency.

The duration of performed notes was measured from the onset of a note until the onset of the next note. The accuracy of these measurements varied for different notes but is usually within ±10 ms, at most within ± 20 ms. The mean tempo for each performance was obtained by dividing the total duration of the tune, until its final note, by the number of beats, and then calculating the number of beats (= quarter notes in all four melodies) per minute (*cf.* Bengtsson and Gabrielsson, 1980). Articulation and sound level of the respective performances were compared by means of the recorded amplitude envelopes (see Figures 3 and 4) and also by calculating the equivalent loudness level as provided in the Swell software (Ternström, 1992). This also provided opportunities for studying spectral characteristics, vibrato, and intonation; some examples are given in Figures 5 and 6.

Listening experiments

Study I: Three listening experiments were conducted: one for each of the melodies A–C. The performances of melody A were judged by seven music psychology students, two males, five females, aged 24–45 years; those of melody B by 14 music psychology students, six males, eight females, aged 23–40 years; and those of melody C by 35 musicians, 21 males (23–69 years old) and 14 females (27–46 years old). All experiments were made groupwise. The order of the versions to be judged was randomised.

Study II: Two different listening experiments were conducted. The first (experiment A) featured 13 musicology students (aged 19–47 years) and was made groupwise, whereas the second (B; $n = 24$) comprised a mixture of lay listeners and musically trained listeners (aged 21–52 years) and was made individually by means of a specially designed computer program for adjective ratings of emotional expression in music. Both groups were evenly distributed with respect to gender.

The listeners were instructed to judge all performances with regard to their "happiness", "sadness", "anger", "tenderness", "expressiveness", "fear" (only in Study II), and "solemnity" (only in Study I). The judgements were made on a scale from 10 to 0, where 10 designated maximum, and 0 minimum, of the respective attribute.

Results

Listening experiments

The results from the listening experiments are described first since they were used to select which performances should be analysed further. However, space limitations necessitate a selection from all the results.

The results in Study I (melodies A–C) immediately revealed that among the three performers in this study the singer was far less expressive than the violinist and the flutist. Generally, his results showed the same tendencies as for the other two performers, but to a much lesser degree; an example of that can be seen in Figure 2. Except for this example the results from the singer are therefore omitted in the following.

We concentrate on the listening experiment concerning melody C, which was the largest in terms of number of listeners and the results of which were also representative for the results concerning melodies A and B (see Table 1). The columns designate the intended expressions and the rows the corresponding adjective scales used by the listeners. Mean ratings for the total group (t) appear uppermost in each cell; below are shown the mean ratings of females (f) and males (m). High decoding accuracy is indexed by high values on the diagonal and low values in off-diagonal cells. Analyses of variance and F tests were used to test for overall differences among the adjective scales within each column (= intended expression). These F tests were highly significant ($p < \cdot 0001$ or $< \cdot 001$) for all intended expressions and were followed by t tests regarding the specific comparisons between the adjective scale corresponding to the intended expression and the other five (non-corresponding) adjective scales. The results of the specific comparisons are indicated by asterisks denoting the *p* value for the difference between the actual mean rating and the mean rating of the adjective corresponding to the intended expression. For instance, the four asterisks at the mean rating (1·7) of the adjective "sad" under the intended "happy" expression performed on the violin mean that the difference between this rating and the mean rating of "happy" (6·1) – the "correct" adjective under the "happy" intention – is significant at the $p < \cdot 0001$ level. As seen in the table, these specific comparisons were in most cases highly significant. There were exceptions, however. The ratings of "sad" and "tender" were often about the same and not significantly different; the listeners also remarked that these qualities were hard to distinguish. The flutist's "angry" version also tended to be perceived as "happy" or "without expression", and the violinist's "solemn" version was also often perceived as "angry".

The females seemed to have higher decoding accuracy than the males. Their ratings on the diagonal were in most cases higher, and their off-diagonal values usually lower, than for the males. The female ratings were in fact more accurate in 32 of the 36 cells (≈ 89%) for each instrument. However, only a few of these differences within cells were significant (*e.g.* the difference in the "happy" scale for the violinist's "happy" performance). Multivariate analyses of variance indicated no significant difference between females and males neither in diagonal cells (Rao's $R_{6,28} = 1{\cdot}48$, $p < \cdot 22$ for the violin versions and $R = 0{\cdot}83$, $p < \cdot 55$ for the flute versions), nor in off-diagonal cells ($R_{30,4} = 2{\cdot}59$, $p < \cdot 18$ for violin versions and $R = 0{\cdot}60$, $p < \cdot 82$ for flute versions).

The results of the listening experiments in Study II (Table 2) were similar to those in Study I. Note, however, that each experiment featured three performers and that Table 2 thus shows the mean ratings across all performers. In Experiment A, all specific comparisons were significant except for the difference between "sad" and "tender". The "sad" and "tender" versions by performer A and C were confounded, whereas the ratings of performer B's "sad" and "tender" versions were separated by one scale unit on both the "sad" ($p < \cdot 10$) and "tender" ($p < \cdot 20$) scales. The specific comparisons of experiment B were also significant except for the difference betwen "fearful" and "sad" under the "fearful" intention. However, this was mainly due to the fact that performer D's "fearful" version was perceived as sounding "sad" rather than "fearful". It should be noted that the last scale in this experiment was "expressiveness" (unlike the earlier listening experiments which used a "no expression" scale); it is thus natural that this rating was not significantly different from the rating in the adjective scale corresponding to the intended expression. The "no expression" performances got a rating of 3·8 in expressiveness, much lower ($p < \cdot 0001$) than the corresponding ratings (5·5–6·8) for the other performances.

Performance analyses

The results of the performance measurements are first described in terms of separate variables and then summarised with respect to each emotional expression.

Tempo

The mean tempos for melodies A–D are displayed in Figure 2. Analyses of variance concerning melodies A–C indicated significant differences between the

TABLE 1

Mean ratings of total group (t; n = 35), females (f; n = 14), and males (m; n = 21) for different emotional expressions of melody C performed on the violin and the flute.

VIOLIN

Adjective	Intended expression: Happy	Sad	Solemn	Angry	Tender	No expr.
Happy	**6.1 t**	0.9****	2.3****	1.4****	0.7****	0.7****
	7.2 f	0.2	2.4	1.2	0.3	0.4
	5.3 m	1.3	2.2	1.6	1.3	0.9
Sad	1.7****	**7.5**	3.7*	2.8****	8.4 ns	4.1****
	1.4	**8.0**	2.9	3.0	8.9	3.6
	2.0	**7.1**	4.3	2.7	7.7	4.5
Solemn	2.7****	4.4****	**5.0**	3.3****	4.1****	1.8****
	2.9	3.9	**5.4**	2.9	2.9	1.9
	2.6	4.7	**4.7**	3.5	5.0	1.8
Angry	2.7****	1.2****	4.3 ns	**8.5**	0.7****	1.5****
	0.9	0.3	2.9	**8.8**	0.1	0.6
	3.9	1.8	5.3	**8.2**	1.1	2.1
Tender	1.3****	6.2**	1.8****	0.4****	**7.5**	2.1****
	1.1	5.6	0.9	0.0	**7.7**	1.4
	1.5	6.6	2.3	1.1	**7.4**	2.6
No expr.	3.1****	1.6****	3.0**	1.7****	2.0****	**7.1**
	2.4	0.5	3.2	1.5	1.5	**7.6**
	3.5	2.9	2.9	1.9	2.3	**6.7**

Probability levels: *.05 / **.01 / ***.001 / **** .0001 / ns = non significant

FLUTE

Adjective	Intended expression: Happy	Sad	Solemn	Angry	Tender	No expr.
Happy	**7.2 t**	0.9****	2.9****	3.8 ns	1.1****	0.8****
	7.9 f	0.4	2.6	3.4	0.7	0.3
	6.7 m	1.2	3.2	4.0	1.4	1.1
Sad	2.1****	**7.0**	2.7****	1.5****	6.9 ns	2.3****
	1.1	**7.1**	2.3	1.1	7.5	1.6
	2.7	**6.9**	2.9	1.8	6.5	2.8
Solemn	2.3****	5.2****	**5.3**	1.5****	4.2****	1.4****
	2.4	4.1	**5.1**	1.1	3.2	0.9
	2.3	5.9	**5.4**	1.7	4.9	1.8
Angry	0.7****	0.8****	3.8**	**4.3**	0.7****	1.1****
	0.1	0.1	2.8	**4.1**	0.1	0.3
	0.2	1.2	4.5	**4.5**	1.0	1.6
Tender	3.3****	7.8 ns	1.4****	0.8****	**6.7**	1.2****
	3.0	7.6	1.1	0.2	**7.1**	0.4
	3.5	8.0	1.6	1.1	**6.5**	1.8
No expr.	2.9****	1.4****	3.3***	4.7 ns	2.0****	**8.5**
	2.3	1.4	2.9	4.4	1.9	**8.6**
	3.3	1.5	3.6	4.9	2.1	**8.5**

Probability levels: *.05 / **.01 / ***.001 / **** .0001 / ns = non significant

TABLE 2

Mean ratings for each emotional expression of melody D performed on the electric guitar.

Intended expression

A

Adjective	Happiness	Sadness	Anger	Fear	Tenderness	No expr.
Happy	**5.8**	1.9****	2.8****	-	2.0****	3.3*
Sad	1.5****	**5.5**	1.7****	-	4.8 ns	2.4**
Angry	1.2****	0.9****	**5.1**	-	0.9****	1.9****
Tender	2.5****	5.5 ns	1.1****	-	**5.3**	2.3**
No expr.	4.3**	2.3****	3.8*	-	3.1**	**5.1**

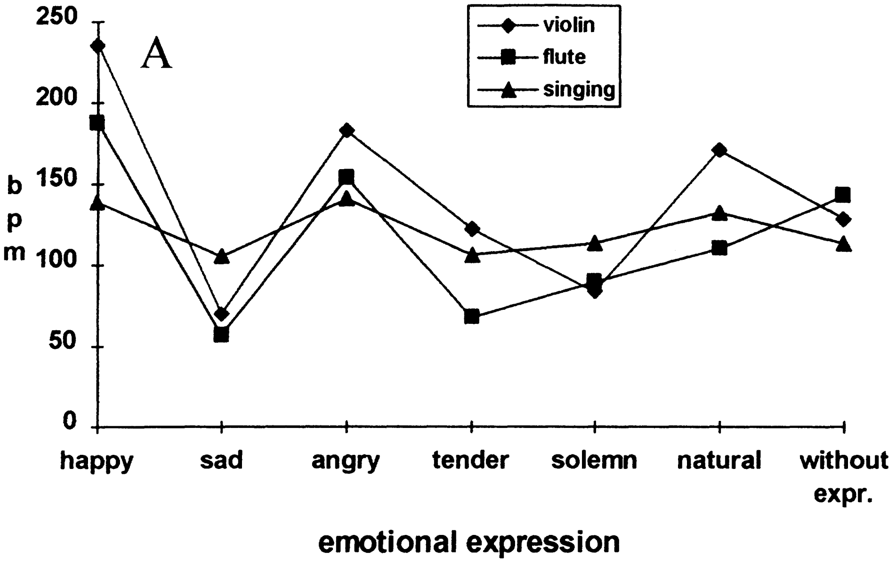
B

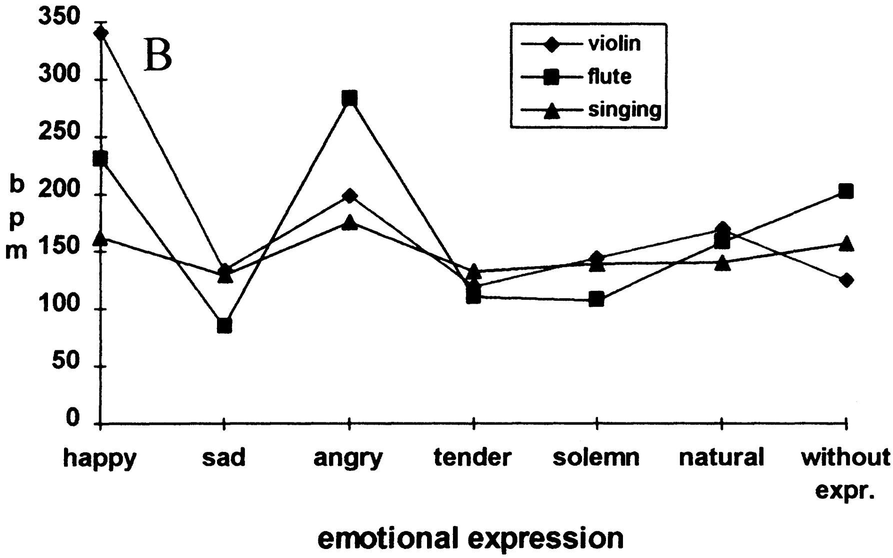
Adjective	Happiness	Sadness	Anger	Fear	Tenderness	No expr.
Happy	**6.0**	1.9****	2.3****	2.5****	-	2.8 ns
Sad	2.4****	**6.7**	2.7****	4.3 ns	-	3.9 ns
Angry	1.8****	1.3****	**7.5**	1.9****	-	1.7****
Fearful	2.1****	3.0****	2.3****	**5.4**	-	2.7*
Expressive	5.7 ns	6.2 ns	6.8 ns	5.5 ns	-	**3.8**

Probability levels: * .05 / ** .01 / *** .001 / **** .0001 / ns = non significant

melodies ($F_{2,20}$ = 39·85; p < ·0001; melody B was played fastest, melody C slowest), as well as between the expressions ($F_{5,20}$ = 20·26; p < ·0001) and a significant instrument by expression interaction ($F_{10,20}$ = 3·56; p < ·01). In general, the "angry" and "happy" versions were played fastest and the "sad" and "tender" versions slowest; the "solemn" and "no expression" versions were in between. The range of these differences varied among the performers. As seen in Figure 2, the singer varied the tempo much less than the violinist and the flutist.

The six performers in Study II (melody D) differed less among themselves than the performers in Study I. However, there were two outliers, performer D's "angry" version and performer F's "no expression" version. Performer D played each phrase of the melody very fast and made short breaks between them. Performer F also played fast but made all notes in the melody about equally long in an attempt to achieve a performance without expression. The mean tempo across performers – disregarding the outliers – differed ($F_{3,9}$ = 9·88, p < ·01) in the same way as in Study I; "happy" (116 bpm) and "angry" (102) were played fastest, "sad" (61) and "tender" (70) slowest, and "no expression" (90) in between. Data for the "fearful" versions are not included because these versions displayed so much variation of tempo that the mean tempo cannot be considered meaningful. In fact, the extreme tempo variation was one of the main characteristics of the "fearful" versions.





Timing

A detailed account of all timing data in all performances would require an article in itself (*cf.* Gabrielsson *et al.*, 1983). Based on our experiences from many earlier performance measurements we concentrate on certain selected features of the performances. The different expressive versions of each melody were compared with regard to the amount of deviation from the nominal values given in the notation, for the piece as a whole and for certain parts, such as measures,

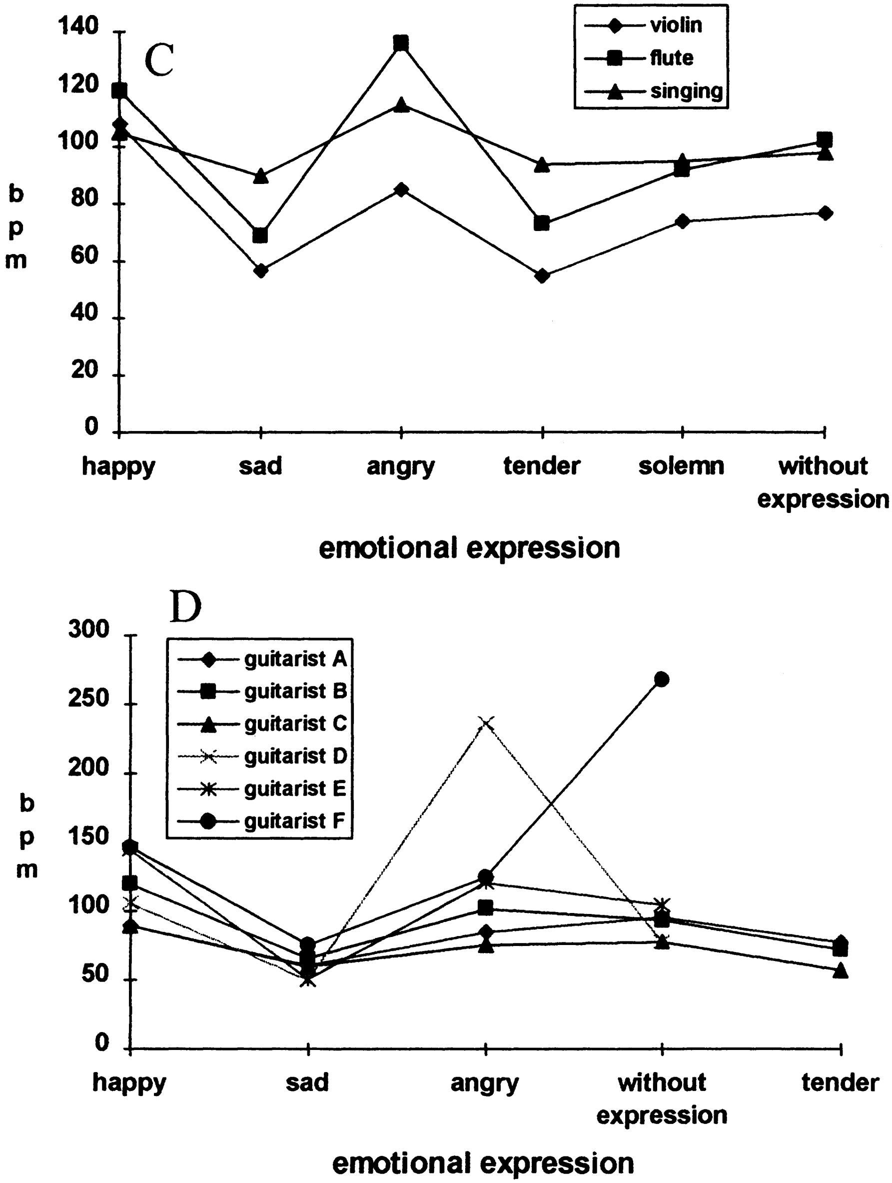


FIG. 2

Mean tempo, beats per minute (bpm; beat = quarter note), for all performances of melodies A–D.

dotted patterns, and the end of the melody. A crude overall measure of the amount of deviation in melodies A and C was obtained by calculating for each performance (*a*) the number of notes whose deviation was less than 10 per cent and (*b*) the number of notes with more than 20 per cent deviation. Analysis of variance showed significant overall differences between expressions in the first-mentioned measure ($F_{5,5} = 9{\cdot}36$, $p = {\cdot}01$); the "no expression" and "solemn" versions had about twice as many deviations less than 10 per cent than the "tender" and "sad" versions. In the second measure, the overall *F* test was nearly significant ($F_{5,5} = 3{\cdot}84$, $p = {\cdot}08$); the "tender" and "sad" versions had 2–3 times as many deviations larger than 20 per cent than the "no expression" and "solemn" versions. Both measures thus indicated that the largest deviations occurred in the "tender" and "sad" versions and the smallest deviations in the "no expression" (*cf.* Kendall and Carterette, 1990) and "solemn" versions. In melody D, the "fearful" version was outstanding with more than half of the notes deviating more than 50 per cent. On the other hand, the "no expression" version had a majority of notes deviating less than 10 per cent.

The deviations at the measure level in melodies A–C, *i.e.* how much the durations of different measures varied among themselves, also showed significant differences among the expressions ($F_{5,5} = 4{\cdot}92$, $p = {\cdot}05$). Again the "no expression" and "solemn" versions had the smallest deviations, the "tender" and "sad" versions the largest. In melody D, the "fearful" version had the by far largest deviations.

The dotted quarter note + eighth note pattern in measures 2, 6, and 7 of melody A was in most cases played with a ratio between 1·8:1 and 2·8:1, that is, considerably lower than the nominal 3:1 ratio. The eighth note in measures 2 and 6 was thus usually played as a prolonged up-beat to the next measure, and the eighth note in measure 7 was relatively prolonged due to the ritardando towards the end of the melody. The largest difference among the expressions appeared between the "no expression" version (2·86:1, relatively close to the nominal 3:1 ratio) and the "sad" version (2·27:1), but the test for overall differences among expressions did not reach significance ($F_{5,10} = 1{\cdot}89$, $p = {\cdot}18$). The same dotted pattern in measures 2, 4, 6, 8 and 10 of melody C was in most cases also performed with ratios below 3:1, except for the "happy" version. There was a significant difference among the expressions ($F_{5,20} = 3{\cdot}20$, $p < {\cdot}03$); the "happy" version was performed with sharper dotting (on average 3·3:1) than the others. Also for the dotted pattern in melody D (measures 1, 5 and 7) there was a strong tendency to differences among the expressions ($F_{5,10} = 2{\cdot}85$, $p = {\cdot}07$). The sharpest dotting was applied in the "no expression" version (mean ratio 2·93:1, close to the nominal ratio) and in the "angry" version (2·64:1). The "fearful" version was again outstanding in that the dotting was completely abolished or even "turned over" in the opposite direction (mean ratio 0·87:1).

The two dotted eighth note + sixteenth note patterns in immediate succession in melody C (measures 3, 5 and 7) were practically always, across performers and expressions, played with the dotting on the third beat of the measure much softer (mean ratio 2·07:1, range 1·3:1 – 2·8:1) than the dotting on the preceding second beat (mean 2·77:1, range 1·9:1 – 4·1:1); the difference was significant ($F_{1,2} = 26{\cdot}89$, $p < {\cdot}04$). The difference among the expressions was also significant ($F_{5,10} = 5{\cdot}30$, $p = {\cdot}01$) but combined with a strong performer by expression interaction ($F_{5,10} = 9{\cdot}34$, $p = {\cdot}001$). The violinist applied the sharpest dottings in the "happy", "angry", and "no expression" versions, whereas the flutist had the sharpest dottings in the "solemn" version. However, both performers made the softest dottings in the "tender" version.

The half-note + quarter-note pattern appearing throughout in melody B is usually performed with a ratio well below the nominal 2:1 ratio (Bengtsson and Gabrielsson, 1980; Gabrielsson *et al.*,1983). When the performers were asked to play this tune with different expressions, however, the ratios varied considerably as seen in Table 3. There were highly significant differences among the expressions ($F_{5,65} = 164{\cdot}57$, $p < {\cdot}00001$) accompanied by an equally strong performer by expression interaction ($F_{5,65} = 96{\cdot}89$, $p < {\cdot}00001$). The violinist used an average ratio of 5·6:1 for the "angry" version and 2·8:1 for the "happy" version. All other versions had ratios below 2:1. The flutist used ratios relatively close to 2:1 in the "no expression", "angry", "happy", and "sad" versions, but lower ratios in the remaining versions.

TABLE 3

Mean and range of half-note:quarter-note ratios in performances of melody B.

	Instrument	
Expression	*Violin*	*Flute*
Natural	1.66	1.76
	1.40–2.14	1.32–2.22
Happy	2.84	1.97
	2.13–4.00	1.32–2.39
Sad	1.81	1.97
	1.24–2.67	1.50–2.23
Angry	5.61	2.09
	3.82–7.82	1.81–2.57
Tender	1.91	1.77
	1.32–2.67	1.19–2.16
Solemn	–	1.87
	–	1.65–2.06
No Expression	1.62	2.00
	1.43–1.77	1.74–2.42

The performance of the "syncopated" eighth note + quarter note + eighth note pattern in measures 1, 3 and 5 in melody D was performed closest to the nominal 25 + 50 + 25 per cent pattern in the "sad" version (26·3 + 49·3 + 24·3 per cent, mean values across the three instances). In the "fearful" version, the pattern was performed differently in all three instances and with practically no similarity to the notated pattern. Disregarding this version, analyses of variance showed significant differences among the remaining five expressions regarding the first tone of the pattern ($F_{4,8} = 9{\cdot}69$, $p = {\cdot}003$), and nearly so for the middle tone ($F_{4,8} = 3{\cdot}52$, $p = {\cdot}06$) and the last tone ($F_{4,8} = 2{\cdot}56$, $p = {\cdot}12$). Considered all together, this meant that the "happy" version showed an increased contrast between the eighth notes and the quarter note in the pattern, (23·3 + 51·7 + 24·9), whereas this contrast was diminished in the "no expression" version (25·7 + 47·8 + 26·3) and partly diminished in the "tender" (28·2 + 47·9 + 23·8) and "angry" (29·1 + 46·9 + 23·8) versions.

Ritardando towards the end of the melody was used in melodies A–C, however usually not in "no expression" versions and "angry" versions. In melody D, however, ritardando was hardly used at all. This may be related to the fact that the performers in Study II belong to the blues/jazz tradition, where ritardando is not quite as commonly used.

Articulation and dynamics

In melodies A–C the violinist played the "happy" and "angry" versions with much "air" between the notes. The remaining versions were mainly performed legato, especially the "solemn" and "no expression" versions; see Figure 3 which shows the violinist's performance of each expressive version of melody A until the first note in measure 3. The "solemn" and "angry" versions were loudest, the "tender" version softest, and the "no expression" version most uniform in loudness. The flutist made the "happy" version even more staccato than the violinist and in contrast to him also used staccato for the "solemn" and "without expression" versions. He varied the loudness considerably less than the violinist, but the relations between the different expressions regarding loudness were the same for both performers.

In melody D, the "happy" and in particular the "fearful" versions were generally played in a staccato manner; see Figure 4, which shows the amplitude envelopes for the first nine notes in the best versions of each emotional expression. Conversely, the "sad", "tender", and "no expression" versions were played more legato or even legatissimo. Furthermore, in contrast to what was found in Study I, the "angry" versions were played fairly legato. It turns out that the guitarists "worked" a lot with each tone during its time course, mainly by applying an intense vibrato or string bending (see next section). As regards sound level, the "angry" versions were clearly the loudest of all versions, followed by the "happy" and "sad" versions. The "no expression" versions were softer and had a very uniform sound level throughout the whole performance. However, softest of all versions were the "fearful" versions with some tones barely making a visible impact on the amplitude envelope.

The shaping of individual notes

Figures 3 and 4 also allow inspection of the amplitude shaping of individual tones in the different expressions. In the violinist's performance (Figure 3), the tone *onsets* were very abrupt in the "solemn" and "angry" versions, rapid in the "happy" version, but slowly increasing in the "sad" and "tender" versions. In a corresponding way the very last tone in the melody was cut off in the "angry" and "solemn" versions but decayed slowly in the "sad" and "tender" versions (not shown in the figure). In the guitar performances, the onsets were fairly rapid throughout due to the use of a plectrum (see Figure 4).

As concerns electric guitar playing, various aspects of *timbre* may be used effectively (disregarding the vast amount of sound processing devices available)

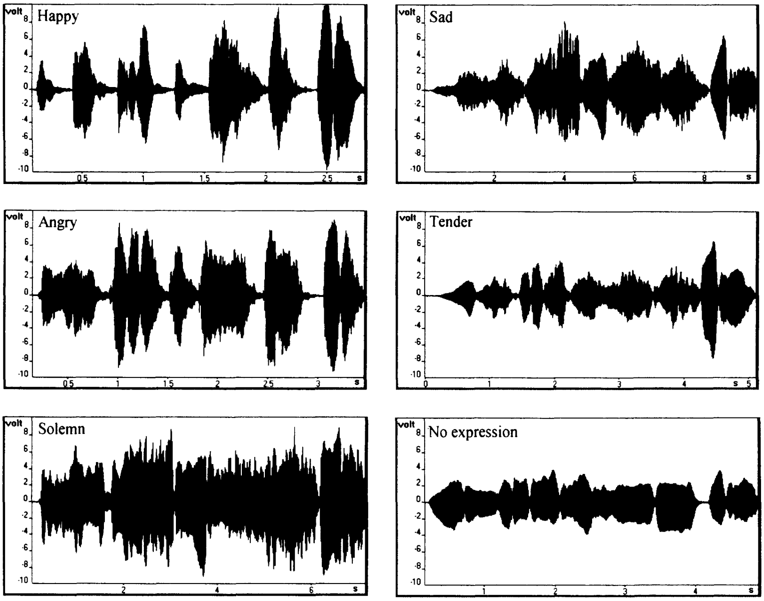


FIG. 3

Amplitude envelopes for different expressions in the violinist's performance of melody A.

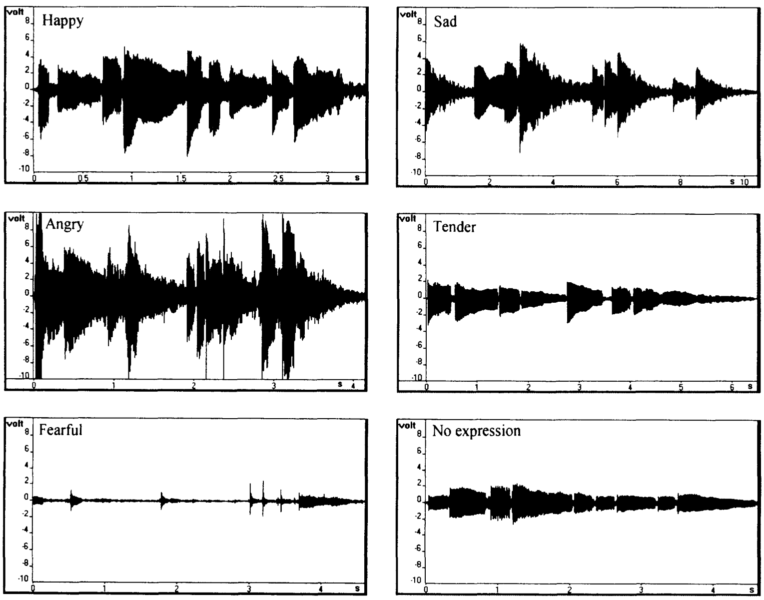


FIG. 4

Amplitude envelopes for the most accurately decoded versions of melody D.

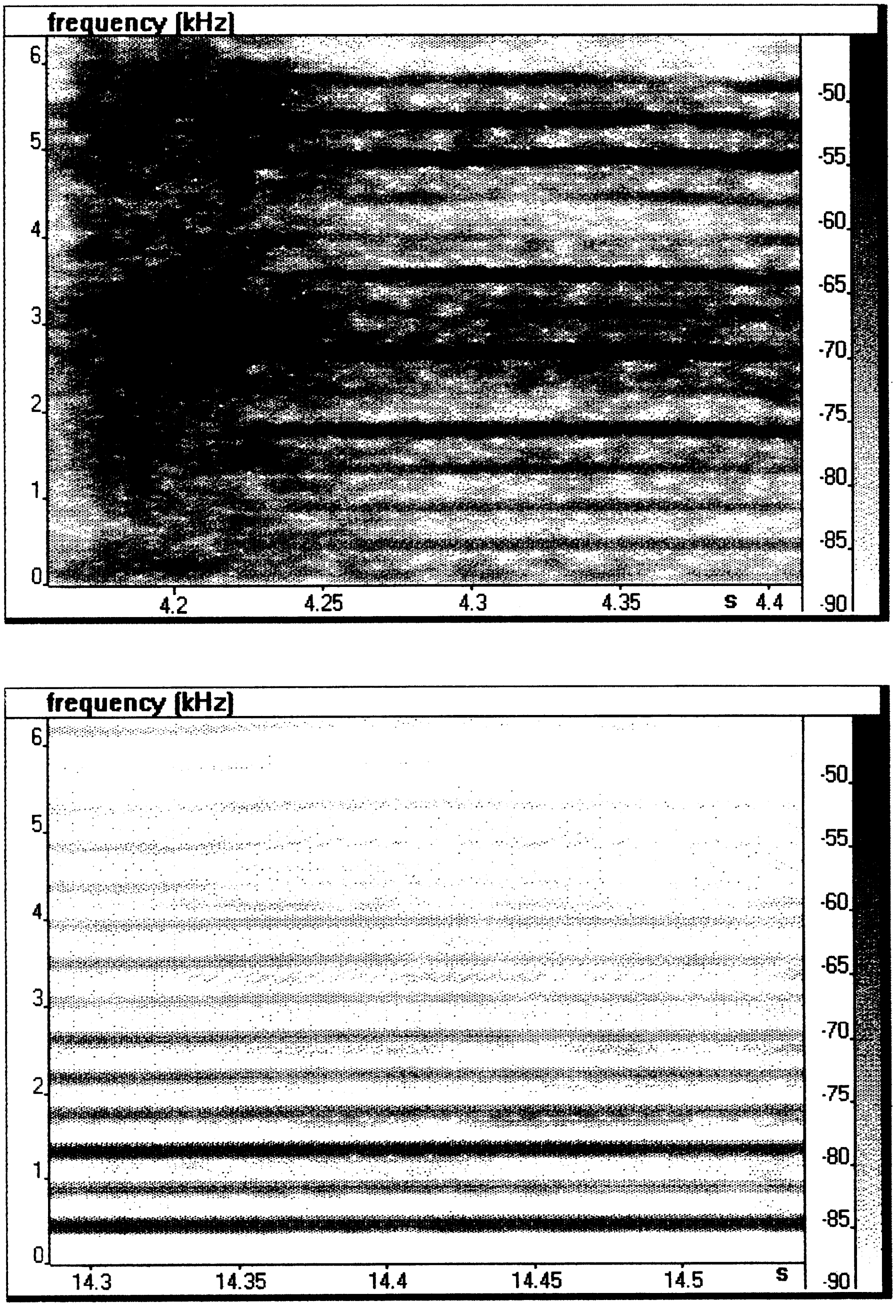


FIG. 5

Frequency spectrum for an "angry" (*upper*) and a "tender" (*lower*) tone in melody D, the electric guitar.

to generate a particular emotional expression. Figure 5 shows the frequency spectrum for a tone from melody D in "angry" and "tender" versions. Time proceeds from left to right, and the vertical dimension represents frequency. The scale on the far right shows relative decibel values for the different degrees of shading in the spectrogram. The inital part of the "angry" tone has an irregular distribution of sound energy, which actually reflects a short burst of noise resulting from hitting the string very hard with the plectrum; after that a regular pattern of partials can be seen, the strongest ones in the middle and upper part of the frequency spectrum. The combination of strong upper partials and the "noisy" attack results in a "sharp" and "rough" timbre (*cf.* von Bismarck, 1974; Gabrielsson and Sjögren, 1979). In contrast, the "tender" tone has no noise in the attack and relatively weak partials, the lower ones stronger than the upper. A "noisy" attack also appeared in the violinist's performance of "angry" versions. It seems likely that differences in timbre may be used by listeners in their attribution about emotional expression, for instance, that "sharpness" and "roughness" indicate "anger". Support for this view was found in some earlier studies using systematically varied and synthesised sound sequences (see Lieberman and Michaels, 1962; Scherer and Oshinsky, 1977).

The timbre is also affected by the use of *vibrato*. Both frequency and intensity vibrato was frequently used by all performers in all versions – except one, namely the "no expression" version (*cf.* Kendall and Carterette, 1990). In Study II, it was observed that the type and extent of the vibrato was different depending on the emotional expression in question. For example, the "sad" versions were played with a deep and slow vibrato, whereas the "fearful" versions were played with a very fast but more shallow vibrato with some irregularity. "Happy" versions, on the other hand, used a fast and very light vibrato.

One technique that was used to great effect in Study II is so-called string bending, which affects the *intonation* of the tone. The guitar player simply bends the string upwards or downwards on the fretboard, which has the result that the pitch of the tone is raised. The pitch change mostly involves a semitone or a whole tone step, but there are also some instances of so-called "blue" notes. Once the intended pitch is reached, the performer may hold this pitch, perhaps applying some vibrato to sustain the tone, or lower the pitch to the intial position. Figure 6 shows an example of string bending in conjunction with frequency vibrato during three tones (A4) in the "angry" version of melody D by performer E. Notice that there is an upward slope for all harmonics in the beginning of each tone. The vibrato is best seen in the highest harmonics of the third tone. Again it can be seen that the lower harmonics are relatively weak and that the strongest partials lie in the middle and upper part of the frequency spectrum. Interestingly, bending was used in the "angry", "sad", and "tender" versions but not in any other expressions. In the "sad" versions, the bending was often intentionally made with a slightly flat intonation, an effect which contributed strongly to the "sad" expression.

Emotional expressions: a summary

The findings presented here partly replicate the results from our earlier studies (Gabrielsson, 1994; 1995; Juslin, 1993; 1995a; Gabrielsson and Lindström, in press) as well as displaying some features not discussed earlier (*e.g.* on intonation, timbre and vibrato). We now summarise the general tendencies – somewhat tentatively – in the form of expression profiles for each emotion. These profiles

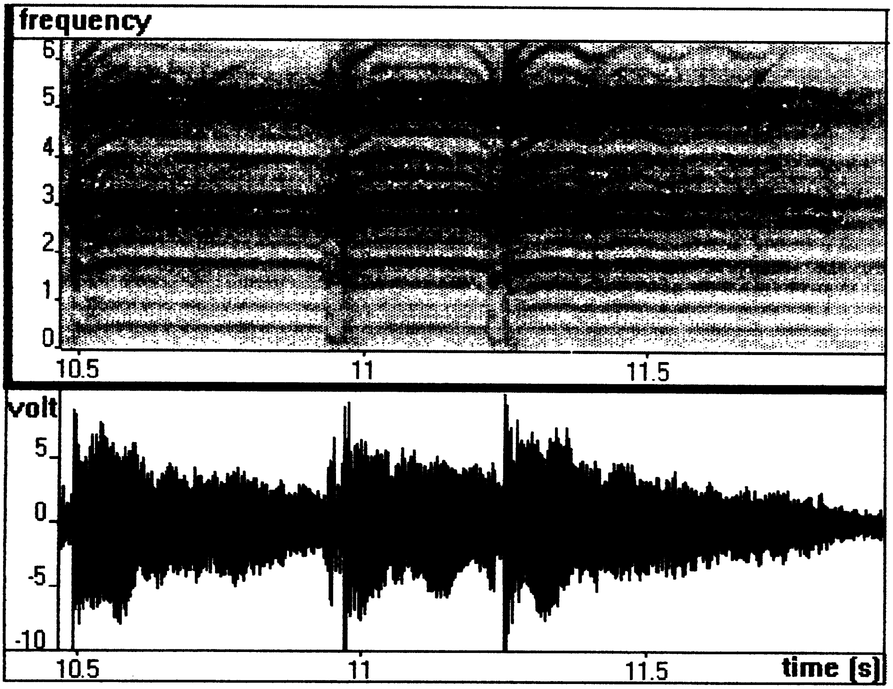


FIG. 6

Frequency spectrum illustrating string bending and vibrato (*upper*) and corresponding amplitude envelopes (*lower*) for three notes in an "angry" version of melody D, electric guitar.

contain a core part that is more or less common for all instruments used here and also some expressive strategies that are typical of the particular instrument employed.

Happiness is expressed by means of fast tempo, moderate variations in timing, moderate to loud sound level, tendency to (relatively) sharpen contrasts between "long" and "short" notes (as in dotted patterns), mostly airy articulation, rapid tone onsets, bright timbre, fast and light vibrato (electric guitar).

Sadness: slow tempo, relatively large deviations in timing, low or moderate sound level, tendency to (relatively) soften contrasts between "long" and "short" notes, legato articulation, slow tone onsets, slow and deep vibrato, flat intonation in bending (electric guitar).

Anger: fast tempo, loud sound level, tendency to (relatively) sharpen contrasts between "long" and "short" tones, no final ritard, mostly non-legato articulation, very sharp tone onsets, harsh timbre, distorted tones.

Fear: highly irregular tempo, very large deviations in timing, low sound level, large dynamic variation, mostly staccato articulation, fast and intense vibrato (fear was used only with the electric guitar).

Tenderness: slow tempo, relatively large deviations in timing, low sound level, tendency to (relatively) soften contrasts between "long" and "short" notes, legato articulation, slow and soft tone onsets, soft timbre, intense vibrato (electric guitar).

Solemnity: moderate to slow tempo, relatively small deviations in timing, moderate or loud sound level, mostly sharp tone onsets.

No expression: moderate tempo, smallest deviations in timing (sometimes all tones equalised in duration), moderate and uniform sound level, no final ritardando, neutral onsets, no vibrato, and "cold" timbre (violin).

Of course, this description is still provisional as it is based upon a relatively small body of data. On-going and future investigations will provide more data and may lead to various modifications of the description. Moreover, differences among performers, instruments, and musical styles make it hard to state general principles.

Discussion

We may now summarise the main conclusions from the present studies: (*a*) the performer's expressive intention had a marked effect on all of the measured parameters in the performance, regardless of the instrument, melody, or performer; (*b*) the performers were generally successful in communicating the emotions to the listeners, although there were individual differences among the performers with respect to encoding accuracy; (*c*) the female listeners showed slightly higher decoding accuracy than the male listeners, although this difference did not reach statistical significance (see also Juslin, 1995a); (*d*) certain emotional characters, such as the basic emotions (*i.e.* "happy", "sad", "angry"), appeared to be somewhat easier to communicate to listeners than other emotional characters, for instance "solemnity". Ironically, the "no expression" character seemed easy to convey as well.

Some further observations should be made. Firstly, a phenomenon occurring in both studies was the tendency for "sadness" and "tenderness" to cluster together in the listeners' adjective ratings. Similar results were found in an earlier study (Juslin, 1993; see also de Vries, 1991). The question arises whether this merely reflects deficiencies in the encoding and/or decoding processes, or whether it also captures something relevant about the underlying emotion dimensions, *i.e.* that "tenderness" and "sadness" are similar to some degree in terms of experiential quality. However, some "tender" and "sad" versions were in fact correctly differentiated by the listeners. These versions were also differently encoded. This seems to imply that the two emotional expressions are in principle separable, but that separation requires a sufficient degree of precision in the encoding process.

Secondly, it seems likely that the various instruments in the present studies differ with respect to their suitability for expressing particular emotions. For instance, it may be difficult to convey "anger" on the flute, or "solemnity" on the electric guitar (*cf.* Behrens and Green, 1993). This points to the importance of studying performances on different instruments, because each instrument presents its own possibilities and limitations regarding expressive means. Earlier investigations have mainly been concerned with keyboard instruments, the piano in particular. This may lead us to overlook important expressive means not available on the piano, such as intonation, vibrato, and timbre. Any emotion may be expressed by means of different physical variables – tempo, dynamics, timing, articulation, intonation, timbre and so forth – in suitable combination. Which variables are used depends on the instrument, and even within a single instrument variables may be substituted for one another, for example, "tenderness" may be achieved by soft loudness, and/or slow onsets and decays, and/or soft timbre, and/or reduced contrasts in timing or dynamics.

Thirdly, there were many differences among the individual performers. For instance, some of them tried to vary the expression while mainly remaining within the limits of the notation, whereas others took advantage of the freedom they had to change everything they wanted except the pitches. Moreover, performers may differ in their technical skill and with respect to what variables they use to achieve a certain expression. We also think that the individual differences may be partly related to personality traits, such as empathy or outgoingness, as well as to differences among different musical genres regarding what amount of freedom in performance that is considered acceptable.

There are a number of critical issues that should be commented on. The task employed in our studies – to play a piece with a number of different emotional expressions – may seem somewhat provoking or unnatural to the performer. The structure of the piece in itself may carry a certain emotional character (*e.g.* "happy"), which presumably makes it more or less difficult to achieve other emotional expressions. However, we deliberately designed the task so as to enforce as large effects on the performance as possible and separate these effects from other variations, such as random variations, technical imperfections, or variations that are made in order to elucidate the musical structure. As mentioned earlier, the musicians showed great interest in the task and provided many comments on the possibilities and principles for achieving the desired expression. In a natural performance situation, the musician may not necessarily have the kind of explicit expressive intentions that were used here (*e.g.* "sad"). Instead, we assume that the performer – when confronted with a musical piece with a certain emotional character – more or less implicitly, and in inter-individually varying ways, employs the expressive principles described here in order to communicate the emotional expression or mood of the musical piece to the listener (Juslin, 1995a).

Only four short, monophonic pieces were used in this investigation. Since the population of music pieces is infinite and since only a very small number can be included in any single investigation, the selection has to be considered in relation to the examples used in our earlier as well as in our on-going studies. We try to use examples from different styles and with a broad range of varying emotional characters, but admittedly the selection partly takes place on an intuitive basis. For comparison we also study how the different expressive intentions affect the performance of rhythm patterns and of "non-melodic" pitch patterns, such as scales or triads. For further comparisons, we are presently preparing investigations on how dancers and actors express various emotions in their performance.

Although listeners find it natural to label musical pieces and performances with respect to emotional expression, it is true that emotion words are often ambiguous and that not all musical pieces are easily described in these terms. On the other hand, it may be impossible to avoid using emotion words, since there is simply no adequate substitute. Clearly, we should be aware of the limitations caused by this problem and try to use the emotion words as consistently as possible. This might be accomplished by adopting a semantic analysis of emotion words based on a theory of emotion (*cf.* Johnson-Laird and Oatley, 1989).

In a way, we may think of the study of music performance as an attempt to account for the characteristic variation found in humans' performances of music. In this view, the "structural expression" approach and the "emotional expression" approach really involve complementary ideas. As Shaffer (1989) notes, ". . . mood and structure are closely related. A player developing an interpretation of the piece needs to find a patterning of expression that works at both levels . . ." (p. 387). Future research should therefore perhaps concentrate on the integration of these two aspects of expression. Another interesting approach may be the application of a modified lens model for the conceptualisation and quantification of music performance (Juslin, 1995b) or the use of various phenomenological methods to describe the more global levels of music performance (Gabrielsson, 1995). Finally, it may be fruitful to study the developmental aspects of recognition of emotional expression in music (for a review, see Gembris, 1995). We might, for instance, investigate whether children are able to decode the expression of basic emotions in musical performances, and whether this ability increases as the children get older.

Lack of sufficient technical equipment for exact measurement has long been considered a limiting factor in reaching a fuller understanding of music performance. However, along with the development of improved facilities for measurement, it has become increasingly clear that the main problem is rather to find ways of interpreting the wealth of performance data in a meaningful way. We argue that to understand the meaning of performance data, they must be considered in relation both to the performer's intention and the listener's experience. Self-evident as this may seem, performance research has merely begun to fully appreciate the implications of this fact.

Acknowledgements

We express our thanks to Guy Madison for much assistance with computer software and to our performers. This research was supported by The Bank of Sweden Tercentenary Foundation.

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