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Abstract

Research in music and emotion has largely focused on responses to tonal music on isolated occasions. This article presents a novel approach to the study of music and emotion that investigates the effects of familiarity on listeners' responses to tonal and atonal music. A mixed-methods longitudinal design was adopted to enable access to the familiarization process. Nineteen student participants (10 musicians; nine non-musicians) embarked on the study. Participants used a range of quantitative and qualitative self-report mechanisms to record their emotional responses to music by Clementi, Schoenberg and Berio over a two-week familiarization period. Results suggested that with increased familiarity, participants showed greater understanding of the musical structure and increased awareness of details in the music, which impacted on the emotional triggers identified by participants. There was evidence for increasing anticipation of emotional events with familiarity. The musical language also showed profound effects: participants found it more difficult to identify the musical structure of the atonal pieces than the tonal pieces; emotional responses to the atonal pieces were lower than those for the tonal piece, and these effects were greatest for non-music students. The implications of these results are discussed.

Keywords

atonal, emotion, familiarity, music, tonal

Introduction

There is a growing body of research on music and emotion, including listeners' emotional responses (see Sloboda & Juslin, 2001). Much of this work, however, concentrates on listeners' responses to tonal music on isolated occasions. This article examines listeners' induced emotional responses to both tonal *and* atonal music, and aims to observe how these responses develop over time as the listener becomes familiar with the music. Though the causes of emotional responses to music may be complex and multi-faceted, ranging from associative features to iconic features or timbral effects (Juslin & Sloboda, 2001), and may depend as much on the way in which the sounds are perceived as the quality and nature of the sounds themselves

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(Lavy, 2001), this article focuses mainly on emotional triggers from within the musical structure. Listeners' perceptions of structural features are likely to change systematically with familiarity; additionally, this focus allows for the attempt to examine differences in participants' responses to tonal and atonal music.

Emotional responses are based upon the music perceived by the listener, and therefore relevant aspects of research in music perception and emotion are considered here, first in relation to the issue of familiarity, and second in terms of musical language (tonal/atonal music).

Familiarity and perception

In order to consider the impact of familiarity on musical perception, it is first important to examine theoretical and empirical evidence concerning the perceptual process. Research in music perception suggests that, as a listener hears music, he or she segments the musical structure according to Gestalt grouping rules and 'sameness' and 'difference' comparison judgements. Musical features such as a variant of a motif, however, are not easily categorized as either 'same' or 'different', and Ockelford (2004) invokes his Zygonic theory of music perception, which allows for similarity relations to be understood. The listener then selects salient features of the group to form 'cues', which Deliège and Mélen (1997) define as 'a kind of conspicuous point that becomes fixed in memory by virtue of its relevance and by repetition' (p. 390). These small, salient features act as memory triggers, allowing the creation of a mental representation (or schema) of the work on several hierarchical levels, without overloading the working memory (cf. Clarke, 2005).

In music listening, a schema may be formed during a first hearing of a piece. After its initial formation, parts of the schema are transferred to the long-term memory, so that when the same piece is heard again, that schema is activated, and any additional information perceived is added. A piece that is similar, but not identical, to the original will either be assimilated into the original schema or used to create a new schema, depending on the extent of the similarity between the two (see Deliège, 2007; Ockelford, 2004).

Research also suggests that familiarity allows the listener to observe new features in the music. Pollard-Gott (1983) asked participants to listen to a real piece of music several times, unguided by any descriptions, analyses, or the score, in order to observe the development of listeners' perceptions. After each hearing of the piece, which occurred within one week, excerpts of the piece were heard in pairs, and listeners were asked to provide similarity ratings. Initial similarity judgements of listeners were based on dynamics, tempo and texture, dimensions that Pollard-Gott (1983) describes as easily accessible and stable. Subsequently, however, thematic features began to have an effect on listeners' similarity judgements. Both musicians and non-musicians changed their focus in this way, though musicians progressed to thematic categorizations more rapidly than non-musicians.

A similar combined effect of familiarity and musical expertise was found in results of procedures testing the cue-abstraction mechanism (Deliège & Mélen, 1997). Although musicians were more efficient at creating schemata, non-musicians showed remarkable improvement with additional familiarity with the piece. Deliège and Mélen state, 'familiarization with the musical structures through repeated listening influences the performance of non-musicians more than musicians: the accuracy of non-musicians' similarity judgements improved linearly with the number of auditions of the segments to be compared' (Deliège & Mélen, 1997, p. 404).

Familiarity, then, appears to increase the detail in the schematic representation of a piece, and enables a deeper focus in the listener on thematic and structural features, rather than

readily-accessible surface features such as dynamics, articulation and tempo. Musical expertise enables musicians to be more efficient at creating perceptual schemata, but non-musicians are able to 'catch up' as they become familiar with a piece of music.

Familiarity and emotion

There is less evidence of research that considers the effects of familiarity on emotional responses to music. Meyer (1956), in his theory of expectation, tackles this issue in four ways. First, there are the limitations of perception: on the first hearing of a piece, a listener creates a map of the structure, but they are largely unable to create expectations about the music. Subsequent hearings allow expectations to develop from the now-familiar structural landmarks or cues, according to cue abstraction theory (Deliège & Mélen, 1997). Second, the limitations of human memory mean that new expectations will generate on every hearing. Third, Meyer suggests that a listener's mood and state of mind will affect how he or she listens to the music and generates expectations, an idea supported by the well-documented contextual effects proposed by others (Lavy, 2001; Scherer & Zentner, 2001). Fourth, when hearing live music, each performance is unique, and therefore expectations will vary.

Empirical studies of the effects of familiarity on both perceived and induced emotional responses to music have also been undertaken. Ritossa and Rickard (2004) investigated the effect of familiarity on liking and emotional responses to music. Though this study reveals some confusion between perceived and induced emotional responses (this common problem is discussed by Gabrielsson, 2002), their findings included a moderate positive correlation between familiarity and the liking of a piece, and suggested that familiarity affected the emotions perceived in the music by listeners. With increasing familiarity, ratings of pleasant emotions heard in the music by listeners increased, and ratings of negative emotions heard in the music decreased: listeners found some pieces less unsettling and disconcerting with familiarity. Other authors investigating the effects of familiarity on perceived emotions have found evidence for the development of anticipatory responses with familiarity (Fredrickson, 1999; Sloboda & Lehmann, 2001).

Iwanaga, Ikeda and Iwaki (1996) studied the effects of short-term repetition on physiological responses and subjective relaxation and tension responses to two pieces of music. With repetition, listeners' heart rates decreased significantly, and subjective relaxation decreased. This suggests that induced emotional responses may change with repeated exposure to pieces of music. These participants heard these pieces five times in quick succession on only one occasion. Though these results are valid for similar situations in real life, they cannot be generalized to normal listening familiarity occurring over a period of days, weeks, or months. To avoid this problem, the study reported here has a longitudinal design to investigate the effects of longer-term exposure on emotional responses to music.

Musical language and perception

Dibben (1996) explores the perception of tonal and atonal music. She highlights the different relationship between the foreground, middleground, and background in reductions of atonal music in comparison with those of tonal music. In tonal music, events at one hierarchical level represent those of a lower level as a consequence of prolongational processes. In atonal music, no such representation exists, because of the lack of prolongational processes in such music.[1] The perception of the tonal hierarchy is highly complex, but Schenker (1979) argued that the fundamental structure he identified in tonal music was merely an abbreviation of a horizontal

arpeggiation of the chord of nature (the harmonic series), and therefore represented all tones (1979/1935, p. 10). It has been argued that Schenker's suggestion is not entirely perceptually accurate (Butler & Brown, 1994); nonetheless, atonal music relies more heavily on repetition than tonal music, and the reductional relationship is considered to be associative, rather than hierarchical (see Straus, 1987). Dibben suggests that the representational reductions used in the perception of tonal music are therefore replaced by associative reductions in response to atonal music. She also suggests an important role for the relative salience of musical features in music perception, and uses the ideas of semiotics to explain other aspects of music perception. Elsewhere, Dibben also highlights the importance of horizontal motion and dissonance (Dibben, 1999).

Few studies of music perception are based on free atonal music; however, studies investigating the perception of serial music may be informative. Krumhansl, Sandell and Sergeant (1987) investigated the extent to which listeners had internalized the principles of serial composition through probe-tone and classification experiments. Their results showed wide-ranging individual differences in listeners, but a sub-group with, on average, more academic musical training and greater experience of atonal music performed more successfully on the tasks. Specifically, they were able to identify modified versions of the tone row, and appropriate subsequent pitches in the probe-tone task. There was some question, however, as to whether these listeners had successfully internalized the tone rows and serial principles, or whether they were relating the pitches to tonal hierarchies, before rating probe tones in accordance with serial, rather than tonal, principles. This might suggest that, when listening to free atonal music, listeners may relate the pitches they hear to tonal implications, even while maintaining their awareness of other important features, such as salience and repetition. Though the mechanisms by which we perceive tonal and atonal music are the same, there may be differences in our perceptual responses.

Musical language and emotion

Emotional responses to atonal music are not explored extensively by music psychologists: the majority use repertoire of the Classical and Romantic periods, and specific triggers for emotional responses to tonal music have been found (Sloboda, 1991). Kallinen (2005) asked participants to nominate musical works that expressed specific emotions, and found that a higher proportion of tonal works were selected than non-tonal works.[2] Two reasons were suggested for this: first, that non-tonal music portrays emotions in a different manner to tonal music; and second, that tonal music is more commonly performed than non-tonal music, and therefore more likely to be nominated in a survey. These interesting findings prompted a study of induced emotional responses to both tonal and atonal music using a method that allowed access to the triggers of such responses in greater detail than hitherto provided.

Aim and research questions

The aim of this study was to investigate the effects of familiarity on perceptual and emotional responses to tonal and atonal music. As this study was largely exploratory in nature, two research questions were devised:

1. How do listeners' perceptual and emotional responses to music change with familiarity?

In line with existing theory and research discussed earlier, listeners' perceptual responses are expected to develop with familiarity, and show a greater awareness of deeper aspects of the musical structure. Musicians may be more efficient in this development than non-musicians. It was hypothesized that listeners' emotional responses would change significantly with familiarity, reflecting the changes in perception suggested above, through an increased number of associative responses gained with familiarity, and in the creation of anticipatory responses to musical structures known to trigger emotional responses.

2. What are the similarities and differences between listeners' perceptual and emotional responses to tonal and atonal music?

Existing research suggests both similarities and differences in listeners' perceptual responses to tonal and atonal music; few studies of emotional responses to music use atonal music.

Method

A novel mixed-methods design was used. Three experiments were conducted as part of the study, each of which took place over a two-week period. The experiments commenced approximately three months apart.

Participants

Nineteen participants (mean age = 22.9) with a range of musical experience (see Table 1) were recruited from the University of Hull, using an opportunity sample. The group of 'musicians' (n = 10; three male, seven female; mean age = 20.2) were undergraduate music students; nine other student participants were recruited from other departments (four male, five female; mean age = 25.9). There was some drop-out between the three experiments, as might be expected. To avoid excessive drop-out in the third experiment, a variation of the normal method that exploited the internet enabled three participants to complete the experiment at home.[3] Nineteen participants completed Experiment 1; 17 completed Experiment 2; and 14 completed Experiment 3.[4]

Materials and apparatus

This study focused on three short pieces of piano music, one of which was tonal and the other two, atonal. The chosen pieces were the second movement of Muzio Clementi's Piano Sonata in F-sharp minor, Op. 25 No. 5; the first of Arnold Schoenberg's Three Piano Pieces, Op. 11; and Luciano Berio's *Rounds* for Piano Solo. All three pieces were unfamiliar to the participants. A single recording of each work was used (see Table 2). The Clementi was chosen for its tonal language, its clear structure, and its conventional harmonic, melodic and rhythmic features. This piece was used as a tonal baseline with which to compare participants' responses to atonal music. The Schoenberg is one of the composer's first free atonal works, but maintains relatively conventional features of form, melody, rhythm and texture. The Berio is less conventional: though it has a ternary form structure, the piece is atonal (although one note, c^1-sharp, may be considered to be a pitch centre in the work), and has very complex rhythmic and textural features, as well as frequent silent pauses.

Table 1. Musical experience of 'musicians' and 'non-musicians'

Participant	Subject of study	Music tuition	Academic music qualifications	Musical performance qualifications	Experiment participation		
					1	2	3
A	Music	4	2	4	Y	Y	Y
B	Music	4	2	4	Y	Y	Y
C	Music	4	2	4	Y	Y	Y
D	Music	4	2	4	Y	Y	N
E	Music	4	2	4	Y	Y	Y*
F	Music	4	2	4	Y	Y	Y
G	Music	4	2	4	Y	Y	Y
H	Music	4	2	4	Y	Y	Y
I	Music	4	2	4	Y	Y	N
J	Music	4	2	4	Y	Y	Y
K	English	3	0	3	Y	Y	Y
L	English	3	0	1	Y	N	N
M	English	2	1	1	Y	N	N
N	Social Sciences	4	0	0	Y	Y	Y*
O	English	3	0	0	Y	Y	Y
P	Psychology	1	0	1	Y	Y	Y
Q	Psychology	2	0	0	Y	Y	Y*
R	English	1	0	0	Y	Y	N
S	Psychology	0	0	0	Y	Y	Y
Total					19	17	14

Notes: Music tuition: 0 = none; 1 = class tuition in school up to the age of 14; 2 = 0–2 years of instrumental tuition; 3 = 2–4 years of instrumental tuition; 4 = 5 or more years of instrumental tuition.
Academic music qualifications: 0 = none; 1 = GCSE music; 2 = 'A' Level music or equivalent.
Musical performance qualifications or equivalent standard on any instrument: 0 = none; 1 = grades 1 or 2; 2 = grades 3 or 4; 3 = grades 5 or 6; 4 = grades 7 or 8.
Experiment Participation: Y = yes, experiment completed; Y* = yes, experiment completed using the online distance method; N = no, participant did not complete experiment.

Table 2. Recordings used in the study

Experiment	Composer (b.–d.)	Piece	Performer	Recording	Duration (mins: secs)
1	Muzio Clementi (1752–1832)	Sonata in F Sharp Minor, Op. 25 No. 5 (Mvmt II: Lento e patetico)	Balázs Szokolay	Naxos 8.550452	3:15
2	Arnold Schoenberg (1874–1951)	Three Piano Pieces, Op. 11 (Mvmt I: Mässig)	Maurizio Pollini	Deutsche Grammophon 423 249-2	3:53
3	Luciano Berio (1925–2003)	*Rounds* for Piano Solo	David Arden	New Albion Records NA089CD	4:34

Each participant was provided with a recording of the relevant piece for the experiment to listen to at home on a daily basis, whilst recording any thoughts, perceptions, feelings, or emotional responses they experienced whilst listening to the music. The same pieces of music were

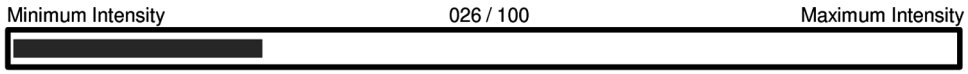


Figure 1. The visual feedback mechanism seen by participants as they were responding to each piece

attached to a custom-designed computer programme (Nte, 2005) that measured participants' self-reported emotional intensity continuously during the piece.[5] Participants heard the recording through high-quality headphones (AKG K141) whilst using cursor keys and a visual feedback mechanism to indicate their level of emotional intensity. This visual feedback mechanism was simply a bar, on a scale of 0–100, that moved according to the participants' control of the cursor keys (see Figure 1; a similar mechanism had been used effectively in a previous study [Daynes, 2004]). The programme recorded the intensity of induced emotional responses every 0.5 seconds, and these data were subsequently converted into line graphs. A one-dimensional measure of emotional intensity, as opposed to a two-dimensional measure, was chosen for a number of reasons. First, the experimental design was demanding for participants, and it was felt that the additional time needed to train participants in the two-dimensional model may have compromised the retention rate of the study. Second, though a continuous response trace of the valence dimension could yield interesting data, a one-dimensional model has been used successfully in previous studies (Daynes, 2004; Fredrickson, 1999), and explored in terms of data analysis (Schubert, 2002). Finally, the qualitative measures employed in this study did allow some, albeit more limited, access to issues concerning valence.

The line graphs generated by the 'intensity' programme were used during the experimental procedure to prompt participants to explain reasons for their reported responses in a semi-structured interview. The three participants who used the online distance method in the third experiment were provided with the necessary software to complete the same procedure at home. This method was adopted to avoid participant drop-out caused by changes in participants' geographical location.

Procedure

Participants attended three response sessions (labelled A, B and C) with the researcher over a two-week period; between these sessions, they were asked to listen to the piece daily (see Table 3).

Within each of the response sessions (A, B and C), the participants' first task was to record their current mood using The Affect Grid (Russell, Weiss, & Mendelssohn, 1989). Participants then completed practice trials with the intensity software before being exposed to the test piece for the first time. To avoid problems such as boredom, and others associated with the immediate repetition of a piece of music, participants answered a brief questionnaire between the first and second hearings of the piece. The test piece was then heard for a second time, and the computer programme response mechanism used.

The participants were then interviewed. The two continuous response traces were converted into line graphs, and participants were asked to identify the triggers of their responses. A typical question was 'What made you increase your intensity at that point?', and the researcher avoided mentioning specific musical features until participants did so. Access to the recording was provided (similar methods are used by Waterman, 1996). For the three participants who used the online distance method, the procedure was identical, except that the communication in the interviews was typed using a real-time online chat programme. These participants were at home during these sessions, alone in a quiet room. They were familiar with the computer programme,

Table 3. An outline of the data-gathering process

2 Weeks				
Day 1 (Session A)	Days 2–7	Day 8 (Session B)	Days 9–14	Day 15 (Session C)
Mood measure (control) Computer programme records continuous emotional responses to music (× 2) Measures of familiarity and liking for the piece Interview based on continuous responses	Participant listens to the piece at home in their own time, once per day, completing a listening diary as they do so.	Mood measure (control) Computer programme records continuous emotional responses to music (× 2) Measures of familiarity and liking for the piece Interview based on continuous responses	Participant listens to the piece at home in their own time, once per day, completing a listening diary as they do so.	Mood measure (control) Computer programme records continuous emotional responses to music (× 2) Measures of familiarity and liking for the piece Interview based on continuous responses

as they had used it with the experimenter, and the experimenter was available online at the time. At the end of this process, the participant was provided with the compact disc (CD) and the week's listening diary, and was asked to listen to the piece each day[6] whilst completing a diary entry.[7] No access to a score of the piece was given. This ensured that all participants would be using aural, not visual, cues when completing their diary entries, and maintained the ecological validity of the study through the relatively realistic listening situation. The diaries were deliberately unstructured, and asked participants to record any thoughts they had whilst listening to the music. The diaries were collected in sessions B and C. The entire two-week procedure was undertaken first with the Clementi, then replicated approximately three months later with the Schoenberg, and again a further three months later with the Berio,[8] with as many of the existing participants as possible. Fourteen participants completed all three experiments.

Results

The majority of the results considered here relate to the continuous response data for each piece; interview responses will also be briefly considered. The continuous response traces were considered in both their original form and as first-order difference figures. The latter approach reduces the risk of serial correlation of the data; that is, that all the data will be very similar simply because of the potential cumulative effects of time on the response mechanism. By calculating the difference in intensity levels between each time point, the change in intensity levels will be observed, as opposed to the actual levels of intensity. This technique is advocated by Schubert (2002) when calculating correlations of such data. This process will also have an effect of 'normalizing' the data by reducing its variance, and thereby providing more meaningful

mean values, and also making it more amenable to inferential statistical tests such as analysis of variances (ANOVAs).

The six continuous response traces produced by each participant in response to each piece were converted to first-order difference figures and subjected to Pearson correlation tests. These produced a set of 747 positive correlation coefficients that were all significant at the 0.05 level, and ranged from 0.088 to 0.41, and three negative correlations, also significant at the 0.05 level, of −0.104, −0.103 and −0.102 (two of which were from the same participant, and both of which were in response to the Schoenberg). None of the data were deemed to be excessive outliers, and none were excluded from subsequent analyses.

Identifying triggers of emotional responses

The traces were examined visually in conjunction with the musical stimuli and participants' comments within the interviews to identify triggers of emotional responses. Figure 2 shows the mean data for each piece, averaged over all participants and over all trials and sessions, in two forms: first, the original traces (i.e. levels of emotional intensity), with the standard deviation of these figures; and second, the first-order difference traces for each piece.

An initial visual inspection of all three of the traces of levels of emotional intensity revealed a gradual upward trend in emotional intensity throughout the piece. This might suggest some cumulative effect of listening to triggers of increases in emotional intensity (though it might also reflect an idiosyncratic effect of the response mechanism). Triggers for increases and decreases in emotional responses were identified from the score and from the interview data, which were coded systematically for their content using NVivo software. Considerable effort was made not to impose categories of response on the data, but to code at a low level initially, and group these codes into other categories. As participants were asked to identify triggers for their emotional responses in their interviews, considerable information was available from these data.

Triggers of increases in emotional intensity. Each of the response traces shows a large increase in emotional intensity at the start of the piece. Some participants reported this as being due purely to the start of the music; others mentioned specific triggers for their responses to the beginning of each piece.

In response to the Clementi, participant H, a music student, discussed expressive (dynamic) features used by the pianist; participant P, a non-music student, described a wider range of musical features that contributed to his response:

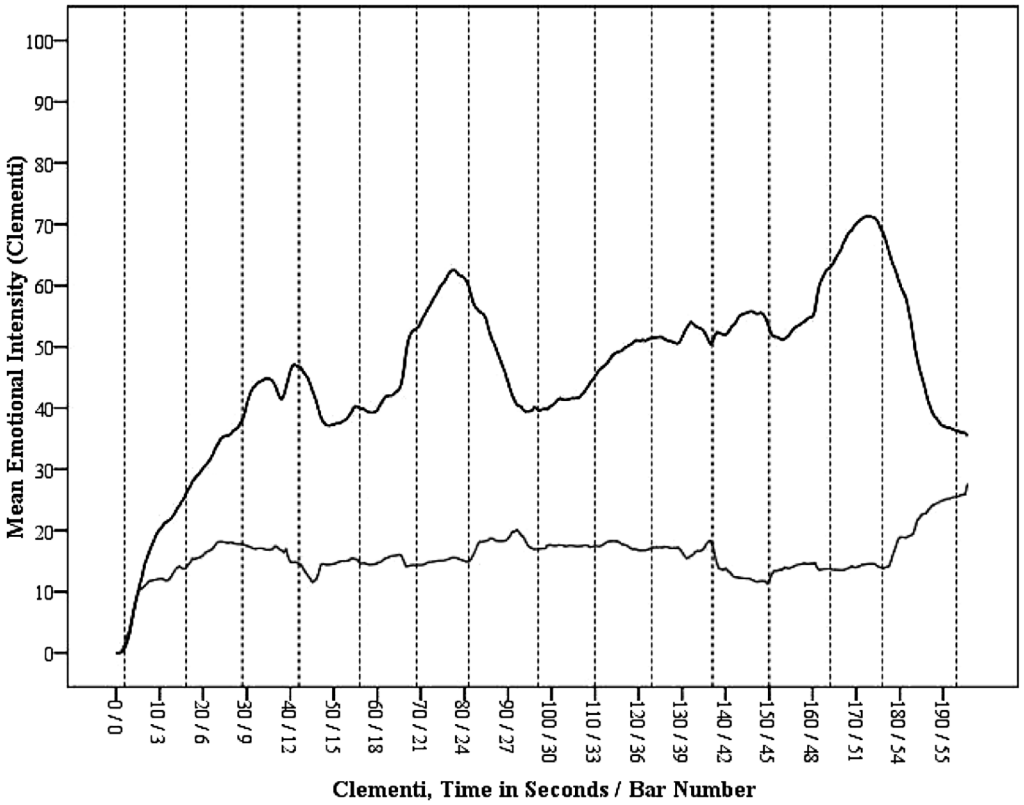
> I think it might have been to do with the [sings melody bars 1^4–2^2 with clear emphasis on bar 2^1] that bit. I think that was my . . . cue for jumping up the scale. (Participant H)

> I quite like those . . . chords and that kind of tempo. It was very . . . rhythmic and . . . in a pleasant key. I'm not too sure on the terminology, but I quite liked that, kinda [sic], tune and tempo, it was a nice combination. (Participant P)

At the start of the Schoenberg, participants discussed changes in movement and also increasing dynamics in the music as triggers for their emotional responses:

> [T]he bass [bar 4] it just gets, it builds up a little bit. And it starts moving more than the small bits that it had done before. (Participant A)

a) Responses to Clementi



Participants' mean levels are shown in black; the standard deviation is shown in grey.

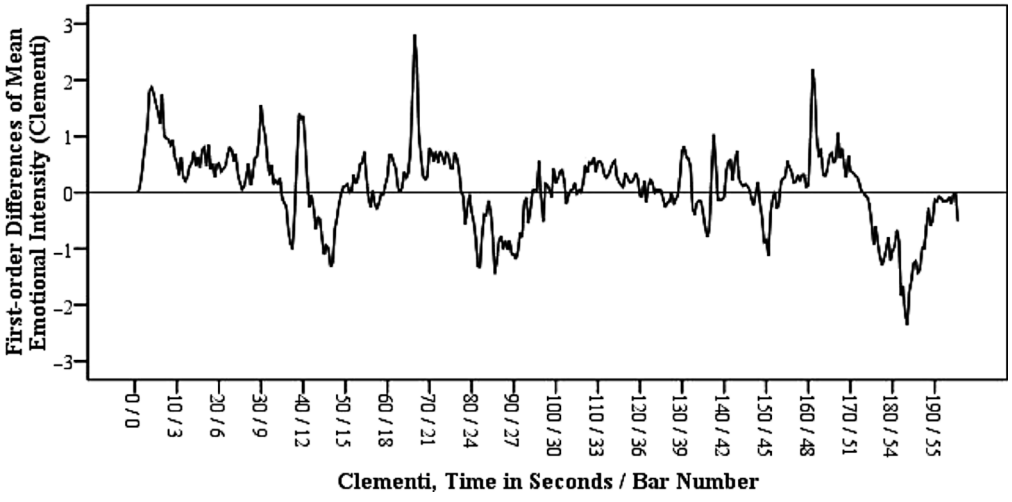


Figure 2. *(Continued)*

b) Responses to Schoenberg

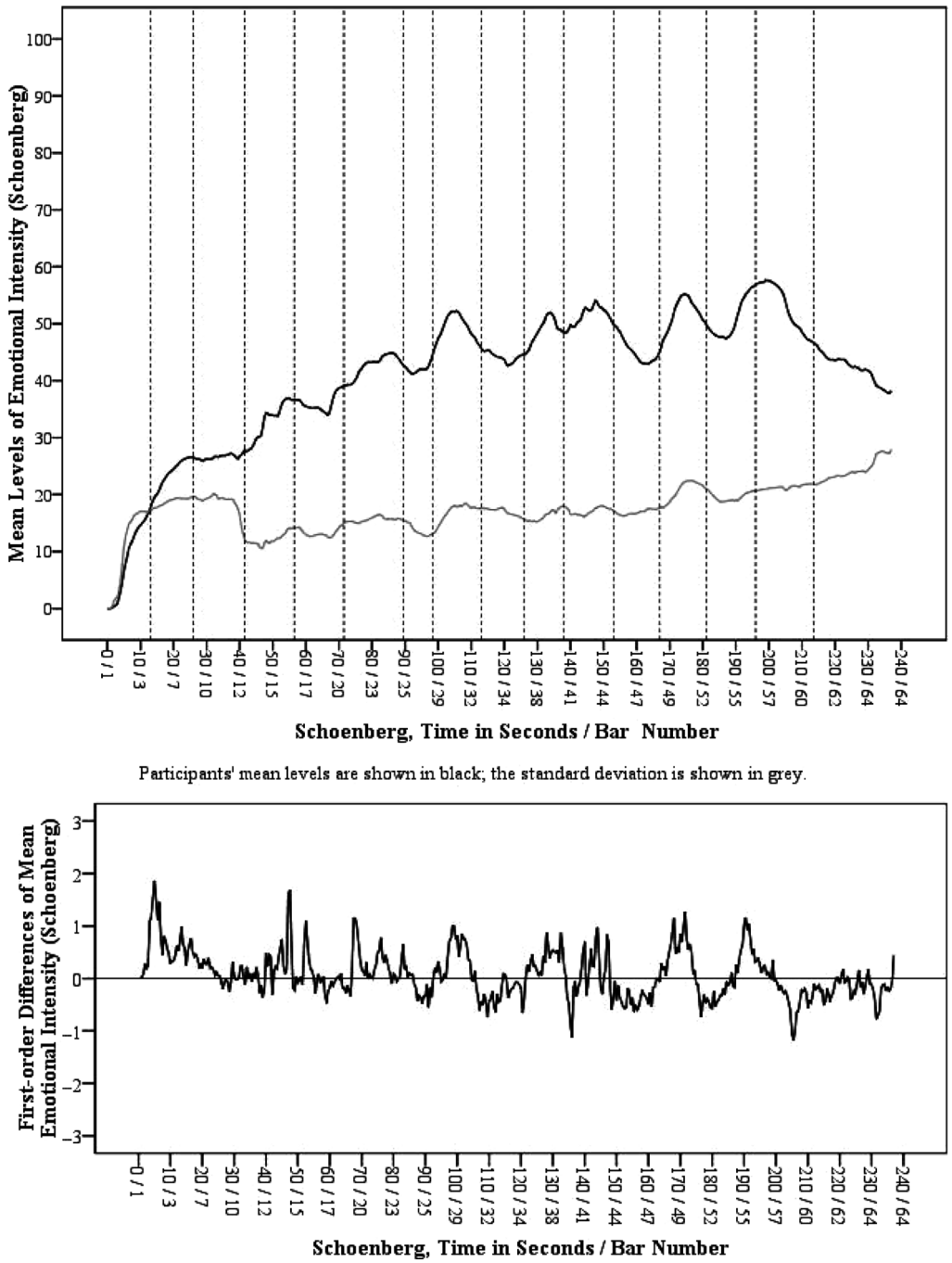


Figure 2. *(Continued)*

c) Responses to Berio

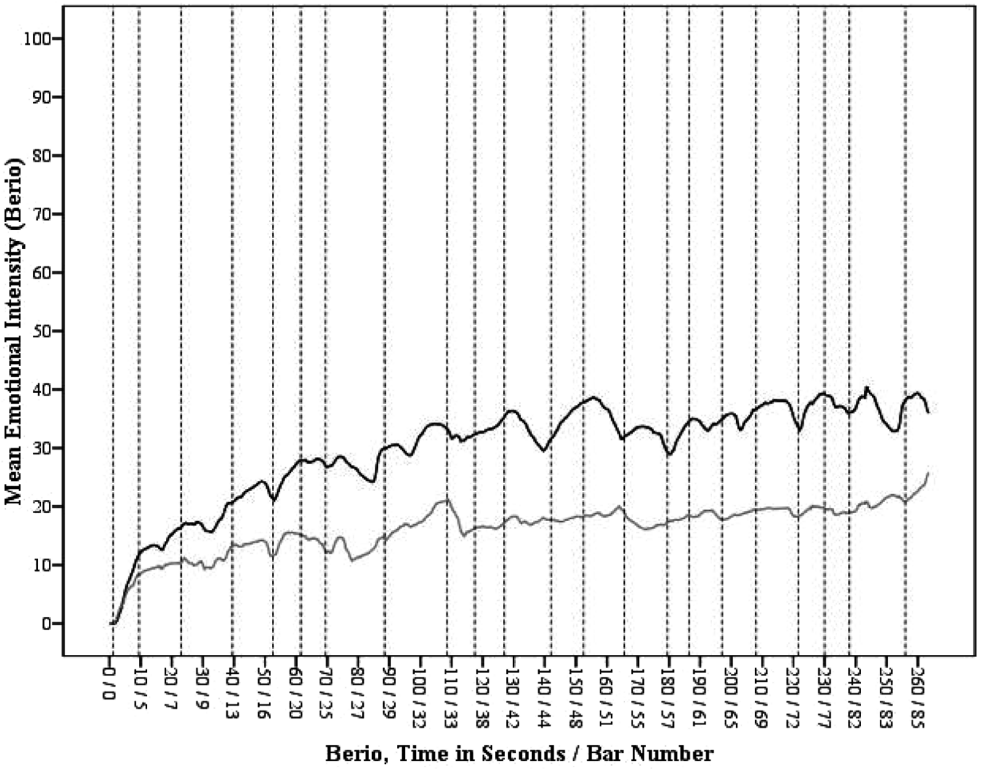


Figure 2. Mean levels, standard deviations, and changes of emotional intensity, averaged over all participants, sessions and trials, in response to the three pieces[9]

> [I]t goes into more of a crescendo here [bars 4–6] . . . the intensity . . . increases, so the graph's going up, but then . . . it keeps . . . increasing and then . . . dying down, like this part [bar 8]. (Participant K)

An increase in dynamic was also suggested by a number of participants as a trigger of their increase at the start of the Berio; others mentioned the articulation:

> [T]here's a feeling of crescendo. . . . See, this bit was quite interesting, because it was bouncy, and. . . coming out of nothing. (Participant C)

> It was like some . . . sort of swell in it, in the music. (Participant G)

In the Clementi, the two largest peaks had similar patterns of increases, and were in response to bars 18–23 and bars 46–51 (see Figure 3 and Figure 4). It is noteworthy that the standard deviation in these areas remained relatively low and constant, suggesting that participants were consistent in increasing at these points (see Figure 2a). Bars 18–19 form a sequential passage, with considerable dynamic and registral contrasts. Although there were increases in emotional intensity throughout this short passage, bar 20 appears to have triggered the most rapid rise in emotional intensity. Here, there are dominant 7th and diminished 7th block chords with a syncopated rhythm, to be played *fortissimo*. In bars 21–23, demisemiquavers are introduced in the right hand. Bars 46–51 form a recapitulation of bars 18–23, and therefore the pattern of similar increases is unsurprising, despite small differences in musical content. In response to these two passages, participants commented on dynamic increases, rhythmic features such as notes of shorter duration and syncopation, melodic features such as rising pitch or imitation, and also the chromatic movement in the bass line, as well as combinations of these features:

> [Bars 18–19] [T]here started getting more notes. (Participant Q)

> [Bars 18–23]: As . . . the notes get higher and higher, the intensity goes up. (Participant M)

> [Bars 46–51]: [I]t sounds like it's . . . getting louder and faster, like it's building up to something. (Participant I)

> [Bars 18–23]: I think it was increasing dynamics, but also because it's going up the scale . . . and . . . it just felt much more . . . like it was going somewhere. (Participant D)

> [Bars 18–23]: I think that was when you had the . . . imitation between, I don't know if it was the two hands or definitely the two different registers, and . . . the bass came in and it was all building up a lot more . . . in dynamic, and it was building up in pitch as well. And the bass was just a bit heavier. (Participant C)

> [Bars 46–51]: The bass notes again . . . going up in chromaticism. I was just listening to it again. It's just really good [laughs]. (Participant A)

The recognition of the similarity of the two passages was also evident:

> It was like what happens about 60 and 70 [seconds] . . . There's like a small, like, motif that keeps changing octaves . . . or pitch, whichever it is. And it heard quite high and then quite low, and it keeps

> rising and rising and rising, and again, with the bass you know that it's just moving towards somewhere, there's a crescendo going upwards. (Participant C)

The combination of rising pitch, notes of shorter rhythmic duration, imitation between two registers, and increasing dynamic appear to have triggered these sharp rises in emotional intensity.

Responses to the Schoenberg showed fewer clear peaks in emotional intensity; instead, there were a larger number of slightly smaller increases, at bars 4–5, bars 28–29, bars 37–38, bars 49–51 and bar 57. In bars 37–38 and 57, the standard deviation remained relatively constant. Again, dynamic variation and increased rhythmic activity were mentioned as triggers of increases in emotional intensity:

> [Bars 4–5]: [T]he bass, it just gets, it builds up a little bit. And it starts moving more than the small bits that it had done before. (Participant A)

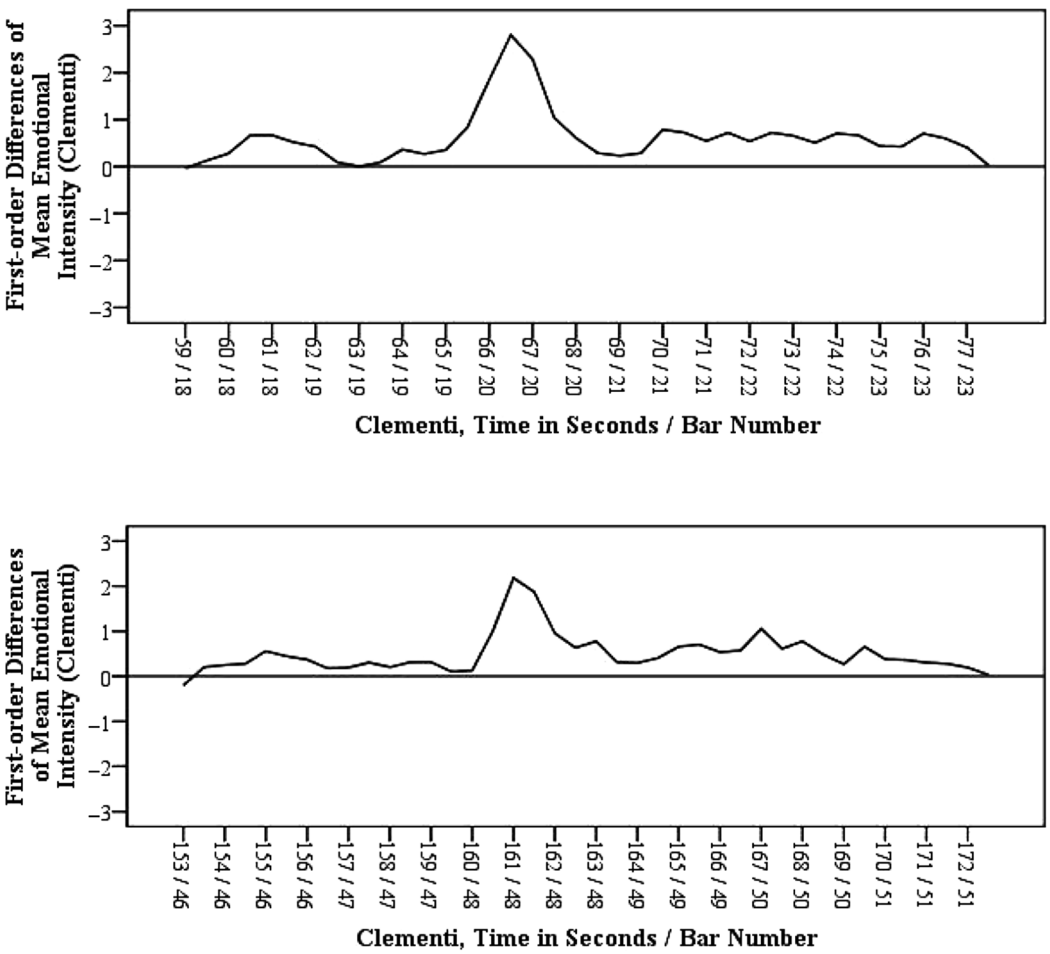
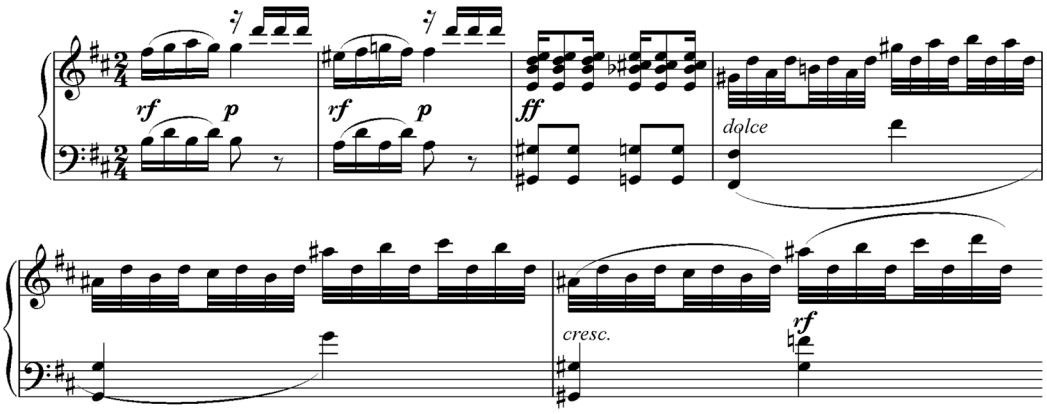


Figure 3. Peak responses to the Clementi

a) Bars 18–23



b) Bars 46–51

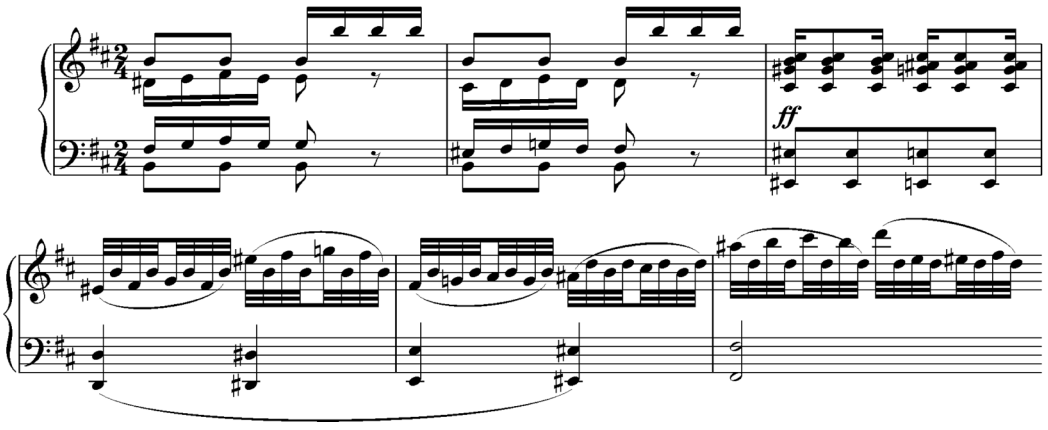


Figure 4. Clementi's Sonata in F-sharp minor, Op. 25, No. 5: II '*Lento e patetico*'

> [Bars 34–38]: It's the patterns . . . the different rhythms . . . and the hands going against each other. (Participant A)

Harmonic features were discussed by other participants, some of whom said that they enjoyed the beginning of the piece because of its relatively conservative harmony. Participants also discussed the more complex harmonies that occurred later in the piece:

> [Bars 4–5]: I do like the beginning though, because it's all relatively nice . . . tonal, you know, proper, real music. Not these funny notes! (Participant D)

> [Bars 49–51]: Yeah. It's like coming back for more, um, the big chords in the bass, and then it's covering quite a big range of the piano, with quite a bit of dissonance, it just makes it a bit more . . . angerful [sic]. (Participant C)

> [Bars 49–51]: The chords underneath. The right hand's doing the . . . little bits on the top, and then the left hand's like building up underneath. So it was the left hand that did it. (Participant E)

As in the Clementi, combinations of musical features prompted increases in emotional intensity. Participant F describes contrasts in dynamic and pitch; participant G discusses the combined effects of dynamics and pitch:

> [Bars 14–19]: You've got these two kind of contrasting ideas: you've got the loudness, and the kind of lower pitch, and then the tinkly kind of pensive high bit that comes out if it. And it, that maintains the tension. Rather than having silence, when you might kind of fade away, having quiet little bits, that pretty at the top of the piano holds it on, and so it's . . . rather than rising and falling, it's progressively rising up. For me personally. It's going towards a kind of greater climax, but at that point it reaches a very interesting point. (Participant F)

> [Bars 28–29]: I think it's because it's loud, for starters. And it's quite high up, and I think I respond more to high notes . . . than the low notes . . . it was faster, to an extent, than it had been before. (Participant G)

The performer's articulation was also noted as a trigger of increases in emotional intensity, particularly at bar 57:

> [Bar 57]: It's a kind of forceful . . . 'I'm gonna play this, and I'm gonna play it now, and I'm gonna make it what I wanna say'. (Participant F)

> [Bar 57]: And also the really kind of like, heavy playing of the keys is really kind of powerful, and I like that. (Participant O)

> [Bar 57]: That's definitely the most intense bar, I think. Because it sounds as if he's slamming the keys down with some force. (Participant R)

A further trigger of increases in emotional intensity was the recognition of repetition in the music, particularly of specific themes in the piece:

> [Bars 34–38]: I think it was the same as before, as that one, it had that same sort of motif to it. (Participant G)

> [Bar 57]: I think that's a return of some sort of big tune that we've heard earlier: there's a sense of familiarity, I think. (Participant A)

Although Participant G noted the repetition in bars 34–38, neither he nor other participants noticed that these bars contain two rising sequences, a feature previously seen to trigger emotional responses in tonal music. Other participants did, however, describe the piece as 'building up' at this point:

> [Bars 34–38]: But this bit's building on itself, so again the same things are coming, and there's lots of things happening. (Participant F)

> [Bars 34–38]: It sounds like it's rushing up to something. (Participant I)

The first of these sequences is an oscillating variation of the original theme of the piece, which is spread over more than five octaves. This sequence reaches its peak at the beginning of bar 38, only to be followed by a miniature sequence on the second and third beats of the bar, which might be heard as a stretto effect (see Figure 5).

In summary, triggers for increases in emotional response to the Schoenberg appeared to be related to increasing dynamics, powerful articulation, rhythmic complexity, harmonic features, pitch-based features, thematic recognition, and repetition and sequential passages.

The Berio appeared to prompt numerous small increases in emotional responses that were often mirrored by increases in the standard deviation, suggesting less consistency in participants' responses. Bars 43–49 and 58–60 show increases in emotional intensity without the

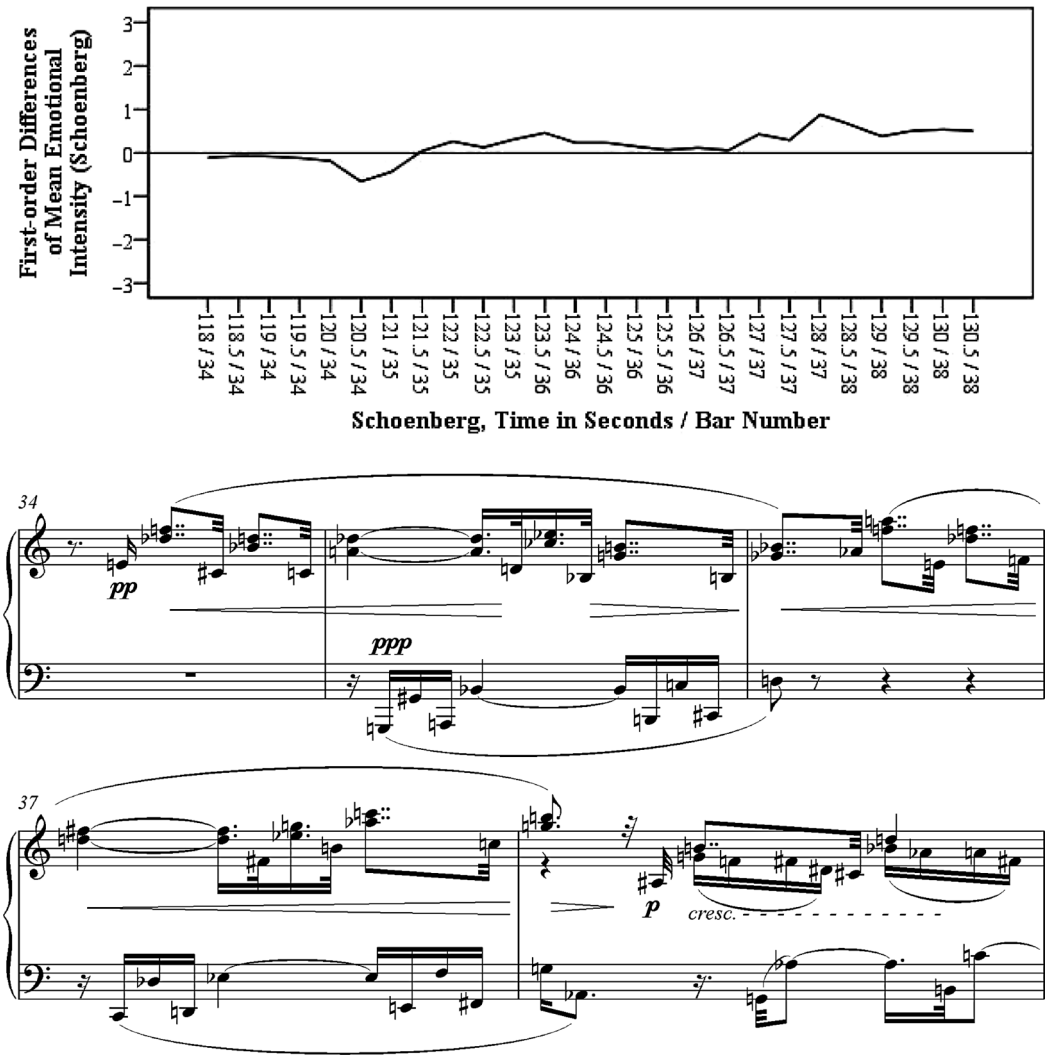


Figure 5. Bars 34–38 of Schoenberg's Three Piano Pieces, Op. 11 No. 1

mirroring of the standard deviation, and are perhaps more meaningful than some other increases; however, other pertinent triggers will be considered here. As in the responses to the Schoenberg and the Clementi, dynamic variation was deemed to be an important trigger of emotional responses:

> [Bars 2–4/58–60]: [T]here's a feeling of crescendo. (Participant C)

> [Bars 2–4/58–60]: It was like some . . . sort of swell in it, in the music. (Participant G)

Rhythmic and textural complexity were also discussed:

> [Bars 17–19/73–76]: [T]he texture's building here. (Participant B)

> [Bars 37–40]: It's sort of swapping between the two hands, in a way, which makes it more interesting. And that trill. (Participant A)

> [Bars 37–40]: I suppose it's the frantic excitement that's going on. There's a gradual build up in kind of activity. (Participant J)

> [Bars 43–49]: There's just so much going on. (Participant F)

Pitch height was frequently discussed as a trigger of emotional response in this piece, sometimes on its own, and sometimes in combination with other musical features:

> [Bars 17–19/73–76]: And it got pretty, and it got higher up the piano, and that's nice. (Participant F)

> [Bars 17–19/73–76]: I think it was going up the piano, and there were more and more notes getting played . . . it was getting higher. So it felt like it was going upwards, and moving on somewhere, instead of just pauses. (Participant G)

> [Bars 43–49]: [T]he shrill note at the beginning. And then it's a bit more jam-packed, but it doesn't actually sound as clumsy. It's like, you've got the deeper notes, and the high pitch, but although parts of it are together . . . at each point, one of them stands out a bit more than the other. And it just doesn't sound as clumsy, it sounds like there's actually something to it, like it's actually building up to something. And then it goes quiet again. (Participant K)

Participants also discussed harmonic features as triggers of their responses, especially in response to two dissonant chords at the end of the 'A' section, which followed a silence:

> [Bar 28/83]: The big chords. (Participant A)

> [Bars 28/83]: [T]he big explosion. (Participant G)

> [Bars 28/83]: It must be the vibration-like sounds that I find intense. (Participant Q)

> [Bars 28/83]: I thought that was quite impressive, you could hear the vibration of the. . . piano, or, I don't know what it was, that sort of echoey sound, I thought that was quite good. (Participant S)

The role of the pianist was also discussed, in the context of dynamics or articulation:

> [Bars 17–19/73–76]: [M]aybe it was just the change of the . . . way it was being played, in a way, it kind of goes from being soft to . . . the change from one thing to another, from one way of playing to another, kind of makes an impact on the listener. (Participant O)

Several participants (three music students and one non-music student) noticed the return of the beginning of the piece in bars 58–60, suggesting their response was due to the return of a familiar theme following a major structural boundary:

> [Bars 58–60]: [I]t's basically a repeat of the beginning bit. (Participant A)

> [Bars 58–60]: That's where the beginning bit comes back, isn't it? (Participant B)

> [Bars 58–60]: This is what I've come to describe as the recapitulation . . . because it's like the beginning. (Participant C)

> [Bars 58–60]: I think that's because that's pretty much a repetition of the very start of the piece, and it seems very familiar, therefore you kind of know what it's doing. (Participant P)

In summary, the increases in the Berio were ascribed to dynamic variation, increased activity or complex rhythmic or textural features, the return of important melodic or structural features, and rising or wide pitch.

Overall, the triggers of increases in emotional intensity were similar for each piece, and included dynamic variation, rhythmic and textural complexity, pitch range and contour, chordal or harmonic features, repeated patterns or sequences, or the recognition of motivic features (see Table 4).

Triggers of decreases in emotional intensity. Triggers of decreases in emotional intensity were less frequent. However, participants frequently discussed these moments in relation to structural boundaries:

> [Clementi]: Oh, it's the cadence point. It just feels like it's releasing everything because it's coming back to where you expect it to be. (Participant B)

> [Schoenberg]: [T]he moment of . . . whatever was happening, has happened, and the sound kind of fades away in the decay of the piano. . . . And then you get . . . something else happening. But at that moment, it's kind of relaxed again, and kind of . . . waiting for the next train to come along. (Participant F)

> [Schoenberg)]: [I]t was just basically, slowing down and coming to an end. (Participant R)

In particular, the Berio contained frequent silent pauses, which prompted the participants to decrease their emotional intensity:

> [Berio]: [A]lways falling for the silences. (Participant C)

> [Berio]: Then there's that pause. (Participant L)

Table 4. Triggers of increases in emotional intensity in response to each piece[10]

Most common triggers	Clementi	Schoenberg	Berio
1 Feature	Dynamic variation	Increasing dynamics/ powerful articulation	Dynamic variation
Example	Bars 18–23	Bar 14	Bars 2–4
2 Feature	Rhythmic complexity	Unexpected chords/ harmony	Wide pitch range or rising pitch
Example	Bar 19	Bars 4–5	Bars 17–19
3 Feature	Pitch contour	Pitch contour	Small rhythmic durations/complex textures
Example	Bars 49–51 (bass)	Bars 28–29	Bars 38–40
4 Feature	Chord/harmony	Repetition/motivic features	Recognition of return of opening
Example	Bars 1–4	Bars 34–38	Bars 58–60
5 Feature	Repeated pattern/ sequences	Rhythmic complexity	Chords/harmony
Example	Bars 5–8	Bars 49–51	Bar 28

Decreasing dynamics were also noted as a trigger of decreases in emotional intensity:

> [Schoenberg]: That bit, where it goes real quiet again. (Participant E)

> [Schoenberg]: See, you can barely hear it. That's why. (Participant Q)

> [Berio]: It goes very low, and very quiet, and very . . . as if it's about to stop, and you . . . I don't know. (Participant G)

> [Berio]: It dies down, and then . . . a little random, sort of bit, and it . . . increases right at the end, and then it just dies down. (Participant K)

> [Berio]: The way that tails off there. (Participant S)

Finally, sparse textures prompted participants to decrease the level of emotional intensity they reported:

> [Schoenberg]: I think it's just because it turns singular, as in there aren't very many notes there. (Participant A)

> [Schoenberg]: [L]ess intensity of dynamic, just, thinner texture. (Participant B)

In summary, triggers of decreases in emotional intensity included structural boundaries, decreasing dynamics, and sparse texture (see Table 5).

As well as being aware of the triggers of their emotional responses, participants were also aware of a number of factors influencing their emotional responses, such as the listening context and the attention they gave to the music. A particularly interesting example was provided

Table 5. Triggers of decreases in emotional intensity in response to each piece[11]

Most common triggers	Clementi	Schoenberg	Berio
1 Feature	Structural boundaries	Decreasing dynamics	Structural boundaries/ silences
Example	Bars 24–28	Bar 59	Bars 55–57
2 Feature	N/A	Structural boundaries	Decreasing dynamics
Example		Bars 31–34	Bars 77–80
3 Feature	N/A	Sparse texture	Sparse texture
Example		Bars 50–51	Bars 77–80

by participant H. This participant had responded very conservatively on the graph, with his trace showing only a few peaks, and the rest of the graph being left at zero. Upon being asked about one of those peaks, he responded:

> [I]t was because . . . that's always quite a mournful bit, isn't it, and suddenly I saw a hearse drive past, and I thought, 'That's quite fitting actually'. (Participant H)

With familiarity, participants were expected to create a greater number of associative emotional responses. An example of such a response was provided by Participant S:

> I just started . . . thinking about the music and . . . just trying to extract the emotion from it, and it reminded me of a film called 'The Pianist', where it was . . . very emotional because he was in Nazi . . . Germany and was a pianist who was persecuted as a Jew, and he was playing the music and it was this sort of music. I don't know what it was, what he was playing but it was very . . . emotional, so it was like . . . a cinemagraphic representation I had . . . in my mind . . . so it just brought back that sort of . . . emotion I think. (Participant S)

Such associative responses generally increased in numbers over the three sessions, with only responses to the Berio showing a slight decrease between the second and third sessions (see Table 6). This suggests that as participants became familiar with the music, they were able to link it with existing knowledge through associative memory processes.

Effects of familiarity and musical language: perceptual responses

Responses provided by participants in the interviews suggested that they noticed an increase in their awareness of surface details and the form of each piece with familiarity. Several

Table 6. Number of times interview content was coded as 'musical association', 'extra-musical association' or 'images'

Session	A	B	C
Experiment 1 (Clementi)	13	32	37
Experiment 2 (Schoenberg)	16	38	47
Experiment 3 (Berio)	10	18	17

participants discussed small-scale features and details of the music that only became apparent after repeated listening:

> [Clementi, session 3]: . . . the inner part . . . where you've got the semiquaver or quaver figures in the middle, and I just noticed it . . . for the first time. (Participant A)

> [Clementi, session 3]: [T]he fluctuations in the bass bit where I've got the little bumps. I think it's the first time I've really . . . noticed them, consciously anyway. (Participant C)

> [Clementi, session 3]: The first few times, it was only the big dramatic changes that caught my attention, but I just started to gradually be . . . noticing all the little changes. (Participant L)

> [Clementi, session 3]: [W]hen you're more familiar with something, you start noticing like, littler things . . . I think there's also the bits where, 'Oh, I didn't realise that that bit came after that bit' . . . it all starts to fit together in your head. (Participant O)

> [Schoenberg, session 3]: There is actually a tune! The first time I heard it . . . I didn't hear the tune coming through, but now I can hear it. And there's fragmented bits throughout the piece; you can just catch a glimpse of it. (Participant A)

> [Schoenberg, session 3]: I'm noticing things that I wouldn't have noticed before . . . the . . . alternating between two different notes, that's the first time I've noticed that. (Participant D)

> [Berio, session 3]: [Y]ou begin to see landmarks in the music, a sort of sustained one note that holds on at the end of different phrases . . . It sounds like a bell or something, to me . . . and the pauses, and then the repeated chords we mentioned before. (Participant H)

Others became aware of repetition in the music and aspects of the formal structure of each piece:

> [Clementi, session 3]: [O]ne thing that I noticed halfway through the second week was . . . that the diminished run that I disliked at first in the middle . . . appears very similarly at the beginning. And it's, it's placed . . . after a different piece of music, after a different theme, and . . . its beginning is veiled, harmonically, whereas halfway through, it's very stark, so there's a stop and then there's this upbeat at this diminished arpeggio. (Participant J)

> [Schoenberg, session 3]: [I]t's been written in blocks, and sometimes a block will crop up again . . . but definitely, there is some repetition of an . . . of . . . not a tonal idea, but like an atonal idea, some pattern, some sequence that's cropped up again. (Participant J)

> [Schoenberg, session 3]: There are a few places where you realize . . . there are some regularities, or there is, you know, in one place it goes: [sings three ascending notes] and then right after that is goes: [sings three ascending notes], so there are some patterns within it that maybe I didn't realize at first, 'cos at first it looked like it was completely without patterns. (Participant N)

> [Schoenberg, session 3]: [I]t sounds like the beginning comes back somewhere, but I don't know if it does. But I didn't kind of notice that at the beginning. (Participant E)

> [Schoenberg, session 3]: I think I recognize the markers of the piece now. Like, when I get to a certain bit, I know . . . where we are in the piece. And . . . I'm more familiar with the little sections, like the bustly bit. (Participant F)

> [Berio, session 3]: I never noticed that it had any sort of structure or form before . . . recently. I was noticing bits coming back, a few days ago. . . . I thought it had absolutely nothing at all when I first listened to it, and then I started recognizing it. (Participant B)

> [Berio, session 3]: Because the first couple of times, the first week or whatever, of listening to it, I didn't realize that there were repeated bits in it. And now I've been listening to it quite a lot, you can tell that there are . . . that it's not all original material, that it's all repeated and stuff. (Participant G)

Music students were more successful in identifying correct structural boundaries than non-music students; all students were more successful in identifying the formal structure of the tonal music than the atonal music. Structure was mentioned more commonly in response to the Clementi (106 times) than the Schoenberg (65 times) or the Berio (33 times). All participants identified the return of the beginning of the first theme of the Clementi, making comments similar to those below:

> Now that's the same as the beginning. (Participant H)

> And then it all starts again. (Participant I)

> [It]t was like just regaining the central theme again . . . of the music. (Participant N)

> [T]here's like a break in the middle and it almost, like repeats itself, but not quite. (Participant O)

In response to the Schoenberg, only seven participants (A, B, E, G, J (musicians); and K and P (non-musicians)) recognized the return of the main theme:

> [T]hat's a return of some sort of big tune that we've heard earlier. (Participant A)

> But it sounds like the beginning comes back somewhere. (Participant E)

Again, in response to the Berio, only seven participants (A, B C, F, G, J (musicians); and P (non-musician)) recognized the return of the beginning of the piece, evidenced by comments such as:

> This is the bit, it's basically a repeat of the beginning bit, in a way. (Participant A)

> This is what I've come to describe as the recapitulation . . . it's like the beginning. (Participant C)

> [T]hat's pretty much a repetition of the very start of the piece. (Participant P)

Several participants seemed to struggle to understand the structure of the Schoenberg or the Berio. Participant H asserted that the Schoenberg must have a structure, but that he couldn't understand it:

> I can't really see the structure; I think that's the problem. I'm a structured person, and this kind of thing is not, to me, it just sounds very much like notes all over the place. . . . I think if I had a score, and I could study it, it would make sense as a piece of music. Because it obviously does have a form and things; I just can't really put my finger on it, 'cos it does sound a bit random. (Participant H)

Participant R suggested that the Schoenberg sounded disjointed:

> This seems more disjointed than the last one, the entire thing. I don't know why. (Participant R)

Participant Q went further, suggesting that the Schoenberg did not have a structure, and that it did not seem like music. Participants K and S described the 'random' nature of the Berio:

> I don't know, bits of it just seem really like . . . there's no kind of continuous . . . I don't know, there's not like a plot, it's really random. (Participant K)

> [J]ust a bit of random music with a few gaps, really. That's what it felt like. (Participant S)

Participant S also described the lack of cohesion in the Berio:

> It's not very cohesive and it doesn't seem to fit together very well, in a conventional sense of music, certainly the sort of music I listen to, I like a beginning, a middle and an end, and it didn't really have that formation. That's probably why I didn't like it. And I didn't particularly like the gaps, and that spoilt the flow a bit. (Participant S)

Overall, participants did seem to have more difficulty identifying the structure of the atonal pieces, and in some cases, this did have a negative effect on their enjoyment of the music.

Effects of familiarity and musical language: emotional responses

The significant correlation coefficients discussed earlier were subjected to a repeated-measures ANOVA, with the within-subjects variable of composer and the between-subjects variable of closeness in time (i.e., the distance in time between the sessions). This revealed a significant effect of composer (F (2, 24) = 26.54, $p < 0.01$), with the Clementi prompting the strongest correlations (and therefore consistency in response) and the Schoenberg and Berio prompting the weaker correlations (and less consistent responses) (see Table 7). Pairwise comparisons with Bonferroni correction[12] revealed significant differences between the Clementi and the Schoenberg ($t = 5.841$, $df = 14$, $p < 0.01$), and between the Clementi and the Berio ($t = 12.775$, $df = 14$, $p < 0.01$), but not between the Schoenberg and the Berio (the two atonal pieces) ($t = 1.378$, $df = 14$, $p > 0.05$).

Table 7. Means and standard deviations of significant correlations between all participants' response traces for Clementi, Schoenberg and Berio

	Degrees of freedom	Mean correlation	Standard deviation
Clementi	388	0.610	0.068
Schoenberg	472	0.674	0.067
Berio	549	0.446	0.055

Table 8. Means and standard deviations of significant correlations between all participants' response traces for closeness in time

	Mean correlation	Standard deviation
Within session	0.546	0.100
Between neighbouring sessions	0.520	0.100
Between distant sessions	0.470	0.079

There was also a significant effect of closeness in time (F (2, 12) = 4.031, $p < 0.05$), with the correlation between traces decreasing, as expected, with the distance in time between the sessions, suggesting that familiarity may have a significant effect on emotional responses (see Table 8). Post-hoc tests using Tukey-Kramer Honestly Significant Difference (HSD) revealed a significant difference in strength of correlations only between data from within a session (A to A; B to B; or C to C) and data from distant sessions (A to C) ($p < 0.05$).

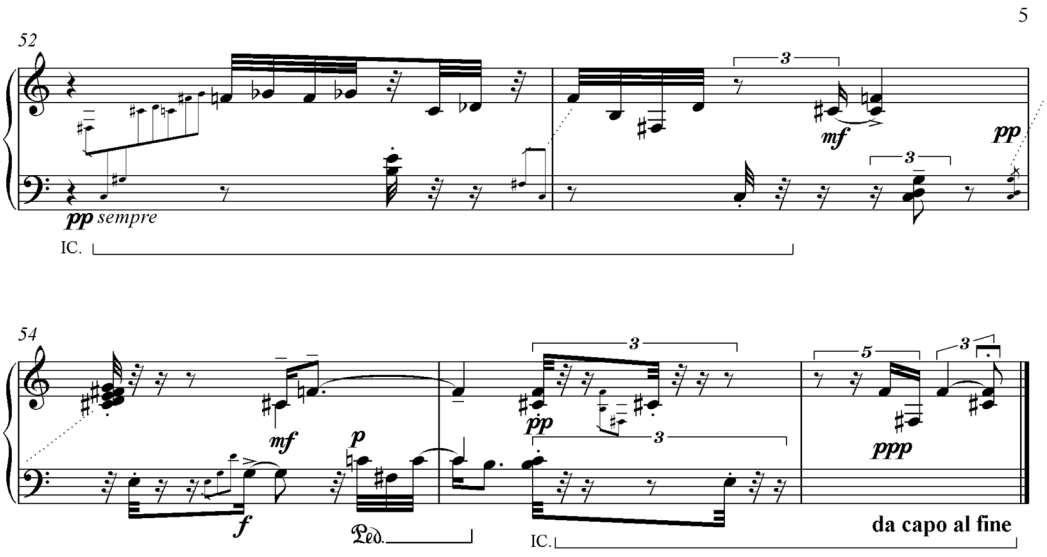
The Berio allowed a brief examination of participants' responses to repeated sections of music through its exact repetition of the opening section of the piece.[13] The distinctive opening of the piece returns after a middle 'B' section of the piece (see Figure 6), which is based on an upside-down version of the music for the 'A' section (this is evident from the similarity of the intervals and opposite contours of the end of the 'B' section and the beginning of the 'A' section, in Figure 6).

Pearson correlation tests revealed that the strength of the correlations between the responses to the opening and final sections of the piece increased over the three sessions, suggesting that the increased awareness of the overall musical structure and repetition revealed in participants' interviews may have affected their emotional responses (see Table 9).

To investigate further differences between responses to each piece and in each session, first-order difference response traces were used to create MCI (mean change in intensity per half-second) figures for each bar.[14] Repeated-measures ANOVAs were conducted on MCI figures for each piece, with within-subjects variables of session (3), trial (2) and bar (56 for the Clementi; 63 for the Schoenberg; and 85 for the Berio) and a between-subjects variable of type of student (2). Apart from the expected effect of 'bar', responses to the Clementi and Berio revealed few significant effects or interactions from these ANOVAs. Responses to the Schoenberg, however, revealed an interaction between session and bar (F (126, 1890) = 1.246, $p < 0.05$). It is difficult to assess whether this interaction is due to random variability or to changes in emotional responses to small areas of the piece with familiarity; however, the lack of an interaction between trial and bar does add a little weight to the latter interpretation. Additionally, an interaction between session and type of student (F (2, 30) = 3.783, $p < 0.05$) suggested that there were differences in the effects of familiarity on emotional responses according to the background of the participant. Whereas the magnitude of music students' responses decreased over the three sessions, that of non-music students rose to a peak in the second session (see Figure 7). The decrease in magnitude of participants' responses might indicate an exposure effect that may reflect some element of boredom resulting from repetition; however, it is important to note that because these are first-order difference figures, if responses are positive, participants are still reporting increases in emotional intensity.

To identify anticipatory responses to the pieces that developed with familiarity, data for each time point were averaged across participants, and across trials, to create a mean response trace

a) The end of the 'B' section



b) The beginning of the 'A' section

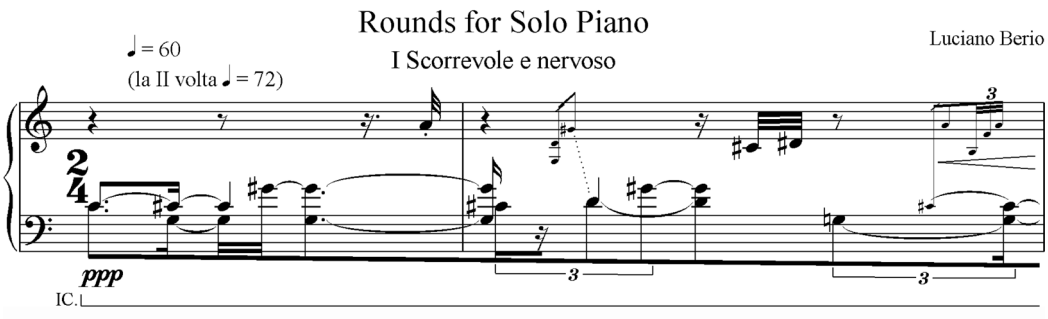


Figure 6. The end of the 'B' section and return of the 'A' section of Berio's *Rounds*

Table 9. Correlations between responses to the A section of the Berio and its return, in each session

Session	*r*	*df*
A	0.546**	27
B	0.578**	27
C	0.804**	27

Note: ** indicates significance at 0.01 level.

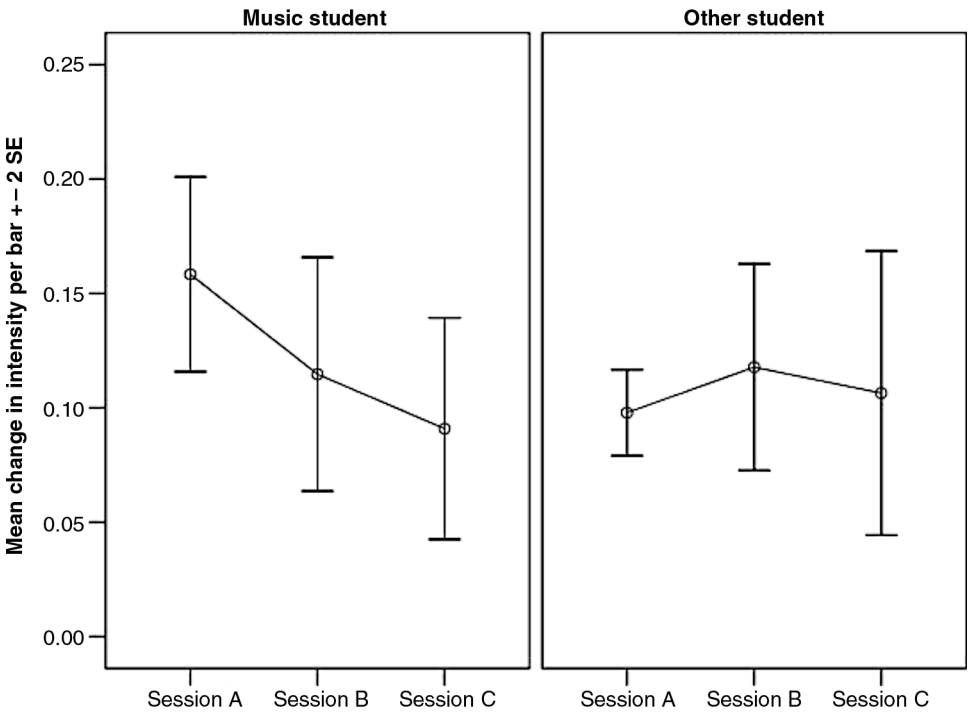


Figure 7. The interaction between session and type of student in response to the Schoenberg

for each piece in each experimental session. This allowed visual inspection of any apparently systematic changes. There was some evidence for anticipatory responses to all three pieces, although these were more obvious and frequent in response to the Clementi than the Schoenberg or Berio. Anticipatory responses were generally found to have been prompted by areas described by participants as emotional triggers. For example, in the Clementi, the area between 27 and 32 seconds (bars 8–10) suggests that participants responded earlier and with a larger increase in the second and third experimental sessions (B and C) than in the first experimental session (A). These bars are marked *forte* and in bar 10, *sforzando*, and are located towards the end of the first section of the piece. There were several similar instances of apparent anticipation of emotional triggers in all three pieces (for more details, see Daynes, 2007). Though visual inspection has been used previously to identify anticipatory responses, a clearer picture might be obtained from a more systematic consideration of these effects.

Overall mean levels of emotional responses to each piece were calculated by averaging the raw data over all of the original time points. This enabled a repeated-measures ANOVA of these data to be conducted[15] with within-subjects variables of composer (3), session (3) and trial (2), and a between-subjects variable of type of student (2), which revealed a highly significant effect of composer (F (2, 11) = 18.78, $p < 0.01$): the Clementi triggered the highest levels of emotional intensity (mean = 49.4, standard deviation = 11.6); the Berio the lowest (mean = 29.9, standard deviation = 13.87); and the Schoenberg in between (mean = 40.1, standard

deviation = 14.3). Pairwise comparisons using the Bonferroni correction revealed significant differences between the Clementi and the Berio ($t = 4.186$, $df = 13$, $p < 0.05$) and between the Schoenberg and the Berio ($t = 3.210$, $df = 13$, $p < 0.05$), but not between the Clementi and the Schoenberg.

There was also a significant interaction between composer and type of student ($F(2, 11) = 5.46$, $p < 0.05$), with non-music students reporting more intense emotional responses to the Clementi than music students, but less intense emotional responses than music students to the Schoenberg and Berio. There was also little overall difference between music students' responses to the three pieces; in contrast, there was a marked difference between non-music students' responses to the three pieces. These effects are shown in Figure 8. Pairwise comparisons revealed no significant differences between the pairs; however, this may be partly due to the necessary stringency of the significance level for pairwise comparisons with this complex design (Howell, 2002). There were no other significant effects or interactions.

In summary, the tonal music prompted more intense responses than the atonal music, and this difference was more pronounced in the responses of non-music students than music students. Familiarity did appear to have some effects on induced emotional responses, particularly in response to the Schoenberg. In response to the Berio, participants' responses to repeated sections of the music appeared to become more consistent as participants became more familiar with the formal structure, as indicated by the increasing strength of the correlations of the response traces to these sections. There was also some evidence for anticipatory responses to

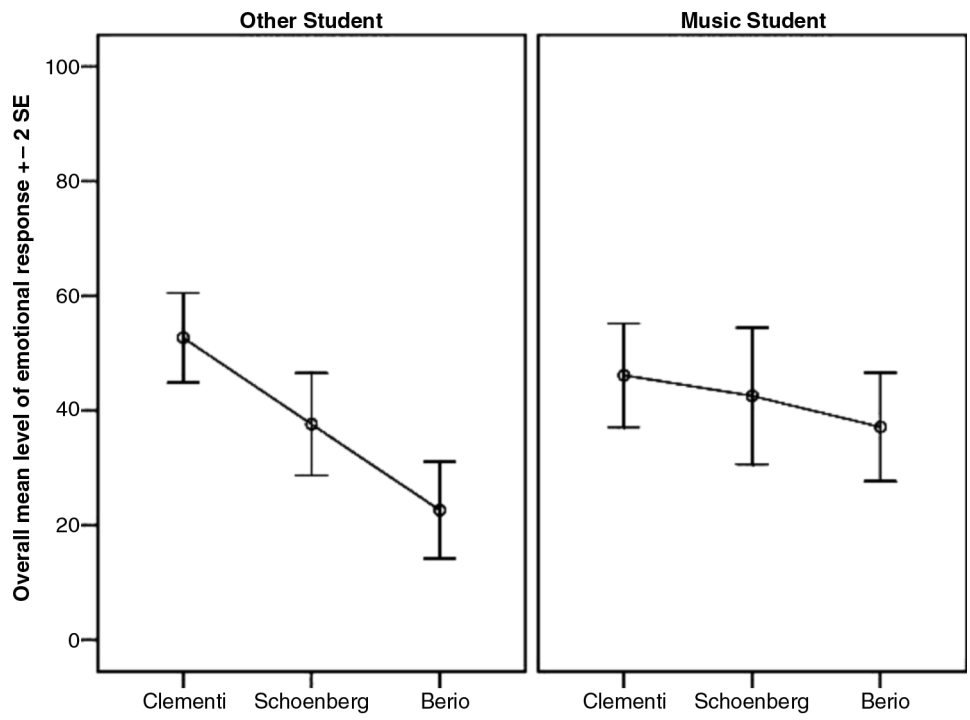


Figure 8. Overall mean levels of emotional intensity: significant interaction between type of student and piece

emotional triggers with familiarity. Other data, including the diary data, are discussed elsewhere (Daynes, 2007; Prior (née Daynes), in press).

Discussion

This study investigated the effects of familiarity on perceptual and emotional responses to tonal and atonal music. The first research question asked how listeners' perceptual and emotional responses to music changed with familiarity. Familiarity appeared to enable participants to identify greater detail in the music and conceptualize the musical structure more successfully. Musical expertise also affected participants' ability to perceive the musical structure, with music students having greater success than non-music students. These findings support those of Pollard-Gott (1983) and Deliège and Mélen (1997). Participants' increasing awareness of musical structure was evident in their emotional responses to the Berio: responses to a repeated section of the piece became more consistent with familiarity. There was also some evidence to suggest that familiarity produced anticipatory responses to emotional triggers, supporting the hypothesis of the study and suggesting that similar findings relating to perceived emotional responses (Fredrickson, 1999; Sloboda & Lehmann, 2001) may be extended to induced emotional responses. Participants' emotional responses were affected by their musical expertise: with familiarity, music students' responses to the Schoenberg decreased, whereas non-music students' responses rose to a peak before decreasing. The lack of an effect of familiarity on the overall intensity level of emotional responses, however, supports the ideas put forward in expectation theories (Cone, 1977; Lavy, 2001; Meyer, 2001; Ockelford, 2006) which suggest that we continue to form expectations concerning the music even though we are familiar with its content. Work by Bharucha (1994) may provide some explanation for this. Bharucha places expectations formed when listening to music into two distinct categories: schematic expectations, which relate to generic patterns found in music of a similar style; and veridical expectations, which relate to the specific piece being heard. He suggests that, whilst familiarity enables us to generate accurate veridical expectations, schematic expectations may be generated simultaneously, and still provoke an 'aesthetic' or emotional response despite the listener's familiarity with the piece in question. This, and the systematic changes found in other aspects of listeners' emotional responses suggest that familiarity should be carefully considered in future research on music and emotion.

The second research question concerned the similarities and differences between listeners' perceptual and emotional responses to tonal and atonal music. The musical language of each piece showed interesting effects. Participants responded with less consistency to the atonal pieces in comparison with the tonal piece, as indicated by the differences in the strength of the correlations between traces. However, participants identified similar triggers for their emotional responses in each piece, including pitch contour, harmonic features, rhythmic features, and repetition of musical features. In the interviews, participants were more successful in identifying the musical structure of the tonal pieces than the atonal pieces, supporting Scruton's (1997) assertion that large-scale form is more difficult to identify in atonal music. There may be several reasons for this. Scruton suggests that the lack of diatonic intervals in atonal and non-tonal music makes that music less memorable (Zielinska & Miklaszewski, 1992), and therefore makes the process of identifying formal structure more difficult than it is in tonal music. Second, though, classical tonal music carries the expectation of a musical form in which the tonal system and its functional harmony is inherently intertwined with the traditional musical structure (Grout & Palisca, 1996; Salzman, 2002). Perle and colleagues (Lansky, Perle, & Hedlam, 2007), for instance, note the 'high degree of interdependence between the

various dimensions of a [tonal] composition, such as pitch, rhythm, dynamics, timbre and form'. Thus the overriding schema for tonal music contains possibilities of formal structures and relevant repetitions, allowing the listener to make a relatively easy classification based on the expectation of a coherent form. The early 20th century not only saw the emancipation of dissonance and the breakdown of tonality in music, but also the increased flexibility in the use of other aspects of music (Grout & Palisca, 1996; Salzman, 2002), and in the relations between musical dimensions (Lansky et al., 2007). This may generate fewer expectations of formal musical structure in listeners, making the identification of such forms more difficult. Even for the inexperienced listener, the absence of one standard feature of the music (tonal or consonant harmony) may make another feature common in all forms of tonal music, such as clear repetition and formal structure, less expected, and therefore less easy to identify. This is an area deserving of further attention from empirical research.

The fact that participants commented on repetition in the Berio and the Schoenberg suggests that participants found the repeated features salient, either because of their repetition (and hence small-scale familiarity) or because of specific musical features within the repeated sections. Though further study is necessary, these findings tentatively support Dibben's (1996) finding that salience plays an important role in the perception of atonal music.

The apparently less obvious and frequent anticipatory emotional responses to the atonal pieces, in comparison with the tonal piece, may reflect the difficulties participants had in identifying the musical structure. If listeners are unable to predict the next event in a piece of music, they are unlikely to respond to that event in an anticipatory manner. This hypothesis could be confirmed through further empirical study; however, some light may be shed by the work of Fred Lerdahl (1988). Lerdahl suggests that the difficulty listeners generally have in identifying structural features of some serial music may be because of the significant differences between the 'grammatical rules' utilized by composer and listener. Though his work is focused on serial music, his explication of the grammatical rules highlights some rules to which free atonal music does not conform. For instance, like serial music, free atonal music is not elaborational or hierarchical; it also compromises the relationship between spatial distance and cognitive distance. Music that does not conform to such constraints, Lerdahl argues, is hard to understand, or has an 'opaque' structure, which may account for some of the difficulty listeners had with the structure of the atonal pieces in this study.

Overall, levels of emotional intensity were lower in response to the atonal pieces than the tonal pieces, and this effect was more pronounced in non-music students than music students. This variation according to expertise might be explained by genre familiarity. If what the music listeners perceive is similar to an existing schema, this may make it easier to process and therefore generate higher levels of induced emotional responses, an idea supported by Gaver and Mandler (1987). If the schema being compared with the perceived music is too distinct in nature or content, the comparison seems unlikely to produce an emotional response. There may be a particular similarity/novelty position for a new piece of music in comparison with an existing schema that produces an optimum level of emotional intensity. Genre familiarity and familiarity for a specific piece may be considerably different in nature, and thus have different effects, and therefore this distinction merits further investigation.

Conclusion

These findings may have wide-ranging implications relating to future research and listeners' engagement in musical activities. Listeners frequently engage in musical activity for its emotional benefits (DeNora, 2000; Juslin & Sloboda, 2001), and therefore the lower reported

emotional intensities in response to the atonal pieces make the function of this music have a different focus. This may be one reason contributing to the relatively small audiences of atonal music and low sales figures for atonal recordings (Burkholder, 1991). The differences between the reported emotional intensity of music students and non-music students in this study suggest that atonal music conveys emotional intensity more successfully to listeners with musical training. It would be interesting to discover exactly which aspects of musical training have this effect. If musical training increases listeners' emotional responses to certain music, and emotional responses to music are a primary motivator for engagement with music, then this would appear to provide additional justification for music-education activities such as pre-concert talks or the provision of programme notes. The identification of the aspects of musical training that contribute to this effect would enable providers of these activities or information to tailor their material to provoke the greatest possible emotional involvement with the music in each listener.[16] The results concerning familiarity might also suggest that pre-concert hearings of a work might aid listeners' perception of atonal works.

This study has several limitations relating to the chosen method and to the participants. The first of these concerns the limited aspect of emotion studied. Though an emotion consists of several facets, such as physiological responses, expressive behaviour and a person's subjective experience, this study only focused on the subjective experience of participants using self-report mechanisms. Although, in some ways, this provided data that were more controlled (participants would be able to filter out extraneous or unrelated emotions), other aspects of the emotional response were not studied: future research may explore a similar approach but with the addition of physiological measures or measures of expressive behaviour.

A second limitation of the study is the small number of musical works used, and the extent to which their musical language may be considered representative of other tonal or atonal works. These participants' responses relate to these specific pieces, and therefore generalization to other tonal or atonal works must be undertaken with caution. There is considerable potential for the detailed examination of responses to other works, to try to establish whether or not similar differences may be found between responses to other tonal and atonal pieces of music.

A third limitation is the relatively small number of participants used, which was partly a consequence of the mixed-methodology design of the study. The statistical tests chosen for the analysis of the quantitative data are very robust, and are likely to provide conservative results with a small sample; nevertheless, the small sample of participants suggests that the generalization of their responses should be undertaken with caution. Future studies should expand the sample size and, in so doing, use a broader cross-section of the population. It could also be informative to collect data from participants regarding their normal listening habits (e.g., hours per week and preferred range and type of music), as this could provide useful information concerning the reasons for between-subject differences in perceptual or emotional responses to specific pieces. Additionally, it would be interesting to investigate the responses of younger or older participants and of adults with amateur or professional musical status. Such replication of the study would help to clarify whether or not these results pertain to the general population. Despite these limitations, this longitudinal approach provided valuable insight into the effects of familiarity, musical experience, and musical language on listeners' perceptual and emotional responses to music.

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Notes

1. Some 'atonal' pieces may in fact utilize groups of notes which do evoke the harmonic series; however, the overarching elaboration of a tonal background in traditional Schenkerian manner is, by definition, not present.
2. This article adopts the definition of 'atonal' used by many musicologists (Dunsby & Whittall, 1988; Griffiths, 1986; Grout & Palisca, 1996; Jacobs, 1996), and refers to music unconstrained by tonality, serial principles, and other systems of organization: the music is not in any key, and all notes are used impartially (Kennedy, 2007). Kallinen's (2005) category of non-tonal music has a wider definition, and as such incorporates not only free atonal works, but also music from the Renaissance period (e.g., Dowland's *Lachrymae*) and quasi-tonal works from the twentieth century (e.g., the first movement of Shostakovich's Symphony No. 5).
3. It is recognized that the relinquishing of control to selected participants by letting them undertake their responses at home could be problematic. The participants were, by this time, very familiar with the procedure, and completed an online interview with the experimenter immediately after listening to the music. The timings were therefore unlikely to be falsified, and as the alternative was a smaller sample of participants, it was decided to proceed with the altered method. The influence of the different surroundings of these participants may provide scope for further study.
4. Calculations in the Results section account for these different sample sizes.
5. It is recognized that emotions have many different facets, including physiological responses and expressive behaviour as well as the subjective experience (Kihlstrom, Mulvaney, Tobias, & Tobis, 2000). As expressive behaviour is often suppressed in the act of listening to classical music, and the sources of physiological responses are sometimes difficult to ascertain, it was decided to focus on the participants' subjective experiences, as accessed through self-report mechanisms such as a computer programme and interviews.
6. The mood rating used as a control measure before the emotional response traces were collected was not required before participants completed their daily listening diaries. This was partly because the qualitative nature of the diary entries made it impossible to gain anything other than a subjective opinion of the effects of mood on diary entries. Additionally, it was important to maintain the brevity of the daily task to avoid participant fatigue or drop-out.
7. It is recognized that participants' diary entries may not be proof that they listened to the whole piece, or at the time specified. The instructions emphasized the importance of honesty, however, and the participants seemed to be compliant. It seemed unlikely that participants would attend daily listening sessions to ensure that they became familiar with the pieces, and more ecologically valid for them to become familiar with the music at home. Listening diaries at least provided some evidence that they had listened to the piece, and ensured that participants were thinking about the music at the time, rather than using the music as background listening.
8. Ideally it would have been good to have sufficient participants to modify the order in which participants undertook the three studies. This is, perhaps, something to incorporate in future studies, to avoid order effects. However, it is hoped that the period of three months between each experiment may have at least partially mitigated any order effects on participants' responses.
9. In the lower of each pair of graphs, the direction of the gradient is unimportant: what reveals whether the intensity is increasing or decreasing is the position of the point in relation to the origin of the graph. Therefore any point greater than zero on the y axis reveals an increase in intensity during that bar; any point less than zero on the y axis reveals a decrease in intensity during that bar.
10. The example bars provided here are not intended to overlap, but it was evident that combinations of musical triggers frequently prompted increases in emotional intensity.
11. See note 10.

12. This technique is advocated by Howell (2002).
13. In the original presentation of this score, in the version for harpsichord, the music for the three sections was identical: the B section of the ternary form structure was formed by the performer turning the music upside down.
14. First-order difference traces contained numerous time points with data as zero: this made them unsuitable for ANOVAs; MCI figures were amenable to ANOVAs. These were calculated by taking the first-order difference figures for the appropriate time points for each bar, and calculating the mean of these figures for each individual participant. This meant that individual profiles for each participant were retained, but the technique reduced the number of time-dependent data points.
15. An ANOVA comparing the profiles of all three pieces would have been problematic due to the uneven number of bars between the three pieces. The arbitrary comparison of responses at specific bar number of all three pieces also appeared misguided. The data were therefore summarized across the whole piece to allow for comparison of responses between pieces.
16. This is not to suggest that the provision of information in pre-concert talks or programme notes would provide the equivalent musical training of a music student, merely that additional information concerning the piece may promote emotional engagement with the music, and in turn, encourage future interaction with similar repertoire.

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