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Abstract

Music has often been shown to induce emotion in listeners and is also often heard in social contexts (e.g., concerts, parties, etc.), yet until now, the influences of social settings on the emotions experienced by listeners was not known. This exploratory study investigated whether listening to music in a group

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setting alters the emotion felt by listeners. The emotional reactions to 10 musical excerpts were measured both psychologically (rating on retrospective questionnaires and button presses indicated the experience of a chill, defined as the experience of a shiver down the spine or goose pimples) and physiologically (skin conductance response) using a new, innovative multi-channel measuring device. In a repeated measures design, 14 members of an amateur orchestra (7 male, 7 female; mean age 29) came in for two testing sessions: once alone, and once as a group. Chills were validated in the data analysis: each chill was counted only if the button press was accompanied by a corresponding skin conductance response. The results showed no differences between conditions (group vs. solitary) for retrospective emotion ratings; however, the number of validated chills did show a non-significant trend towards experiencing more chills in the solitary listening session. Also, skin conductance responses during chills were significantly higher during the solitary listening condition. This and other results suggested that music listening was more arousing alone, possibly due to the lack of social feedback and of concentration on the music in the group setting.

Keywords

chill, emotion, group, music, social, social facilitation

Introduction

Music has often been shown to induce pleasurable emotional responses. These reactions are often accompanied by measurable physiological reactions, such as changes in skin conductance, and in heart and breathing rate (e.g. Grewe, Nagel, Kopiez, & Altenmüller, 2007a; Krumhansl, 1997). Very strong affective reactions can include ecstatic *chill* or *thrill* experiences, which are accompanied by shivers down the spine or goose pimples and activate the peripheral nervous system (Goldstein, 1980; Grewe, Kopiez, & Altenmüller, 2009; Panksepp, 1995; Sloboda, 1991; Salimpoor, Benevoy, Longo, Cooperstock, & Zatorre, 2009). Past studies have concentrated primarily on the experience of individuals listening to music alone; the influence of social settings on emotional induction through music has not yet been explored.

The dearth of research regarding emotions experienced when listening to music with other people is paralleled in the domain of general emotion research: emotions are generally regarded as consequences of a cognitive appraisal process (Scherer, 2004), and social influences on this appraisal have been rarely investigated (Manstead, 2005). This is especially true in connection with music, despite the many social aspects of music apparent in everyday life (North & Hargreaves, 2008). These include, for example, peer groups influencing music preferences (also described as a mean for self-socialization and identity building of adolescents, Müller, Glogner, & Rhein, 2007). The social bonding aspects of music are even posited by some scholars to lie at the evolutionary origins of music (Cross, 2009; Freeman, 2000; McNeill, 1995). Preliminary evidence for this social bonding hypothesis was recently presented by Kirschner and Tomasello in two studies. The first showed that children's drumming synchronization was improved in a social context and the second suggested that joint musical activity improved pro-social and cooperative behaviour (Kirschner & Tomasello, 2009, 2010). Also Wiltermuth (2010) experimentally showed that moving and singing in synchrony lead to greater compliance behaviour. Research investigating strong experiences with music (SEM) in adults extends these findings by demonstrating that the social context in which the music was heard influenced the emotions experienced (Gabrielsson & Lindström Wik, 2003). More recently, Lamont (2009) reported that SEMs occurred mostly in live concert settings with other people being present. It is this latter aspect that the current study investigates by asking the question: how does the presence of others (as in a concert setting) alter emotional experiences during music listening?

Music and emotion

In our study, emotion is understood as it is specified by the component process model presented by Scherer (2004). According to this model, an emotion episode is triggered by a cognitive evaluation process and consists of coordinated changes in three major reaction components: physiological arousal, motor expression, and subjective feelings. Changes in these components may be highly synchronized to adapt optimally to the eliciting circumstances. Furthermore, Scherer distinguishes between *utilitarian* and *aesthetic emotions*, which differ in appraisal concerning goal relevance. The absence of direct personal relevance in aesthetic emotions leads to rather diffuse, reactive physiological and behavioural changes in contrast to distinct and proactive changes in the case of utilitarian emotions, including so-called *fundamental emotions* (Ekman & Davidson, 1994; Scherer, 2004). Since there is still ongoing controversy about whether music induces basic, fully synchronized emotions or aesthetic, diffuse emotions (Juslin & Västfjäll, 2008), we decided to measure both (using validated chills, subjective feelings, and sympathetic arousal).

There has been much research dedicated to understanding emotions in music. According to Juslin and Västfjäll (2008), music affects emotion through different mechanisms: brain stem reflexes, evaluative conditioning, visual imagery, episodic memory, musical expectancy, emotional contagion, and cognitive appraisal. There has also been much research dedicated to understanding the chill response that many people experience when listening to music. Panksepp (1995) theorized that the evolutionary origins of chills might lie in separation-stress systems helping to promote social bonding. He attributed the origin of chills to a bodily reaction to the separation calls young animals made when left alone by their parents. The call-induced coldness (“shiver down the spine”) in those parents has been interpreted to function as a motivator for social reunion (Panksepp, 1995; Panksepp & Bernatzky, 2002). Sloboda (1991) investigated this phenomenon in humans by using questionnaires to collect reports of participants’ strongest emotional reactions to music over the five years prior to the survey. The questionnaires included items inquiring after physiological reactions (such as chills, tears, laughter, etc.) and examined the relationship between the occurrence of such experiences and musical parameters. His analyses showed that there do seem to be musical events related to these experiences; for example, chills appear to coincide with new and/or unprepared harmonies as well as with sudden dynamic or textural changes (a similar finding was also described by Guhn, Hamm, & Zentner, 2007). Does this finding imply that those pleasurable chills people experience when listening to music are only a physiological reaction to certain abrupt changes in the acoustic stimulus? If so, everyone should experience chills when listening to music that contains the musical events necessary to stimulate chills. Yet this is not the case – music responsiveness is highly individual (Blood & Zatorre, 2001). The results of Grewe, Nagel, Kopiez and Altenmüller (2007b) support the claim that chills are not automatic reflex-like responses; there are no musical structures that induce chills across most participants. Rather, it seems likely that “a cognitive, implicit evaluation triggered by attention-raising structures leads to an emotional process and a chill occurs in the context of this process” (Grewe et al., 2007b, p. 312). Thus, familiarity with and preference for the music presented influence the intensity of listeners’ responses (Grewe et al., 2009; Salimpoor et al., 2009).

The importance of familiarity can be used to explain the differing results between the studies conducted by Grewe and colleagues and by Panksepp: one of the songs in the Grewe et al. study (“Making Love out of Nothing At All” by Air Supply) was also played in Panksepp’s (1995) experiment but with differing results. Grewe et al. found a much lower occurrence of chills during this piece, possibly due to the fact that Panksepp’s participants had a higher familiarity with

and preference for that music at that time (the study was conducted about 15 years earlier than Grewe et al.'s experiment). Another explanation for this difference could be the way in which the participants were tested: while Grewe and colleagues tested each participant individually, Panksepp tested his participants while they were all sitting together, which could have added social influences as a confounding factor.

Social influences on music listening

There are several routes of music-induced emotion genesis (as described by Juslin & Västfjäll, 2008), which could involve social processes. In evaluative conditioning, the unconditioned stimulus could be social: for example, the good friend, with whom one often attends concerts, could affect the conditioned stimulus (in this case, the music in the concert). Emotional contagion also has a social dimension. The music's emotional expression (Gabrielsson, 2002) might be attributed to a musician or composer, and the music itself is claimed to have voice-like perceptual characteristics (Juslin & Västfjäll, 2008). Also, observing somebody else's emotional reactions to music could lead to emotional contagion on the side of the listener. Social aspects can also explain the influence of episodic memory on emotional experiences when listening to music, such as when a past social event, such as the loss of a loved one, is remembered with music.

Furthermore, cognitive appraisal might also be socially affected. The appraisal theory of emotion claims that emotions emerge from cognitive evaluation of the emotion-eliciting event, regarding the dimensions of novelty, urgency, coping potential, norm compatibility, and goal congruence (Juslin & Västfjäll, 2008). This evaluation process could be subject to social influence, because norms are socially determined and social acceptance is a very important human goal (Aronson, Wilson, & Akert, 2004). For example, Fischer, Rotteveel, Evers, and Manstead (2004) showed that participants are affected by the emotions of others, confirming their emotional assimilation hypothesis. Manstead & Fischer (2001) suggest that appraisals are often influenced by social experiences. In such cases, they term this phenomenon *social appraisal*. This can happen in two different ways: in one, another person is part of the emotional event appraised (e.g., being insulted by someone leads to social appraisal); in the other, social appraisal occurs when we observe another person's reactions to an emotional event. In this case, the person is not part of the emotional event but still has an influence on our appraisal. This type of social appraisal shapes one's perception of emotional situations, making it possible for other people to be involved in the construction of appraisal. Such a process is exemplified by a man watching a sexist comedy in the company of a woman; her presence might influence the man's amusement, leading to different emotions than if he had been watching the film with other men or by himself (Manstead & Fischer, 2001).

Another theory that includes social aspects when explaining emotion is the *social facilitation theory*, which predicts that the mere presence of others leads to increased arousal (Zajonc, 1965). Because of this increased arousal, dominant (already learned) responses occur more frequently and the learning of new responses is impaired. Zajonc explains this connection through the attainment of an optimal or too-high arousal level, which in turn depends on the task that participants are requested to complete. Causes of this group-induced arousal can be (a) generally increased attention; (b) the fear of being evaluated by others; or (c) a distraction by the group (Aronson et al., 2004). However, social situations do not always lead to social facilitation; rather, the opposite phenomenon, *social loafing*, has been observed too. The latter refers to the situation in which group members cannot accurately evaluate the performance of

their peers (Aronson et al., 2004). Under such circumstances, individuals have no fear of being evaluated and relax, leading to a state of decreased arousal, which in turn improves performance on difficult tasks. Summarizing the two theories: social situations could lead to increased or decreased arousal during music listening, depending on the amount of social control the listeners have over each other.

The scarcity of research on the effect of social influences in music-related topics (for a review see Crozier, 1997, and North & Hargreaves, 2008) is also true of research on music in the context of social facilitation and loafing (North & Hargreaves, 2008), though researchers (e.g., Davidson, 1997) acknowledge that social facilitation might occur quite often (for example, in performers through the presence of an audience at a concert). Davidson reports an anecdote about the famous singer Caruso, who claimed he could only sing his top Cs convincingly if he had an audience. In an internet-based experiment, Salganik, Dodds, and Watts (2006) found that music listeners tend to orientate their choices on the behaviour of others. In a similar internet-based experiment, Egermann, Grewe, Kopiez, and Altenmüller (2009a) observed that ratings of musically induced emotion are affected by social feedback. Another approach was taken by Radocy (1975), who used confederates to ascertain whether participants' judgments would be influenced by other people. Participants were asked to match pairs of simple tones differing in loudness or pitch, and complied with the confederates in 30% (pitch ratings) and 49% (loudness ratings) of trials when incorrect social feedback was given. Investigating preferences of musically untrained listeners, Furman and Duke (1988) found that ratings of unfamiliar orchestral music were also affected by social feedback, but that this did not occur with familiar pop music. Finnäs (1989) showed that the mechanism behind everyday music-related social influences may be an assumed majority peer group opinion: publicly expressed preference ratings of adolescents (in front of their classmates) were lower for traditional music compared to ratings given privately. In summary, the results of previous research suggest that both music and emotion are subject to social influences, yet the question of how social listening influences the experience has not yet been experimentally investigated. However, there has been research observing that musical emotions do differ when the music is heard in a group versus solitary setting. Employing the experience sampling method, Juslin, Liljeström, Västfjäll, Barradas, and Silva (2008) reported that episodes collected in social settings (e.g., when with friends) evoked different musical emotions compared to solitary settings. A similar result was described by Ziv (2004), who found that music listeners' narratives of intensive music listening situations differed according to whether people were together or alone. What is not yet known is whether these differences occurred because of the presence of others, or because the music used in the social and solitary settings was different.

Aims and research question

The current study investigates whether listening to music in a group setting alters different measures of emotion. Since previous theories and research (Aronson et al., 2004; Juslin et al., 2008; Ziv, 2004) suggested that the presence of others influences emotional experiences and arousal, we decided to focus on this social influence factor. We did this by manipulating social influence in a within-subject design to simulate natural music listening contexts with others (group listening vs. solitary listening). We also decided to take a multi-dimensional measurement approach, since music-induced emotions were shown to manifest in different psychological and physiological emotion components. Thus, retrospective emotion ratings were combined with continuous online registrations of chills and a psychophysiological activation measure

(skin conductance, one of the most responsive indicators of emotional arousal, Grewe et al., 2009; Salimpoor et al., 2009). This was done in parallel for all the participants in the group listening condition. A group was defined as two or more people who interact and are interdependent, meaning that their needs and goals lead to reciprocal influence (Aronson et al., 2004). Our participants were all members of an amateur orchestra because, first, musicians are more likely to experience strong emotions during music listening (Grewe et al., 2007b); and second, an orchestra is a preexisting group based on collaboration (Davidson, 1997). Additionally, only music excerpts from the classical repertoire were used, since orchestral musicians would probably be familiar with this genre. This was important, since familiarity and preference have previously been shown to correlate positively with emotional reactions to music (Kreutz, Ott, Teichmann, Osawa, & Vaitl, 2008).

The theories of social appraisal discussed in this paper suggest that it is possible for the presence of others to enhance emotion during listening, but also that the music may be experienced as less emotional, due to a lack of concentration of the participants on the music or due to social loafing. Thus, we did not form a directed hypothesis and designed this to be an exploratory study.

Methods

Participants

To increase the level of group cohesiveness, the 14 participants were, as described, all members of an amateur orchestra (consisting of amateur musicians, music students, and music teachers). Seven were male and seven female, and their mean age was 29 years ($SD = 10.5$ years, range = 22–63 years). The mean length of musical training was 16.6 years ($SD = 6.3$ years, range = 8–25 years), and the most familiar music style was classical music ($M = 5.61$, $SD = 1.1$, range = 4–7, rated on a scale from 1 = “not familiar” to 7 = “familiar”).

Procedure

In a within-subject design, participants came in for two testing sessions: once by themselves, and once as a group. They were randomly divided into two groups: one came in for the solitary session first and the other for the group session. They were seated in a circle in comfortable armchairs in the group session. The music was presented at a pleasant sound pressure level using a Sony STR-DB 795 receiver through a Teufel multi-channel loudspeaker system. The procedure was kept constant in the solitary condition, except that each participant listened alone.

Measurements

Emotional reactions were measured both psychologically and physiologically, which allowed us to capture the different emotional reaction components as well as to measure utilitarian and aesthetic emotions (Scherer, 2004).

Psychological measurements. In order to measure a variety of subjective feelings, questionnaires assessing the felt intensity of 11 different emotional adjectives (also used by Krumhansl, 1997) were filled out between each excerpt and after the last session. Additionally, participants

were instructed to press a button of the Group Online Response Digital Interface (GORDI; Kopiez & Wolf, 2003) when they experienced a chill. This device was connected to a computer running the software Cubase and recording the button presses from all 14 participants in parallel on separate channels via MIDI. Chills were explained to participants as strong emotions accompanied by an experience of goose bumps or shivers down the spine. We chose to record chills because they have previously been shown to indicate strong emotions, combining reactions in the two emotional components of subjective feelings and physiological arousal (Grewe et al., 2009).

Physiological measurements. For the physiological measurements, a self-developed 16-channel skin conductance measuring device was used. Sixteen direct current generators were assembled in parallel in one device. The skin conductance level (SCL) is primarily based on sweating reactions and changes in blood flow (Boucsein, 2001). These reactions have been widely used as indicators of psychological reactivity, especially as indicators of arousal, orienting responses, and startle responses. Skin conductance response (SCR) reflects the changes in SCL over a short period and is therefore best suited to measure reactions to affective musical events. We measured SCR on the middle segments of the index and middle fingers of the hand not used to press the chill-indicating button. The SCR data was sampled with a rate of 67 Hz using DT Measure Foundry Soft- and Hardware from Data Translation. This was done in parallel for all 14 participants in the group setting. Kendall Meditrace Ag/AgCl-electrodes (27 mm diameter) were used in both settings. To avoid signal loss due to cold hands, participants covered their hands with a warm blanket, which also functioned to hide the button presses from the other participants in the group.

Stimuli

Stimuli were 10 one minute-long musical excerpts (see Table 1) previously shown to contain chill-inducing musical parameters (Grewe et al., 2007b) and were selected from the genre reported to be most familiar to the participants: a broad range of classical music.

Table 1. Musical stimuli

Presentation no.	Composer	Piece	Style
1.	Bedřich Smetana	"The Moldau"	Classical music
2.	Ludwig v. Beethoven	Piano Concerto No. 5, Op. 73 (3. movement)	Classical music
3.	Jean Sibelius	"Finlandia", Op. 26	Classical music
4.	Alan Silvestri	"Forrest Gump Suite"	Film music
5.	Wolfgang A. Mozart	Requiem d-minor, K. 626: "Lacrimosa"	Classical music
6.	Felix Mendelssohn	"Hebrides Overture", Op. 26	Classical music
7.	Edward Elgar	"Nimrod" from the <i>Enigma Variations</i> , Op. 36	Classical music
8.	Klaus Badelt	"The Medallion Calls"	Film music
9.	Richard Wagner	"Lohengrin" Overture	Classical music
10.	Rolf Lovland	"Serenade to Spring"	New Age

The presentation order of the excerpts was the same for both the solitary and group listening conditions, which eliminated the possible confound of order effects, since the order in the group condition had to be the same for all participants.

Data analysis

SCR data. For analysis of the SCR data, Matlab (Version 7.2) was used. First, the SCR data was range-normalized for each participant, which was done by finding the maximum and minimum of her/his recordings and calculating the difference between them. Then that data was divided by the individual ranges, resulting in SCR recordings with a range of 1 for all participants. Due to the normalization procedure, SCR data will be presented in arbitrary units. On account of our small sample size, the fact that the data did not follow the Gaussian distribution, and the fact that we could not confirm equality of variance, significance tests for SCR-data were done using the non-parametric Permutation Test with 5000 permutations (Good, 1994). This test compares two data sets based on two matrices. For each permutation, elements of the two matrices are randomly distributed on two new matrices. When fewer of the random permutations than the tolerated alpha error (e.g., 5%) result in a bigger difference when compared to the difference between the two original groups of data points, the test considers the two groups to be significantly different.

Chill validation. For a chill to be included in the data, the button press had to be accompanied by a corresponding peak in SCR (see also Grewe et al., 2007b). This was done by including only those button presses where a $0.05 \mu\text{S}$ SCR (Boucesin, 2001) in a 5-second time window before the chill onset (button press) was found by a peak detection Matlab function (Billauer, Version 3.4.05). We were able to compute the number of validated chills (per participant and per excerpt) from the resulting data. Differences in the number of validated chills were tested for significance using the non-parametric Wilcoxon test (used because of the small sample size and the fact that these data also did not follow the Gaussian distribution). For those Wilcoxon tests, the approximated effect size ϕ was calculated additionally using Formula 1 (Ziegler & Bühner, 2009).

$$\phi = (z^2/N)^{-2} \quad (1)$$

Ziegler and Bühner defined that $\phi = .10$ indicates a small effect, $\phi = .30$ indicates a moderate effect, and $\phi = .50$ indicates a strong effect.

Results

Analysis of emotion ratings

In order to reduce the number of dependent variables, we applied a factor analysis to the 11 adjectives used to rate the induced emotion. The result was a structure with fewer dimensions consisting of three partial feelings: representing a) positive emotion; b) negative higher arousal emotion; and c) negative lower arousal emotion (see Table 2). The following analyses will be based on these three extracted factor values.

To merge groups of music excerpts with a similar emotional effect, a hierarchical cluster analysis was computed using the resulting three emotion factors (Ward method, squared

Table 2. Rotated component matrix: results of factor analysis (principal components analysis)

Factor	Rating adjective	Component		
		1	2	3
a) positive emotion	contented	0.856	.078	-0.11
	relieved	0.818	.001	-.037
	happy	0.812	-0.141	0.263
b) negative higher arousal emotion	afraid	-.030	0.738	-0.225
	angry	-0.284	0.672	0.21
	anxious	.072	0.666	-.073
	surprised	0.391	0.538	.044
c) negative lower arousal emotion	disgusted	-0.322	-.026	0.665
	amused	0.209	-0.164	0.609
	contemptuous	-0.256	0.458	0.584
	sad	-0.14	.009	-0.57
Percent of variance explained by factor		23.02	18.10	15.11

Note: The extraction was based on a Principal Component Analysis using the Varimax rotation method with Kaiser normalization. The rotation converged in 4 iterations. The factor solution was adequate for this data (Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .673, Bartlett's Test of Sphericity: approx. chi-square = 685.472, $df = 55$, $p < .05$).

Euclidian distance). A three-cluster solution was adequate to group the 11 excerpts according to their emotional effect (see Table 3). The first and largest cluster contained six excerpts in which the positive emotion factor (a) was given the highest rating; the second cluster contained two excerpts in which the negative higher arousal emotion factor (b) was given the highest rating; and the last excerpt cluster contained two excerpts that induced emotions in the negative lower arousal factor (c).

Subsequently a General Linear Model was computed using three repeated measurement factors: 1) emotion factor; 2) the listening situation (solitary vs. group); and 3) the excerpt group cluster. Due to the lack of sphericity, the Greenhouse-Geisser correction for degrees of freedom was applied where necessary. We found no overall difference in the intensity of the emotion-rating factors, but a significant influence of the different excerpts group clusters ($F(1.301, 26) = 6.851$; $p < .05$). Thus, we can conclude that overall, the different excerpts induced different emotions in the participants. There was also a significant interaction between emotion rating factor and excerpt cluster, implying that different clusters influenced different emotion factors differently ($F(2.312, 52) = 16.919$; $p < .0001$). There was no significant effect

Table 3. Means of ratings factor values grouped by music excerpt cluster

Factor	Cluster 1	Cluster 2	Cluster 3
a) positive emotion	0.2597	-0.5162	-0.2576
b) negative higher arousal emotion	-0.1178	0.5922	-0.242
c) negative lower arousal emotion	0.0238	-0.7946	0.7531
Number of excerpts in group	6	2	2

of the listening situation, nor a significant interaction between listening situation and emotion-rating factor or excerpt group cluster.

Analysis of SCR data

Figure 1 presents the median SCR of all participants averaged over time and excerpts, but separated by condition. A Wilcoxon test showed that the SCR was significantly higher during the solitary condition when compared with the group condition, $z = -2,794$, $p < .05$, $\phi = .75$. Thus, the estimated effect size for this difference is strong.

A time-series analysis of the SCR for all excerpts showed at least one significantly higher region in the solitary setting compared to the group setting in nine of the ten excerpts (Permutation test; Bonferroni corrected by 10 excerpts; $p < .005$). As an example, Figure 2 shows the SCR time series group median for both conditions during excerpt No. 7. Nine significant higher regions in the alone setting can be observed in the comparison of conditions. The time-averaged SCR was also significantly higher (Wilcoxon test, $z = -3.296$, $p < .05$, $\phi = .88$), and had a higher number of validated chills ($M = .72$ vs. $M = .22$) in the alone condition (Wilcoxon test, $z = -1.92$, $p < .05$, $\phi = .51$).

Analysis of chills

Comparing the number of validated chills between the two listening conditions (solitary vs. group) showed that the group median of the validated chill number was .5 per excerpt in the solitary and .25 per excerpt in the group setting (averaged over all excerpts, see Fig. 3). A Wilcoxon test indicated that there was a non-significant trend towards more chills in the

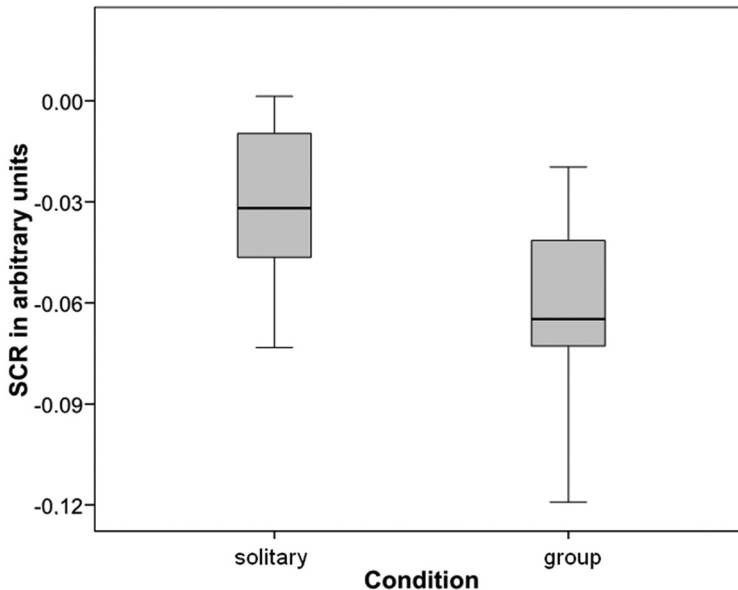


Figure 1. Box plot of the median SCR averaged over time and all excerpts, separated by conditions solitary and group.

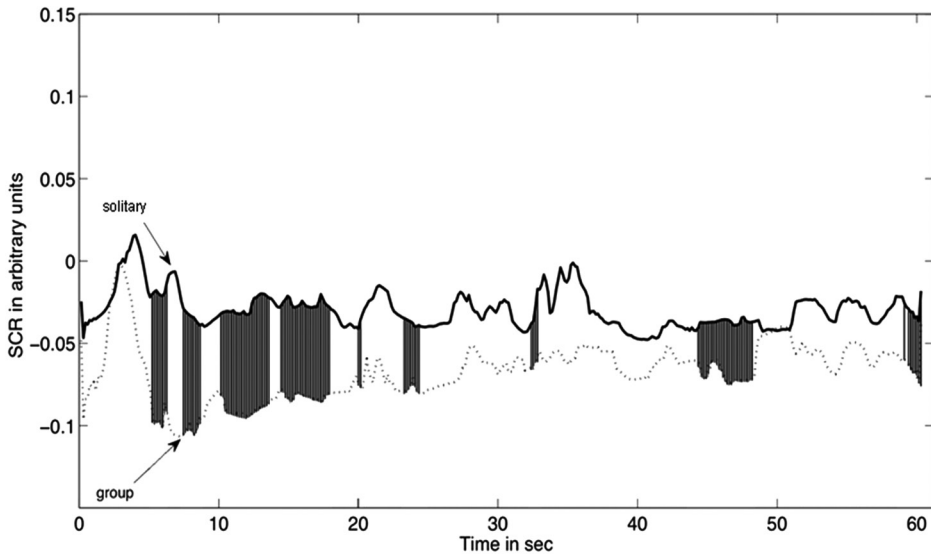


Figure 2. Time series SCR of excerpt No. 7 “Nimrod” from the *Enigma Variations* by Edward Elgar. The upper solid line represents the group median of the solitary setting, the lower dotted line the group median of the group setting. Significant differences are highlighted by vertical lines (Bonferroni corrected for comparing 10 excerpts: $p < .005$).

solitary setting ($z = -1.786$, $p = .074$, $\phi = .48$). Using the software GPower (Faul, Erdfelder, Lang, & Buchner, 2007), the power of this test was computed, indicating that an effect of this size investigated with a sample $n = 14$ had a 38% chance of becoming significant. The chance could have been increased to 70% by using a sample of 30 participants. The SCR data in the near vicinity of the chill-indicator button presses revealed that the median SCR peak during the solitary condition was significantly higher than in the group setting (Fig. 4).

Discussion

To our knowledge, this study is one of the first to investigate the influences of a social (group) setting on emotional experiences with music. In this experiment, all physiological measures of emotion suggested that listening to music privately was more arousing than listening in a group. The time-averaged SCR was also higher averaged across all excerpts in the solitary setting. An analysis of the individual excerpts indicated that participants showed more excitement when alone; a time-series analysis of the SCR also indicated that there was more activity during the solitary condition. Although it was only a non-significant trend, participants tended to have more validated chills in the solitary condition. However, there was a moderate effect size, making it possible that the lack of significant results was due to the small sample size. Unfortunately, technical constraints made it impossible to increase the number of music listeners we could measure simultaneously in the group condition.

The significantly higher level of SCR that accompanied the chills in the solitary condition implies that sympathetic arousal during chills was higher in the solitary condition. These results suggest that music was more physiologically arousing when heard privately and/or the presence of others decreased responses during music listening. Interestingly, no significant differences were found between the two conditions for the subjective ratings of emotion. Thus,

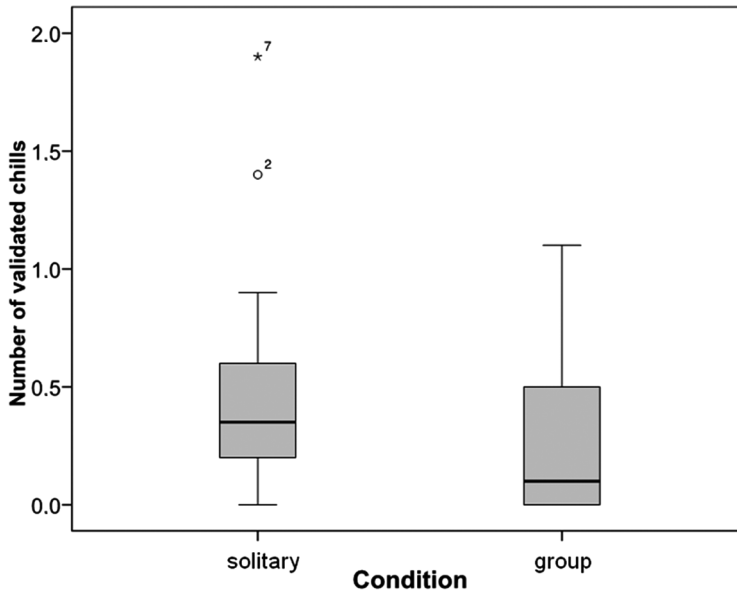


Figure 3. Box plot of the averaged number of validated chills per excerpt and participant for the solitary and group conditions.

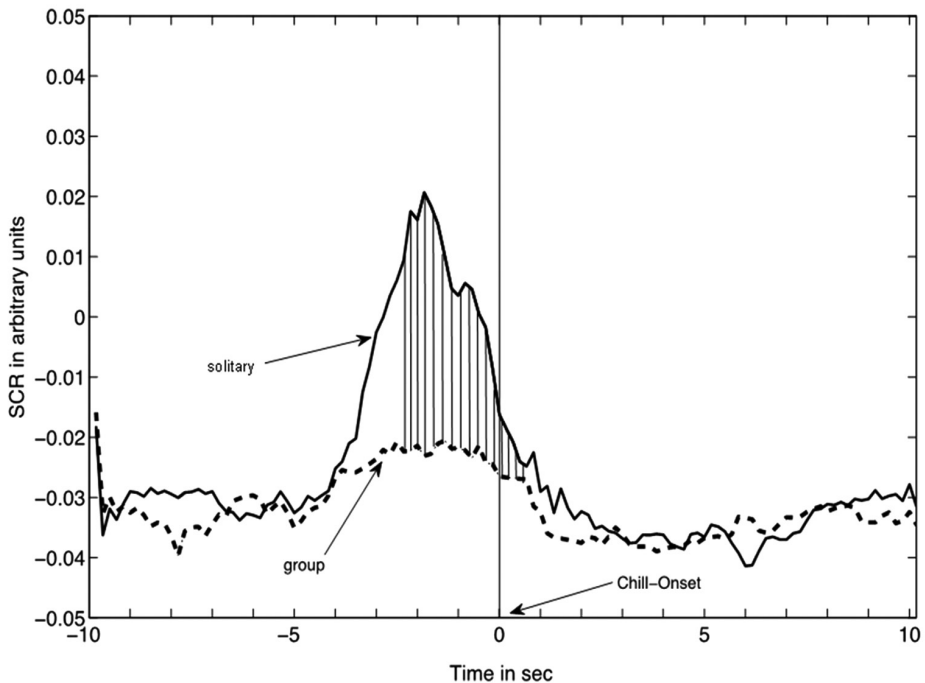


Figure 4. Median SCR during reported chill-onset separated by condition solitary (134 events, upper solid line) and group (91 events, lower dotted line). Significant differences are highlighted by vertical lines ($p < .05$).

there seems to be a dissociation between physiological measurements and subjective feelings, at least when analysing data groupwise (averaged over all participants). This phenomenon was also reported by Grewe et al. (2007a) and emphasizes Scherer's theory (2004), which distinguishes between aesthetic and utilitarian emotions. The music in this experiment induced both these types of affective phenomenon: a few more synchronized utilitarian emotions (validated chills) and, more frequently, less synchronized aesthetic emotions (subjective feelings).

The comparative lack of arousal in the group situation contradicts the social facilitation theory (Zajonc, 1965), as the presence of others did not increase participants' general physiological arousal. Other studies have found similar evidence against the social facilitation theory. For example, a study investigating the enjoyment experienced while watching a televised basketball contest showed that participants did not enjoy watching points scored more when they were in a group compared to by themselves (Sapolsky & Zillmann, 1978). These authors conclude that social facilitation does not always occur in social settings. Also, Abrams and Manstead's (1981) experiment failed to find support for social facilitation, measured as errors in music performance in group settings. These results may contradict the social facilitation theory because the theory is based on what could be considered as an oversimplified genesis of emotion. The presence of others might increase arousal, but according to the appraisal theory of emotion (Scherer, 2004), this would be the result of a cognitive appraisal process. Thus, social appraisal would be present (Manstead & Fischer, 2001). Such a process would be determined by many different factors; the simple cause and effect chain (cause: presence of others; effect: arousal) posited in the social facilitation theory reduces the complex nature of emotion to an unrealistic extent.

The previously presented literature suggests four different explanations for the results of this experiment:

1. Participants did not receive any explicit social feedback from their peers. They did not know what the other participants were feeling, nor did they speak or see when the others pressed the chill buttons. This might have lowered the probability of having a shared experience, which would have increased the feeling of togetherness (see Overy & Molnar-Szakacs's *Shared Affective Motion Experience* [SAME] theory, 2009). Asked to evaluate retrospectively how much participants thought they interacted with each other, they provided a very low average rating ($M = 2.3$, $SD = 1.1$, rating scale from 1 = "no interaction" to 7 = "strong interaction"). This meant that no direct emotional contagion could take place, also decreasing social appraisal (Manstead & Fischer, 2001). Another form of social influence that has been shown to affect people's ratings of emotion to music is the rating given by other preceding study participants (Egermann et al., 2009a). This information was not available to the participants in the current study, making it even less likely that they would experience any social influence on their emotions.
2. The private nature of the emotion ratings might also have led to the phenomenon of social loafing (Aronson et al., 2004). This theory predicts that tasks carried out in a group lead to lowered arousal when there is no observable direct control by group members on the other individuals' performances. In our study, participants knew that their responses could not be seen and evaluated by their peers, which might have led them to relax more.
3. The evolutionary perspective on the origin of chills (Panksepp, 1995; Panksepp & Bernatzky, 2002) might also help to interpret the trend towards more chills in the solitary setting. Chills in animal studies were shown to be reactions to separation calls of isolated offspring; the solitary setting might also have led to feelings of loneliness promoting the occurrence of chills. Unfortunately, this interpretation remains rather

speculative, since the feeling of loneliness was not measured and it might be questionable whether a similar feeling could be induced in humans in an hour-long experiment.

4. An analysis of the questionnaires revealed that a majority of participants (11 out of 14) enjoyed listening to the music by themselves more than in the group. Although our participants were used to performing music together, the experimental group set-up (including the electrodes to measure SCR) may have felt artificial and uncomfortable. Thus, we are not sure whether our laboratory set-up was able adequately to simulate a natural group music listening setting (such as a live concert) with natural social influences. Furthermore, this artificial group set-up may have caused participants to concentrate less on the music and more on the other participants or the set-up. Ziv (2004) found that listening in the reported solitary settings was accompanied by a higher concentration on oneself and one's emotion compared to the social listening settings, and Saarikallio (2006) reported in her survey on mood management that listening alone is the most frequent behaviour indicated when adolescents intentionally listen to music to change how they feel. Also Larson's (1995) review article emphasizes that for adolescents, listening to music privately is a vehicle for emotional reflection and identity building. Other research in adults emphasizes the importance of concentrating on the music for the experience of strong emotions chills as well (Grewe et al., 2007a, 2007b). Egermann, Nagel, Kopiez, and Altenmüller (2009b) demonstrated that an increase in self-rated concentration on music was positively correlated to felt arousal and the number of chills reported. Perhaps the novel set-up and presence of friends caused the participants to pay less attention to the music in the group listening setting presented here, thus decreasing arousal and chills. Grewe et al. (2007b) support this theory with their report that chill respondents found listening privately to be the more natural way to experience music.

In summary, there are four theories which could be used to explain our results: the lack of social feedback; the possibility of social loafing; the evolutionary function of chills; and a lack of concentration in the group setting. It would be interesting to modify the experimental design in such a way as to make the set-up more conducive to the induction of a positive, emotionally intensifying social influence. This could be done by allowing participants to receive emotional feedback from the other participants (similar to a natural concert experience) via an online measurement system that would allow all participants to see their peers' ratings of the music. This change would not only be more effective in leading to social appraisal processes (Manstead & Fischer, 2001), but could also prevent social loafing (as all participants would know that they were being observed). Another change that would be interesting to implement would be to add a measure of concentration, which would allow us to see when participants were being distracted by their peers. The experiment may also have benefited from focusing less on the chill experience. Although the music was preselected to be chill-inducing and was from a genre with which the participants were very familiar, chills occurred very rarely in our study: participants reported an average validated chill rate of .35 to .1 per minute, and one participant did not have chills at all. Studying such a rare phenomenon as chills might increase the chance of random non-coordinated noise in the data. A possible improvement would be to include instead different measurements such as ratings of valence and arousal (Egermann et al., 2009b; Nagel, Kopiez, Grewe, & Altenmüller, 2007; Russell, 1980) or ratings on the Geneva Emotion Music Scale that has been especially designed to capture the unique aesthetic emotions induced by music (Zentner, Grandjean, & Scherer, 2008). Finally, a between-subjects design might decrease the possibility of participants guessing why there are two different listening situations and using a bigger sample (also including more

representative non-musicians) might also lead to different results, since smaller differences with smaller effect sizes would be visible due to a higher test power.

The results of this study emphasize that the role of attention is probably involved in the emotions experienced during music listening. They also highlight the need to study musically induced emotion in many different social circumstances, as these situations might affect the outcome of appraisals modulating physiological responses. Juslin and Västfjäll's (2008) list of mechanisms explaining emotional responses to music is still missing an explicit social reference, which may have to be added. Whether social influences intensify or lower emotional responses to music, their importance should not be overlooked. We understand that our study is exploratory and only a first attempt to fill this gap.

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