Assessing Emotional Experiences of Opera Spectators in Situ

Klaus R. Scherer[1,2], Stéphanie Trznadel[1], Bernardino Fantini[1], Eduardo Coutinho[3]

[1]Swiss Center for Affective Sciences, University of Geneva

[2]University of Munich

[3]University of Liverpool

Corresponding address: Klaus R. Scherer, Department of Psychology, University of Geneva, Boulevard du Pont-d'Arve, 40, CH-1211 Geneva, Switzerland. E-mail: Klaus.Scherer@unige.ch.

Acknowledgements

ASSESSING EMOTIONAL EXPERIENCES OF OPERA SPECTATORS IN SITU

1   Abstract

2   Opera performances elicit strong emotional reactions in listeners. Yet, empirical

3   demonstrations of these effects in situ are rare. Here we report a series of studies

4   examining the emotional reactions of participants invited to the dress rehearsal of three

5   different operas at the Geneva opera house before large audiences. Using a new affect

6   checklist developed specifically for in situ studies of music performances, we asked

7   participants to record 1) the intensity of 12 different types of affective reactions they

8   experienced during selected scenes or 2) the frequency with which they experienced

9   these emotions during specific acts or the opera as a whole. Results showed a high

10   degree of specificity regarding the emotional impact of the operas as a whole and of

11   individual scenes/acts. For one opera, Verdi's Macbeth, we also asked participants to

12   rate both the emotions they actually felt during the opera scenes and the emotions

13   expressed by the music or the singers' interpretation. Results confirm that spectators are

14   clearly able to separate their own affective responses from what they perceive to be the

15   emotions portrayed by the orchestra or on the stage. In addition, we evaluated the effect

16   of different types of pre-performance information sessions (on plot or music) as well as

17   of participant personality and prior mood. Overall, the results demonstrate the feasibility

18   of measuring highly differentiated emotional audience reactions to an opera

19   performance with a brief validated checklist during actual performances in the opera

20   house and the validity of self-reported emotions.

21

22   *Keywords*: music and emotion, opera performances, affective reactions, felt and

23   perceived emotions, mood and personality effects

24

Introduction

25

26   In recent years, the capacity of music to elicit emotions in the listener has

27 become a major topic for scientific inquiry, both theoretical and experimental (see

28 contributions in Bhatara, Laukka, & Levitin, 2014; Cochrane, Fantini, & Scherer, 2013,

29 and Juslin & Sloboda, 2011). Much of this work has focused on instrumental music,

30 probably partly due to a philosophical tradition that holds that the essential question is

31 to what extent "absolute music" (i.e., instrumental music without any programmatic

32 content) can elicit emotional reactions (Kivy, 1990; Konečni, 2008). As amply

33 documented in the literature, theorists and researchers disagree with this claim and

34 consider music as a performance art, of which there are many different genres, all of

35 which are able to induce affective states. In fact, singing and especially opera have been

36 traditionally considered as the most emotional types of music (Cohen, 2016).

37 Specifically, operatic performances consist of a dramatic plot as developed in the

38 libretto, the singing and acting of the singers, the music played by the orchestra, and the

39 (often elaborate) scenery and costumes, all of which are likely to involve many of the

40 mechanisms by which emotions are induced in listeners. In opera, the vocal characters

41 and the orchestral music that supports them interact with many other elements such as

42 literature, dance, visual art, scenic movements, and lighting to create a dramatic context,

43 which are all conducive to the production of strong emotions in the spectator. The

44 causes of the emotional effects in an opera performance are therefore multifaceted, and

45 it is important to examine the extent to which each of these major factors influence

46 emotion elicitation. Scherer, Zentner, & Schacht (2001/2002) asked a large group of

47 participants in a music science conference to rate the importance of the following

determinants for their affective reaction to music: musical structure, acoustic features, interpretation, technical quality, listener's mood, affective involvement, context factors, or listener personality. While musical structure was given the highest rating of the list of determinants followed by technical, acoustic, and interpretational features, listener and situational context factors also received high ratings.

Scherer and Zentner (2001) called the underlying mechanisms for these factors *routes* and provided a number of examples: I1) specific types of appraisal (such as novelty, unexpectedness, pleasantness), (2) music-related memory associations, (3) contagion, and empathy, (4) entrainment and proprioceptive feedback, and (5) facilitation of pre-existing emotions (disinhibition). They suggested a *route model* to highlight the major pathways through the cognitive and emotional systems involved, with each of these recruiting a large number of neural and somatic structures and many different mechanisms in terms of the underlying machinery. Juslin and Västfjäll (2008) have suggested a highly similar list of mechanisms in the form of a theoretical framework called BRECVEM (brainstem reflex, rhythmic entrainment, evaluative conditioning, contagion, visual imagery, episodic memory, and musical expectancy). Scherer and Coutinho (2013) have pointed out that three of the BRECVEM factors can be subsumed under the "appraisal" route: brainstem reflex as a low-level novelty and intrinsic pleasantness check; evaluative conditioning as the precondition for creating valenced associations; and musical expectancy as part of the discrepancy of expectation check. Episodic memory is covered under the memory mechanism, as is visual imagery in the form of memory-dependent constructive imagination. Empathy and emotional contagion cover the BRECVEM contagion mechanism. Rhythmic entrainment corresponds to proprioceptive feedback, which also contains emotion facilitation.

72   Specifically, the route model assumes that these mechanisms operate via

73   complex, multiple, nonlinear interactions between different determinants that can be

74   broken down into four classes, to elicit emotions in the listener: Structural features

75   (segmental and suprasegmental aspects of music), Performance features (Performer

76   skills, intentions, moods), Listener features (musical expertise, stable dispositions,

77   current motivational/mood state), and Contextual features (location, event).

78   This model was originally intended for instrumental music and needs to be

79   extended by additional factors to cover the essential elements of opera as described

80   above. In particular, the Structural features need to be complemented by three important

81   factors: Plot, Lyrics, and Staging. Particular attention also has to be given to the vocal

82   dimension, as the singing voice is one important specificity that characterizes opera in

83   relation to other performing arts. Given the difficulty of measuring and experimentally

84   manipulating these factors in ecologically valid settings, such as concert halls and opera

85   houses, these theoretical suggestions have rarely been investigated empirically (with

86   some exceptions: e.g., for opera, Balteş & Miu, 2014; Vaitl, Vehrs, & Sternagel, 1993;

87   see also http://www.transforming-musicology.org/news/2014-11-13_hearing-wagner-at-

88   being-human/; for Lieder, Coutinho & Scherer, 2016; for electronic music, McAdams,

89   Vines, Vieillard, Smith, & Reynolds, 2004). One of the central questions with which

90   this research is confronted, is the validity of self-reported emotions induced by listening

91   to music: Can listeners really report a highly differentiated spectrum of music-elicited

92   emotions or do they mostly report what they perceive or believe the music is designed

93   (and/or the interpreter intends) to express? This issue is particularly salient for vocal

94   music, since the dramatic plot or the text generally also express emotional content --

95   often much more explicitly than "pure music".

96   The aim of this article is threefold:

97   1)   Examine the feasibility of measuring felt emotional reactions to opera

98   performances *in situ*, immediately after the performance of selected scenes or acts.

99

100   2)   Evaluate the difference between *perceived* affect (as shown by the singers on

101   stage) and actually *felt* affect (by the audience). It is often suggested in the literature that

102   self-reported emotional responses are affected by the perceived "emotional character" of

103   the music. Earlier studies investigating the relationship between felt and perceived

104   emotions for instrumental music suggest that although the emotions experienced by

105   listeners may sometimes reflect those they perceive in a piece of music, there are major

106   differences between the two, mainly in the emotional intensity and valence (Evans &

107   Schubert, 2008; Hunter, Schellenberg, & Schimmack, 2010; Kallinen & Ravaja, 2006;

108   Konečni, Brown, & Wanic, 2008; Zentner et al., 2008, Study 2). In particular, very

109   often the feeling evoked by a sad piece of music is rated as highly pleasant by the

110   listener, a paradox which has found a lot of attention in the recent literature (Kawakami,

111   Furukawa, Katahira, & Okanoya, 2013; Taruffi & Koelsch, 2014;Vuoskoski & Eerola,

112   2017). However, it is possible that the emotions acted out on an opera stage in both

113   singing and acting has a stronger impact and is more likely to be directly mirrored in the

114   spectator's reported feelings.

115

116   3)   Investigate the possibility of empirically assessing the role of some of the

117   features outlined above in an operatic setting, in particular the effect of Listener

118   features, as described in the *routes* model, namely a) prior information/knowledge, b)

119   personality, and c) mood state. As to 1), many opera houses offer their public

introductory talks by experts before the performance, generally assuming that listening to these talks will affect the nature of the audience reaction, resulting in greater appreciation. Also, an extensive literature on the effect of musical knowledge, training, or capacity on music appreciation (see, for example, Bigand, & Poulin-Charronnat, 2006) suggests that these factors may also influence the listener's emotional reaction. Here, we experimentally varied part of the expertise/prior knowledge feature by providing an introduction either to the music or to the plot and the staging to subgroups of the participants. The important role of listener background factors like personality disposition and preferences, as well as mood *before* the performance on emotional reactions had been empirically confirmed in the study by Scherer et al. (2001/2002) and there is evidence for such effects in the literature (see, for example, Liljeström, Juslin, & Västfjäll, 2013; Hunter, Schellenberg, & Griffith, 2011). In order to examine such effects in an operatic context both personality and mood before and after the performance were assessed by questionnaire.

We describe a series of studies conducted during dress rehearsals of different operas in a major opera house to study the nature and intensity of the emotions invoked in groups of participants in the audience. We chose highly different works from the operatic repertoire to represent different types of music and plots with different characters and actions. In addition, we obtained separate data for different acts of an opera to allow comparison between different plot structures.

In all cases, the major dependent variable—emotions elicited by the operatic performance—was measured by the beta version of a new emotion assessment

144   instrument, an extended, fuzzy-set version of the Geneva Emotional Music Scale

145   (GEMS; Zentner et al., 2008): the GEneva Music-Induced Affect Checklist (GEMIAC),

146   which was developed specifically for use in field studies, including performances in

147   concert halls and opera houses (Coutinho & Scherer, 2017). The development of the

148   checklist was based on an empirical investigation of the semantic structure of the

149   relevant terms through a series of hierarchical cluster analyses. The beta version of the

150   GEMIAC (abbreviated βGEMIAC here) differs only slightly from the final published

151   version. We used this short, 12-item, fuzzy-set checklist, specifically developed for in

152   situ studies, rather than the GEMS, because there would not have been enough time

153   between acts without an intermission to rate the large number of items. We used the

154   same checklist to obtain ratings of both felt and perceived emotions.

155   Obviously, the naturalistic setting of the studies, a public opera performance in

156   an opera house, did not allow for systematic separation of the different factors outlined

157   above. Thus, there is always a specific combination of structural factors—plot, lyrics,

158   segmental and suprasegmental aspects of music, staging, performer skill, and expressive

159   intention—the respective effects of which cannot be disentangled. However, given the

160   present scarcity of empirical research in an ecologically valid music setting, it seems

161   useful to examine the following questions:

162

163   1. Can we identify specific "feeling profiles" for the affective reactions to different

164   operas and for specific acts or scenes of an opera?

165   2. Is it possible to differentiate the emotion *elicited in the spectator* by an operatic

166   performance and the emotion the spectator *perceives as being expressed* by the

167   performers?

168   3. How does concrete *prior information* about certain aspects of operatic

169   performances (music vs. plot and staging) affect the spectators' emotional

170   responses?

171   4. What are the effects of individual differences between spectators including

172   *personality and mood state* on emotion elicitation?

173

174   Although one might have hunches on what to expect regarding some of these

175 questions from plausibility and past research, we resisted the temptation to formulate

176 specific hypotheses or even expectations, given the nascent state of theorizing and

177 empirical research in the area of emotional effects of operatic performances. We hope

178 that the findings of this series of studies can establish a more solid basis for hypothesis-

179 guided future research.

180   **Method**

181 **General Procedure**

182   We invited groups of participants via advertisements placed in various public

183 spaces of the University of Geneva to attend the general dress rehearsal of selected

184 operas presented at the Grand Théâtre de Genève. We specified that prior experience

185 with opera and intrinsic interest were required because we wanted participants willing to

186 devote their full attention to the operas and the rating task rather than be motivated only

187 by the payment. In addition, to be able to generalize results to opera-attending

188 audiences, participants needed to have a minimum of understanding of the nature of the

189 operatic event under study. Many, but not all, participants were students in different

190 fields.

191   Choosing from the seasonal offerings of the Geneva Opera House, we selected

192 operas from different historical periods: a romantic opera (Giuseppe Verdi's *Macbeth*),

193 a 20th-century opera (Richard Strauss' *Der Rosenkavalier* - The Knight of the Rose or

194 The Rose-Bearer), and a contemporary opera (Giorgio Battistelli's *Richard III*). In a

195 preliminary study, we used a performance of Richard Strauss' *Elektra* (not reported

196 here). The musical and dramatic textures of these operas are highly divergent and were

197 thus expected to express and induce different emotions.

198   To manipulate expertise/prior knowledge (at least to some extent) we provided

199 prior information about the operas by dividing the groups of participants into subgroups.

200 Each of these received a 30 minute oral introduction to either the plot of the opera and

201 the staging by the director (staging group), or the musical structure as written by the

202 composer (music group). In the case of two operas, there was also a control group that

203 did not receive any prior information. Participants were able to ask questions.

204   In all cases, participants attended the dress rehearsal, that is, the final

205 performance before opening night, without any interruptions or interventions, in front a

206 full house of invited spectators. In each case, the participant group sat in a special

207 section of the first balcony, apart from the general public. They were asked to perform

208 their ratings as soon as possible after the end of the selected scene or after the curtain

209 fell after an act. There was sufficient time for the ratings to be completed. Participants

210 were asked not to interact with each other during the performance and the rating

211 periods. Two members of our group made sure that such interactions did not occur.

212

213 **Questionnaires**

214   **Emotional experience felt during the performance.** We assessed the participants'

215   emotional experience during the operas with the βGEMIAC. This emotional experience

216   questionnaire comprises 12 fuzzy emotion categories with two to three items each (see

217   Supplemental Material Online (SOM) Section A for a list of the categories and summary

218   labels as well as an example of the original questionnaire). The same questionnaire was

219   used during the selected parts and at the end of the opera, the only difference being that

220   the participants were asked to rate the *intensity* of the emotions felt during brief scenes

221   (on a 5-point scale ranging from 1 = *not at all* to 5 = *very much*) and the *frequency* at

222   which they felt these emotions during acts or the whole opera (on a 5-point scale ranging

223   from 1 = *not at all* to 5 = *frequently*). The reason for using these different formats is to

224   get at different types of information - the ratings about the feelings of emotion

225   experienced during a specific scene are measured in terms of relative intensity of the

226   reaction and are made as close in time as possible to the occurrence of the reaction (in

227   order to be clearly remembered and not superseded by new impressions and reactions).

228   This is why, in the case of operas in which we focused on individual scenes (Macbeth,

229   Richard III) we asked participants to provide intensity ratings as soon as possible after

230   the chosen scenes. In some cases we wanted to get an overall, summative evaluation about

231   the prominent feelings experienced throughout different acts (Rosenkavalier) or the opera

232   as whole (Richard III). It is unreasonable to assume that participants can recall the precise

233   intensity of the many different affective experiences during the 2-4 hours of watching the

234   operas. In consequence, we asked them to rate the frequency with which they had

235   experienced specific emotions during the act or whole opera after the final curtain fell,

236   giving them sufficient time to recall their affective experiences during the evening. Both

237   procedures are commonly used in music research, including studies of symphonies or

238   Lieder recitals. While the two ratings formats are not directly comparable, they both give

239   an indication of the relative importance or preponderance of different types of affective

240   experiences.

241   We also investigated the influence of various individual difference and context factors

242   (routes) on participants' emotional experience as follows:

243   *Personality*. Participants responded to the 13 items of the French version of the Ten-

244   Item-Personality-Inventory (TIPI: Gosling, Rentfrow, & Swann, 2003;

245   http://gosling.psy.utexas.edu/wp-content/uploads/2014/09/TIPI-French-Carlisle.doc), a

246   brief inventory for the Big Five dimensions.

247   ***Mood before and after the opera.*** Participants were asked to rate their current mood

248   before and after the opera on six 5-point, bipolar scales: Bad-good, Sad-happy,

249   Dissatisfied-content, Calm-excited, Tired-energetic, Lethargic-awake (adapted from the

250   6-item mood scale validated by Wilhelm & Schöbi, 2007).

251

252   **Description of Analyses and Results**

253   The above description summarizes the general approach across all studies. As

254   the issues examined and methodological procedures used varied slightly across studies,

255   we describe the specific purpose and the specific procedures in a brief paragraph at the

256   beginning of the report of each study. In line with the questions enumerated at the end

257   of the Introduction, analyses and results are described in four separate parts: 1) within-

258   opera analyses (participants' judgments of the intensity of emotional reactions for each

259   act/scene and frequency of specific during the opera as a whole), and 2) between-opera

260   analyses (comparison of emotion profiles across operas). 3) Information effect: the

261   effect of the manipulation of the introductory information session (plot/staging vs

262   music), and 4) Individual differences: the effects of individual differences (age, sex,

263   personality, mood) on the emotional reactions reported.

264

265   **Statistical Analyses**

266   Data were transferred from the paper questionnaires used on-site to IBM SPSS

267   (version 22) for analyses. To control for response style differences between participants,

268   we standardized the raw data (z-transforms) for each person. Even though ratings on the

269   *intensity* of specific reactions to scenes/acts and the overall *frequency* of these reactions

270   in the opera as a whole are not directly comparable, the use of standardized scores (with

271   a mean of 0 and standard deviation of 1) allows a reasonable estimate of the relative

272   importance of specific emotions in the reactions to scenes/acts versus the opera as a

273   whole. To correct significance levels for multiple comparisons (given that the 12 fuzzy

274   items are individually tested) we used the Benjamini-Hochberg (BH) procedure

275   (Benjamini and Hochberg, 1995), setting the critical value for a false discovery rate

276   (FDR) to 0.10. Only effects for which the p values were inferior to the critical level of

277   the BH procedure are reported as significant.

278

279   **Results**

280   **Within-Opera Analyses**

281   In this section, we describe the emotional experience profile for each opera and

282   its selected parts from the ratings on the 12 fuzzy categories of the emotional experience

283   questionnaire. The central purpose of this approach was to investigate the extent to

284   which different parts of an opera generate unique emotional profiles (compared to the

285   integrated overall experience at the end of the performance) and the capacity of the new

286   GEMIAC affect checklist to capture such differences. Repeated-measures analyses of

287   variance (ANOVAs) were performed for each of the data sets, according to the variables

288   measured.

289   *Study 1 - Macbeth* **(Verdi)**

290   Verdi's operas are strongly marked by his musical characterization of the

291   protagonists. The composer's lyrical inspiration and inventiveness express and represent

292   different feelings by using specific musical figures. In Verdi's operas, there is a clear

293   architectural construction of the whole drama, which creates the global environment in

294   which the protagonists live, act, and feel. In the case of *Macbeth*, the structure of the

295   plot is perfectly symmetrical, with two parts each composed of two acts and beginning

296   with a witchcraft scene. Each part has a specific emotional atmosphere: the first part is

297   characterized by love, sexual impulses, pride, and desire of power, and the second is

298   dominated by shame, guilt, sorrow, and despair. This creates a powerful contrast

299   between the stability of the general symmetry and the melodic fragmentation of the

300   music and singing. In the different contexts, the individuality of the characters is

301   represented by specific melodic lines and figures, especially by the expressive strength

302   of the voices (the orchestra instruments often simulate human vocal utterances). These

303   figures strictly adhere to the psychological reality of the protagonists, whose emotions

304   are highly variable and specific to each dramatic moment.

305   We investigated two issues in the case of this opera: (1) potential differences in

306   emotional response to different scenes of the opera (in each of three acts), and (2)

307   potential differences between the participants' *perception or inference* of the emotions

308   of the characters as intended by the composer and interpreted by the protagonists (as

309   expressed in the music/singing) versus the participants' *perception of their own*

310   *subjective experience* while listening (a factor in the analysis we will refer to as

311   *Modality*).

312   ***Procedure.*** Thirty-nine participants (72% female, mean age 27 ± 9.5 years) were

313   recruited via advertisements at the University of Geneva. Participants were invited to

314   come to a performance of *Macbeth* and were asked to complete the βGEMIAC during

315   three particular scenes (from Act I scene 7, starting with the words: "*Or tutti sorgete,*

316   *ministri infernali*"; Act II scene 5, starting with the words: "*Si colmi il calice di vino*";

317   and Act IV scene 4, starting with the words: "*Una macchia è qui tuttora!*"). For each

318   scene, participants were first asked to rate, on a scale from 1 to 5, the *intensity* of

319   emotions they *perceived* on the stage, that is, the emotions they thought the singer was

320   trying to convey, and then the *intensity* of emotions they themselves actually *felt* while

321   watching and listening. We did not randomize the order of the two questions given that

322   the expression-impression sequence seems more natural and because randomization

323   may produce artifacts unless there is a large N and a large number of trials. Participants

324   were asked to record their ratings immediately after the end of the scene.

325

326   ----Figure 1 here----

327   ----Table 1 here----

328

329   ***Results.*** The mean ratings of the intensity of both perceived and felt emotions on

330   the 12 βGEMIAC items for the three scenes in Act I, Act II, and Act IV are shown in

331   Figure 1. A repeated-measures ANOVA was carried out on the z-transformed data *for*

332   *the felt emotions only* to determine differences between the three scenes. The results are

333   shown in Table 1 (tests violating the sphericity assumption had the degrees of freedom

334   corrected as indicated in the table) together a comparison of significant differences

335   between the means (multiple comparisons corrected using the BH criterion). As

336   suggested by the patterns documented in Table 1 and Figure 1, there are significant

337   differences (with strong effect sizes) for the *felt* emotions of Sadness, Power,

338   Animation, Nostalgia, Interest, Enchantment, and Tenseness between the three focal

339   scenes in Acts I, II, and IV.

340   Scene 7/Act I generates stronger feelings of Power, Animation, and Interest than

341   do the scenes in Acts II and IV. In direct contrast, the focal scenes in Acts II (Scene 5)

342   and IV (Scene 4) produce stronger feelings of the opposite emotion classes of Sadness

343   and Nostalgia. This is easily explained by the great differences in the emotional content

344   of the scenes and the corresponding music composed by Verdi to illustrate these affects.

345   Scene 7 in Act I reveals Lady Macbeth's quest for power and royal status when she

346   urges Macbeth to kill the king during his visit to the castle. In contrast, the focal scenes

347   in Acts II and IV are both centered on emotional crises in the face of impending doom.

348   In Scene 5/Act II, Lady Macbeth, adopting a dominant stance, sings a sprightly drinking

349   song but Macbeth's developing madness is becoming noticeable. Finally, in Scene

350   4/Act IV, the Lady also realizes the full extent of evil she has brought about and the

351   impossibility of undoing the consequences.

352   The scenes in Acts I and IV produce stronger feelings of Enchantment. This can

353   be in large part explained by the large number of unusual and mysterious events

354   occurring in these acts. The opera starts in Act 1 with the powerful witch scene with the

355   enigmatic prophecy and the whole first act is dominated by mystery, both dramatically

356   and musically. Act IV is equally full of mysterious puzzling events, from the moving

357   forest to the sleep walking of Lady Macbeth.

358   Finally, the scenes in Acts I and II elicit stronger Tenseness than Scene 4 in Act

359 IV, most likely due to the suspense involved in the unfolding action and the aggressive

360 actions being planned and committed. In contrast, in Act IV, dominated by Lady

361 Macbeth's desolation and resignation, the dire end is easily predictable.

362

363   ----Table 2 here----

364   ----Figure 2 here----

365

366   To understand the relationship between perceived and felt emotions, we

367 computed a repeated-measures ANOVA with *both* the Scene/Act and Modality factors

368 (perceived vs. felt) as within-subject factors. The results (with appropriate adjustments

369 for lack of sphericity) are shown in Table 2. The main effects for Scene/Act (Table 2a)

370 are not discussed here, as the mean of the perceived and felt feelings is not of interest.

371 Strong main effects for Modality (Table 2b) are found for Power, Animation, Sadness,

372 and Nostalgia. As discernible from the patterns in Figure 1, more Power and Animation

373 is attributed to the actions and expressions of the singers, whereas more Sadness and

374 Nostalgia is felt by the participants. It is interesting that these are exactly the emotion

375 classes that showed strong main effects for scene/act differences. The interaction effects

376 yielded by the ANOVA (Table 2c) help explain this result. Again we find highly

377 significant effects with strong effect sizes for Power, Animation, Sadness, and

378 Nostalgia, as well as for Enchantment and Tenseness. In Figure 2, we plot the estimated

379 marginal means for these interactions for ease of interpretation. The graphs for Power

380 and Sadness (Figure 2, left side) clearly show that the difference between perceived and

381 felt emotions occurs in Act II. The protagonists on the stage still express Animation and

382   Power (in particular Lady Macbeth's toast is full of energy and strength), but the

383   spectator already sees what is coming and reacts with an increase in sadness.

384   The graphs for Enchantment and Tenseness (Figure 2, right side) show that it is

385   again in Act II where we find the greatest discrepancy between perceived and felt

386   emotions, most likely because the spectators can now predict how things will turn out in

387   the end. In consequence, while the protagonists, especially an apparently relaxed Lady

388   Macbeth in the enchanting drinking song (*brindisi*), remain in character, the spectators

389   feel little enchantment and much tenseness in view of the dire forebodings. In scene 4 in

390   Act IV participants perceive Lady Macbeth's sadness and tenseness but feel

391   enchantment listening to this famous aria.

392   These results illustrate the potential role of multiple mechanisms interacting in

393   the elicitation of emotions by different types of music, as suggested by Scherer and

394   Zentner's (2001) route model, in particular specific types of appraisal, contagion,

395   empathy, and entrainment. However, although the similarity between perceived and felt

396   emotions in Acts I and IV might well be linked to empathy and contagion, or even

397   entrainment, the wide divergence between perceived and felt emotions in Act II is most

398   likely due to complex appraisals of the imagined future events and their consequence

399   (see Discussion).

400

401   ***Study 2 - Richard III* (Battistelli)**

402   The opera, or "dramma per musica", as the composer prefers to call it in the

403   spirit of Monteverdi's operas, describes Richard's rise to power and throne. His ascent

404   to kingdom is made possible by an extraordinarily large number of political

405   assassinations, including those of his young nephews in the Tower of London. The

406   libretto is directly taken from Shakespeare's drama, using the original verses, but many

407   parts were cut to center the opera on the character of Richard III and his maniacal

408   ambition, which pushes him to arrange the serial murders.

409   Musically, the opera proceeds in an unbroken flow of vocal and instrumental

410   fragmented utterances, with forceful repeated figures and a few recurring themes, such

411   as the choral tribute to the newly crowned Richard at the end of Act 1. Wordless choral

412   singing accompanies the recount of the murder of the king's nephews and the scene in

413   which Richmond (Henry VII), surrounded by corpses, proclaims in a speaking voice the

414   end of the War of the Roses.

415   Battistelli's musical language is extremely dense and full of tension. The

416   orchestra, with a reinforced percussion section, deploys dark and incisive tones. The

417   vocal writing rejects every formal style, putting all the potentiality of the voice, from

418   the speaking declamation to the lyric expression, at the service of the drama, to

419   highlight the different emotional aspects of the opera.

420   In this opera we examined potential differences in emotional response to a key

421   scene and to the opera as a whole. The specific scene chosen (Act II, scene 3) contains

422   the malediction of Richard by his old mother because of the murders he committed.

423   ***Procedure.*** Forty-eight participants (73% female, mean age 26 ± 6 years) were

424   recruited via advertisements at the University of Geneva. During a performance of

425   *Richard III*, participants were given the βGEMIAC to complete during a specific scene

426   and after the whole opera. For the specific scene, participants were asked to rate the

427   *intensity* of 12 emotions they might have felt during the scene. For the whole opera,

428   they were asked to rate, after the final curtain, the *frequency* at which they felt those 12

429   emotions throughout the opera.

430   *Results.* The βGEMIAC profile means for the z-transformed data to compare the

431   ratings for scene (intensity) vs opera as a whole (frequency) are shown in Table S1 in

432   the SOM Section B and displayed in Figure 3.

433

434   ----Figure 3 here----

435

436   The Part-Opera differences cannot be analyzed with standard statistical

437   procedures for the significance of differences because the scene ratings were based on

438   intensity and the whole opera rating on the frequency of emotions. In an exploratory

439   vein, we used a profile comparison method (Deshpande, Van der Sluis, and Myers,

440   2013) to obtain some quantitative information of the differences. The results, shown in

441   Table S1 in the SOM Section B, suggest the strongest profile differences for Awe,

442   Harmony, Tenderness, Boredom. In all of these cases, the difference in the emotional

443   value between the scene and the opera is due to higher scores for the felt emotions in the

444   whole opera compared to those in the specific scene. Very high similarity is found for

445   Tenseness, Interest, Animation and Sadness, possibly due to the frightening nature of

446   the violent malediction scene that has, to some extent, affected the ratings of the whole

447   opera. As could be expected from the representation of a contemporary opera with its

448   innovative musical language, epistemic, knowledge-related emotions (astonishment,

449   curiosity, interest, wonder, surprise, doubt; see Scherer, Coutinho, 2013, p. 125) prevail

450   over other types of emotions, the dominant emotion categories in this opera being

451   Interest, Animation and the absence of Boredom.

452

453   ***Study 3 - Der Rosenkavalier* (Strauss)**

454   Hofmannsthal's libretto and Strauss' score are dominated by the Marschallin's

455 reflections and emotional feelings about the flow of time. The different scenes of the

456 opera create a sort of emotional crossover, with a crescendo of positive emotions

457 (tenderness, love, trust, joy) and a parallel decrescendo of negative emotions: The

458 Marschallin's attitudes and emotions shift from initial melancholy and sadness, and

459 even anger, to the final acceptance in Act III that the passage of time cannot be stopped.

460   In Act I, the Marschallin acknowledges with fear, sadness, and anger that time

461 relentlessly flows because each instant of the present passes irreversibly into the past.

462 For a long time, her love for the much younger Octavian had been an effort to affirm the

463 persistence of a younger emotional self inside an aging body. At the beginning of the

464 opera, with nostalgia and despair, she finally recognizes that this will no longer be

465 possible and she laments clocks and mirrors, which remind her that time is passing

466 away. At the end of the opera, she becomes conscious that life is a process, in which

467 one continuously takes, holds, and leaves pleasures and emotional experiences. The

468 heart of *Der Rosenkavalier* is the touching final trio sung by the Marschallin, Sophie,

469 and Octavian, during which the Marschallin leaves the scene to the ecstatic singing of

470 the young lovers, who can now look to a bright future together. But the Marschallin also

471 no longer looks to the past and to the flow of time, but starts to look to her own future.

472   The question addressed in studying this performance was the difference in

473 emotional response to the three acts of the opera.

474   ***Procedure.*** Eighteen participants (80% female, mean age 27 ± 7 years) were

475 recruited via advertisements at the University of Geneva. Participants were invited to

476 attend a performance of *Der Rosenkavalier* and were given the βGEMIAC

477 questionnaire to report on their emotional experiences. In this case, no specific scenes

478   were chosen but participants were asked, after each of the three acts, to rate the

479   *frequency* with which they had experienced the 12 emotion classes. The frequency

480   rating format was chosen because of the length of the acts and the variety of different

481   scenes which would have made it difficult to remember the respective intensity levels of

482   affective reactions.

483   *Results.* The βGEMIAC profiles for the there acts are displayed in Figure 4 (for

484   a listing of the main effects revealed by the repeated-measures ANOVA and the mean

485   values, see Table S2 in SOM Section B).

486

487   ----Figure 4 here----

488

489   There was a significant main effect of Part for Animation, $F(1.85, 17) = 6.24$, p

490    $= .006$, $\eta^2 = .27$, and a tendency (given the BH criterion) for Interest, $F(1.67, 17) =$

491   3.87, $p = .039$, $\eta^2 = .19$, reflecting the higher values attributed to these emotions in Act

492   II compared to Acts I and III (corroborated by significant quadratic trends in the

493   ANOVA), a result that may be due to the lively and animated scene around the

494   confrontation between Octavian and Baron Ochs and his footmen in Act II. The means

495   also suggest a continuously rising feeling of tenderness of the participants from Act I

496   and continuing across Act II to Act III (supported statistically by a significant linear

497   contrast, $F(1, 17) = 6.03$, $p = .025$, $\eta^2 = .26$). This may be due to the affectionate duet

498   between Sophie and Octavian in Act II and the compassionate finale, the Marschallin

499   gracefully renouncing her lover, encouraging him to obey his heart, upon which the two

500   young people embrace each other in a soaring duet of love.

501

Between-Opera Analyses

It is difficult to compare the differential emotional impact across the three operas as a whole, given the differences between scenes and acts within each opera as described above. However, given the major differences between the operas with respect to the period of their creation and their general style, it does seem of interest to attempt at least an approximate comparison in an exploratory fashion. As the final act of an opera is often apotheosis of the work and as spectators' ratings of the last period in the opera may partly reflect the special character of the opera as a whole, we propose to compare the ratings for the last act across the three operas (whole opera for Richard III). It should be noted that, due to the specific questions asked in each of the studies, intensity ratings were used in Macbeth and frequency ratings in *Der Rosenkavalier* and *Richard III.* Figure 5 illustrates the differential patterns in the emotional reactions to the three operas. *Der Rosenkavalier* obtained significantly higher ratings on Harmony and Tenderness, *Macbeth* received higher ratings on Sadness and Nostalgia, and *Richard III* higher ratings on Tenseness and Interest. Only Enchantment and Awe are rated in a highly similar fashion for all three operas. These patterns cannot be tested for significance with standard statistical procedures given the difference between frequency and intensity ratings. However, given the similarity of results obtained with frequency and intensity scales in the literature (Krabbe and Forkman, 2012) and the fact that the z-scores in each case indicate the relative predominance of certain emotions in a metrically comparable fashion, we used nonparametric analyses for exploratory comparison. The results for the ratings of the last act in the three operas are shown in Table S3 in SOM Section B. There are important differences for all emotions except Enchantment and Awe, confirming the excellent resolution provided by the GEMIAC scale. In particular, they show that while

526   established music evaluation dimensions like enchantment and awe do not well

527   discriminate (as all opera produce these feelings to some extent), the new scales added in

528   the GEMIAC provide clear differences for the three operas. The standardized profiles

529   shown in Figure 5 confirm the patterns found in the detailed analyses of the different

530   operas and the respective acts, providing typical profiles for the overall emotion induction

531   potential of the different works under study.

532   ----Figure 5 here----

533

534   The remainder of the article deals with questions 3 and 4, listed at the end of the

535   introduction. Given the large amount of data to be analyzed in order to respond to these

536   questions, we decided to perform the analyses with component scores following a

537   Principal Component Analysis (PCA) of the complete set of the ratings on the 12 fuzzy

538   emotion categories to facilitate comparisons and to increase the stability of the effects,.

539   The results of the PCA (Eigenvalue > 1; VARIMAX rotation) is shown in Table 3. Five

540   factors are extracted according to criterion, explaining 68% of the total variance. The

541   rotated loadings for the five components are readily interpretable and can be labelled as

542   follows: 1 Aesthetic_Enjoyment (feelings of harmony and clarity being generally

543   associated with beauty and the absence of sadness and tenseness pointing toward calm

544   enjoyment), 2 Intellectual_Challenge (animation and excitement being generated by

545   interest and discovery as well as wonder), 3 Melancholy (feelings of nostalgia and

546   sadness combined with powerlessness), 4 Awe (feelings of veneration and

547   transcendence combined with enchantment and wonder), and 5 Tender_Involvement (an

548   active, outgoing form of tenderness in the absence of bored indifference). These five

549   component scores will be used as measures of the emotional reactions of the

550   participants to the opera performances in all analyses reported in the remainder of the

551   article.

552

553   ----Table 3 here----

554

555   **Information Effects.** This section focuses on the third question for this series of

556   studies mentioned in the introduction, the potential role of receiving prior information

557   about the music or the plot/staging on the emotional effects of the opera performances.

558   We manipulated the amount of prior information by organizing introductory information

559   sessions for subgroups of the participants.

560

561   *Methods.*

562   As in the normal introductory talks organized by the Grand Théâtre for its visitors,

563   we organized three different introductory talks in separate rooms at the opera house, one

564   on the plot of the respective opera and the staging by the director given by the chief

565   dramaturge of the Geneva opera and one on the special characteristics of the music and

566   the composer by a musicologist regularly involved in such introductory sessions. The

567   duration of each of these talks was approximately 30 minutes, allowing for questions from

568   the audience. The same experimental design was used for the performances of Macbeth

569   and Richard III - introductions to plot/staging, music/composer, and a control group

570   receiving no information (see details under General Methods; Rosenkavalier had been

571   excluded because of the small number of participants).

572   In the interest of economy of space and ease of understanding, we used only the

573   data for opera as a whole for Richard III and for Act IV for Macbeth), using the emotion

574   rating component scores (based on the PCA) for this analysis. As shown in table S4 in

575   SOM Section B) the results of the multivariate ANOVAs for the information session

576   manipulation did not yield a single significant result. The effect sizes were generally very

577   low. The multivariate Fs were also far from significance. These results suggest that

578   receiving information during a brief 30 minute introduction to the opera, either on

579   plot/staging or music, may not be sufficiently powerful to affect the emotional experience

580   of people during the opera.

581

582   **Individual Differences.** Question 4 to be examined in this series of studies, as

583   mentioned in the introduction, concerns the prediction by the *route model* that the

584   emotions elicited by the opera might depend on dispositional and situational individual

585   differences due to factors such as personality and mood. As in the preceding analyses, we

586   decided to examine this question by combining the data across the three operas, to be able

587   to generalize results and increase statistical power. Here we also used the component

588   scores for the emotion ratings to reduce the amount of information to be processed.

589

590   *Age and gender.* We ran an ANOVA on the component scores for the emotion

591   ratings (Table S5 in the SOM Section B) with age category (< 25 versus > 25) and

592   gender as between subject factors. There was a significant difference in gender for the

593   category Aesthetic-Enjoyment ($F = 14.67$, $p < .001$, partial eta$^2 = .13$), with males

594   feeling more "calm enjoyment" than females. There were, however, no differences

595   between the two age categories, and no interaction effect of age and gender.

596

597   ***Personality.*** Before examining the correlations between the emotion ratings and

598   personality, a PCA was run on the personality items to check if they could be grouped as

599   general traits. The analysis extracted 5 components out of the 13 personality items (see

600   table S6 in the SOM Section B), which, as expected given that the TIPI scale is based on

601   the Big Five tradition, match the Big-Five traits: Openness (items open, critical and not

602   reserved), Discipline (items disciplined, health oriented and organized), Extraversion

603   (likeable and extraverted), Conformity (conventional and not rebellious) and Emotional

604   stability (calm, independent and not anxious). We then looked at the correlations between

605   the component scores for the emotion ratings and the component scores for the personality

606   dimensions (Table S7 in the SOM Section B; including the information on a

607   bootstrapping option). The results revealed only one significant correlation between the

608   emotion component Awe and the personality dimension Openness ($r = .33$, $p = .001$, 95%

609   C.I. = .16 - .49), suggesting that people who scored high on the Openness dimension were

610   more fascinated during the performance than other spectators.

611

612   ***Mood.*** We also ran a PCA on the mood items (see table S8 in the SOM Section B),

613   and extracted three components (largely compatible with the findings of Wilhelm &

614   Schöbi, 2007), which we labeled as follows: Mood-Positive, Mood-Active and Mood-

615   Excited. We found three correlations between the component scores for the mood ratings

616   *before* the performance and the component scores for the emotion items (see table S9 in

617   the SOM Section B, including information on a bootstrapping option). Mood-Excited was

618   negatively correlated with Aesthetic-Enjoyment ($r = -.25$, $p = .01$, 95% C.I. = -.42 − -

619   .06), suggesting that the more excited a listener was before the performance, the less

620   sensitive he or she was to the aesthetics of the performance. Mood-Active was also

621   negatively correlated with Melancholy (r = -.26, p = .007, 95% C.I. = -.42 − -.09).

622   Although a correlation does not establish causality, it is possible that the more active a

623   person was before the opera, the less melancholic they would feel while listening

624   (melancholy being generally associated with passivity); finally, Mood-Positive was

625   negatively correlated with Awe (r = -.33, p = .001, 95% C.I. = -.51 − -.13), meaning that

626   people who were in a positive mood before the performance felt less impressed by it. As

627   to the mood ratings *after* the performance, only one significant correlation emerged --

628   interestingly exactly the same as the correlation with mood before the performance -

629   Mood-Excited After was also negatively correlated with Aesthetic-Enjoyment to about

630   the same extent (r = -.26, p = .01, 95% C.I. = -.42 − -.10), suggesting that the excited

631   listeners were somewhat less affected by the performance, possibly being less sensitive

632   to the aesthetics of the performance. These results demonstrate the need to further

633   investigate the special role of aesthetic and epistemic emotions in the domain of music

634   appreciation (Scherer, 2004).

635

636

637   **Discussion**

638   Our first question was whether we could identify specific emotion profiles for

639   different operas and for specific acts or scenes of an opera by using an in situ approach

640   and asking a group of participants to record their reactions on a dedicated checklist. The

641   results strongly indicate that this is indeed the case. There were major, and clearly

642   interpretable, differences in participants' emotional reactions to the different operas, as

643   well as differences between acts and scenes within each opera, particularly in the case

644   of *Macbeth*, where the different acts elicited different emotions, such as power and

645   animation (Act I) and sadness and tenseness (Acts II and IV). Significant differences

646   were also found for *Richard III* (more enchantment and interest for the opera as a

647   whole) and *Der Rosenkavalier* (higher animation and interest in Act II and a linear trend

648   for increasing tenderness across the three acts of the opera).

649   Our second question was whether we could differentiate the emotion elicited in

650   the spectator and the emotion perceived as expressed by the music and the performance.

651   This is important in the light of critical evaluations of research on music and emotion

652   which often claim that participants basically report what they feel the music expresses

653   rather than their own feelings. As mentioned in the Introduction the danger of this

654   confusion is all the more serious in opera, given the explicit role of emotion displays in

655   the plot and interpretation of the singers. However, our results for Macbeth echo the

656   earlier findings showing a large degree of independence of these two aspects. Thus, the

657   sleepwalking aria in Scene 4 of Act IV is seen as expressing high tenseness and sadness

658   on the part of Lady Macbeth, which is partly reflected in the participants own feelings,

659   but the aria is also experienced by them as very enchanting. We also find the opposite

660   pattern - joyful music producing tenseness: During the brindisi scene in Act II

661   participants perceive the expression of high power and enchantment but feel themselves

662   high tenseness and sadness, presumably because they are appraising the dire

663   consequences to be expected in the future.

664   A recent study highlighted empathy as a possible link between perceived and felt

665   emotions in music (Egermann & McAdams, 2013). The findings suggest that

666   participants with higher scores for empathy saw the difference between their felt and

667   perceived scores diminished (see also Miu & Balteş, 2012). Our results for *Macbeth* are

668   compatible with this pattern: The high level of perceived power/animation (and the low

669 level of sadness/nostalgia) perceived in Lady Macbeth's expression of determination to

670 act in Act I scene 7 seems to be shared by the participants. Empathy and similar

671 mechanisms may indeed be partly responsible for this similarity between perceived and

672 felt feeling -- possibly due to the ratings of participants with high dispositional empathy.

673 As suggested by Scherer & Coutinho (2013, p. 140) the induction mechanisms are

674 numerous and ubiquitous and can be recruited in various combinations at several levels

675 of the emotion induction process.

676   The results for our third question showed that in this case there was no significant

677 effect of introduction/prior information (i.e., receiving a briefing on music or plot/staging

678 compared to a control group) on the emotions attributed to the different parts of the

679 operas. It is possible that the introductions of about 30 minutes were too short to be

680 effective, although they were delivered by professionals who generally animate such

681 sessions for the opera public (for about the same length of time). Clearly, this negative

682 finding would need to be replicated before drawing any further conclusions. One

683 possibility might be that in music and opera the knowledge domain does not directly

684 impact on the affect domain. It is interesting, though, that previous studies found no

685 differences in emotional experience between music experts and non-experts (with a much

686 greater degree of knowledge and expertise involved; Bigand, Vieillard, Madurell,

687 Marozeau, & Dacquet, 2005).

688   We found some interesting effects of individual differences on the emotional

689 ratings. First, male participants felt more aesthetic enjoyment (which comprises calm,

690 harmony, and absence of tenseness and sadness) than females. We can only speculate

691 why this is so. Maybe it is linked to findings showing that females often respond in more

692   empathetic fashion to music than males, privileging the underlying social relationships

693   (Egermann & McAdams, 2013; Balteş & Miu 2014).

694   As predicted by the *route model* outlined in the Introduction, we found significant

695   effects of mood and personality on the emotional reactions. The participants' mood before

696   the performance affected their emotional experience during the different operas. People

697   who were in an excited mood before the opera felt less aesthetic enjoyment. This is

698   probably explained by the fact that, as shown before, aesthetic enjoyment is part of a

699   "calm" dimension that includes the absence of tenseness and sadness). People who were

700   in a positive mood before felt less awe during the performance which suggests that

701   generally positive mood is not necessarily conducive to being awed by transcendence or

702   the sublime. Similarly, people who were in an active mood before the opera felt less

703   melancholy during the performance.

704   Personality variables correlated only weakly with participants' affective reactions.

705   However, there was a significant positive correlation between Openness and the feeling

706   of Awe. This corresponds to the finding that individuals who generally score high in

707   Openness on the Big5 personality inventory tend to be particularly sensitive to art and

708   beauty (McCrae, 2007), suggesting that opera spectators with a high degree of Openness

709   to experience might be more sensitive to non-functional qualities of music involving

710   transcendence, the sublime, and awe.

711

712   *Limitations*. This study has a number of limitations, mainly related to the lack of

713   complete experimental control. However, it seems virtually impossible to impose

714   stringent controls in settings such as a performance in a big opera house. To empirically

715   study the elicitation of emotion by operatic performances in situ, one has to accept the

716   inherent limitations of ecological settings, as there is no other option for obtaining

717   reactions of the public to a live performance. We also used groups of paid participants,

718   mostly young people, rather than the usual population of opera visitors with a higher

719   age level. Although this limits generalizability, it also has a positive effect: the absence

720   of habitual preferences. Our participants were interested in and somewhat

721   knowledgeable about opera but they did not participate in the study because they

722   particularly liked one of the operas. This makes the ratings much more comparable than

723   would be the case with unselected members of a normal audience who may often have

724   chosen to attend because of their preferences or social habits.

725   There is also an inherent limitation because it is impossible to use the same rating

726   format to get the intensities of different emotions experienced during a brief scene that

727   just ended and to get a summary assessment of the frequency with which different

728   emotions have been experienced throughout a complete opera. This means that it is

729   impossible statistically to compare directly the difference in impact between scenes and

730   whole operas. We have standardized the different measures and analyzed them

731   separately, interpreting both of them in terms of the relative importance or prevalence of

732   certain emotions.

733   **Conclusion**

734   A rapidly growing number of experimental laboratory studies of musically

735   induced emotions, generally using recordings of different types of instrumental or

736   synthetic music, are providing major additions to our knowledge about the underlying

737   mechanisms, especially concerning the role of musical structure or architecture in terms

738   of form, timing, rhythm, or tonal structure. The experimental manipulation of some of

739   these factors allows rigorous testing of specific hypotheses. However, if it is generally

740   difficult to transpose real-life issues into the laboratory in an ecologically valid fashion,

741   it is all the more difficult in the case of emotional effects of music, for which the

742   performance aspect is a central ingredient. This is especially the case for opera as

743   *Gesamtkunstwerk,* in which drama, stage setting and lighting, dynamic movement of the

744   protagonists on the stage, affect expression in speech, singing and face/body

745   movements, and powerful embedding in the music played by a large orchestra all

746   contribute to the overall emotional effect. Although large-scale video projections in a

747   university lecture hall can provide an approximation of the overall setting and the

748   performance of singers and musicians (see Coutinho & Scherer, 2016, for a comparison

749   of a church setting for Lieder with a video reproduction in an auditorium), it is highly

750   desirable to study the phenomenon in an authentic performance context, such as an

751   opera house.

752   A major impediment for studies of this sort has been the nature of the

753   measurement instruments for emotional reactions (e.g., the widely used GEMS scale;

754   Zentner et al., 2008), which generally require participants to describe their affective

755   reactions on a large number of items. The work reported in this article has employed the

756   beta version of the new GEMIAC checklist (Coutinho & Scherer, 2017), specifically

757   developed to be used in the framework of in situ music performances in different public

758   settings. The GEMIAC consists of a checklist with a small number of fuzzy-set items,

759   fitting on a single page but representing the major dimensions of emotions likely to be

760   elicited by different kinds of music performances, including aesthetic emotions. It is

761   particularly well suited to be used during brief pauses in musical works to obtain ratings

762   of emotional reactions that are as close as possible to the musical stimuli that produced

763   them. The checklist can even be employed in a dynamic fashion to capture audience

764   reactions on the fly (as demonstrated in a recent concert given by a well-known string

765   quartet with over 200 spectators who recorded their emotions online as they occurred in

766   the course of the music).

767   As indicated in the introduction, in the absence of appropriate research models

768   the current work was conceived as an exploratory venture rather than as a test of

769   specific hypotheses. However, the results reported above can be used to address a

770   certain number of questions and hypotheses posed in the literature. Below, we

771   summarize the contributions of this research to the field.

772   On the methodological side, the GEMIAC has fully confirmed the hopes that the

773   developers had entertained: Participants completed their ratings reliably and in very

774   short periods of time. They showed themselves highly satisfied with the procedure,

775   especially the fact that there was only a minimal interruption of the enjoyment of the

776   musical event. It is to be hoped that the availability of this new tool will generate an

777   increasing number of empirical studies of emotional reactions to different kinds of

778   music performances in naturalistic settings.

779   Importantly, our results show that the relatively small number of fuzzy-set

780   emotion descriptions is largely sufficient to differentiate the affective reactions that

781   were targeted in this research. One important issue was to trace the differences in

782   emotional response to different parts of an opera and different operas. The results show

783   very marked differences in the relative importance or prevalence of certain emotions

784   between different acts for Macbeth and between a central scene and the opera as a

785   whole for Richard III demonstrating the fine resolution provided by the instrument and

786   the dynamic affective sensitivity of the spectators. One remarkable finding is the

787   prevalence of epistemic emotions for Battistelli's opera Richard III with its resolutely

788   contemporary musical score eliciting strong interest (and, correspondingly, the absence

789   of boredom). Another result that shows the high resolution of the rating scales is the

790   strong increase in feelings of tenderness across the three acts of Der Rosenkavalier, very

791   much in line with musicological analyses of the music (especially in the final scene). In

792   response to question 1) at the end of the introduction, we found that we could indeed

793   identify specific "feeling profiles" for the affective reactions to different operas and for

794   specific acts or scenes of an opera.

795   As to question 2), the results for Macbeth show that we can differentiate the

796   emotion *elicited in the spectator* by an operatic performance and the emotion the

797   spectator *perceived as being expressed* by the performers. This is particularly important

798   with respect to the mechanisms of emotion elicitation suggested in the *route* or

799   BRECVEM models and the various hypotheses proposed in different contributions to

800   the literature. One particularly popular hypothesis is that felt emotions almost always

801   correspond to expressed emotions, due to entrainment, congruent appraisal, contagion

802   or empathy. While the results for Acts I and IV or Macbeth would be consistent with

803   any of these explanations, Act II really stands out as the felt emotions are essentially

804   diametrically opposite to the emotions expressed by the protagonists in the opera, ruling

805   out entrainment, contagion, or direct empathy based on expression. We have suggested

806   that this discrepancy may be due to the spectators see the impending disaster coming,

807   implying a predictive empathic appraisal process. Further theoretical and empirical

808   work is needed to more clearly define the potential mechanisms and develop appropriate

809   research designs to examine these.

810   The effect of prior information (concerning the music vs. plot/staging) on the

811   affective responses to the performance, Question 3), seems to be negligible. One might

812   have assumed that a detailed introduction to the plot would favor empathy or appraisal

813   mechanisms but that does not seem to be the case. This does not mean that the

814   introductory information sessions organized by many opera houses just before a

815   performance are without effect and thus superfluous – they may well have an important

816   effect on cognitive appreciation and thus be an important aspect of the overall

817   enjoyment of a visit to the opera and increase in general culture.

818   Finally, on question 4, the potential effects of individual differences between

819   spectators, including personality and prior mood, on emotion elicitation, our results

820   suggest that these may be less important than generally believed, although we found

821   some interesting leads that are worth pursuing. However, we only scratched the surface

822   of potentially important individual differences such as musicianship, musical capacity,

823   music preferences and motivations for music use. Recently a new modular tool to

824   broadly assess participant background for music research has become available

825   (MUSEBAQ; Chin, Coutinho, Scherer, & Rickard, in press) which can greatly facilitate

826   future research and provide for better comparability of the samples in different studies.

827   Overall, the empirical examination of the route model of emotion induction via

828   music of different genres requires a combination of laboratory approaches with in situ

829   studies; allowing the assessment of complex interactions between the different

830   determinants specified by the model. Future research needs to use more experimentally

831   controlled methods to chart some of the most important routes and our results suggest

832   the need to consider that several mechanisms may be active depending on different

833   conditions. Our results confirm, in a real-life musical setting, earlier findings of the

834   important differences between emotions felt while listening to music from emotions

835   simply perceived or inferred from salient features of the music or the performance. This

836 does not mean that these are entirely independent as they may well influence each other

837 (e.g., via interactions between the different induction routes, see Scherer & Coutinho,

838 2013). Further work on the nature of these induction mechanisms will need to

839 disentangle these complex processes -- a discovery process that will require both

840 controlled laboratory and in situ research at public music venues.

841   A major desideratum for future work is to further differentiate the nature of the

842 affective reactions produced by music. Given that the generic term "emotion" often

843 leads to confusion in the sense of implying rather strong reactions, such as "basic"

844 emotions, it is important to fine-tune the dependent measures in this research tradition.

845 Konečni (2008) has rightly pointed out that music can produce a whole panoply of

846 cognitive, affective, and physiological reactions that should be distinguished. In

847 addition, the need to acknowledge the central role of aesthetic feelings and music-

848 specific affective reactions has been highlighted for some time (Konečni, 2005; Scherer,

849 2004; Scherer & Zentner, 2008). There have been recent efforts to systematically chart

850 the semantic space of aesthetic emotions (Hosoya, Schindler, Beermann, Wagner,

851 Menninghaus, Eid, & Scherer, in press). This work has allowed the development of a

852 new scale to measure aesthetic emotions in response to different works of art, including

853 music – the Aesthetic Emotions Scale (AESTHEMOS). With 21 subscales the

854 instrument covers prototypical aesthetic emotions (e.g., the feeling of beauty, being

855 moved, fascination, and awe), epistemic emotions (e.g., interest and insight), emotions

856 indicative of amusement (humor and joy), negative emotions (e.g., the feeling of

857 ugliness, boredom, and confusion) as well as activating (energy and vitality) and the

858 calming (relaxation) effects of aesthetic experience (Schindler, Hosoya, Menninghaus,

859 Beermann, Wagner, Eid., & Scherer, 2017).

860   We conclude that, given the scarcity of available models and the exploratory

861   nature of the current research, our findings need to be replicated and extended in future

862   research on different types of music, including vocal music and especially opera. We

863   feel that restricting research on music and emotion to instrumental (pure or absolute)

864   music is stifling progress in this field, especially that all types of music need to be

865   performed by musicians and singers in a certain physical place (or on electronic media).

866   In consequence, the effects of the "pure" music can never be separated from the effects

867   of interpretation and local context. In addition, listeners will always differ in terms of

868   social-demographic variable, personality, mood, prior information and expertise and

869   these will obviously color their emotional experiences. In consequence, studies in this

870   area need to make much more of effort to capture all potential variables of influence and

871   determine their relative effect size and the nature of their interaction. We believe that

872   with the work reported here we have shown that this kind of in situ research is possible

873   and promising, especially as new instruments become regularly available.

874

References

875

876   Balteş, F. R., & Miu, A. C. (2014). Emotions during live music performance: Links

877   with individual differences in empathy, visual imagery, and mood.

878   *Psychomusicology: Music, Mind, and Brain*, *24*, 58–65.

879   doi:10.1037/pmu0000030

880   Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical

881   and powerful approach to multiple testing. *Journal of the Royal Statistical*

882   *Society Series B*, *57*, 289300.

883   Bhatara, A., Laukka, P., & Levitin, D. J. (2014). Expression of emotion in music and

884   vocal communication: Introduction to the research topic. *Frontiers in*

885   *Psychology (Emotion Science), 5*, 1-294, doi 10.3389/978-2-88919-263-2.

886   Bigand, E., & Poulin-Charronnat, B. (2006). Are we "experienced listeners"? A review

887   of the musical capacities that do not depend on formal musical training.

888   *Cognition, 100(1)*, 100-130.

889   Bigand, E., Vieillard, S., Madurell, F., Marozeau, J., & Dacquet, A. (2005).

890   Multidimensional scaling of emotional responses to music: The effect of musical

891   expertise and of the duration of the excerpts. *Cognition and Emotion, 19(8)*,

892   1113-1139.

893   Chin, T.C., Coutinho, E., Scherer, K. R., & Rickard, N. S. (in press). MUSEBAQ: A

894   modular tool for music research to assess musicianship, musical capacity, music

895   preferences and motivations for music use. *Music Perception*.

896   Cochrane, T., Fantini, B. & Scherer K. R. (2013). *The emotional power of music*.

897   Oxford: Oxford University Press, United Kingdom.

898 Cohen, A. J. (2016). Music in performance arts: Film, theatre and dance. In S. Hallam,

899   I. Cross, & M. Thaut (Eds.), *Oxford handbook of music psychology* (2nd ed., pp.

900   725–743). Oxford, United Kingdom: Oxford University Press.

901 Coutinho, E., & Scherer, K. R. (2016). Emotions induced by music in natural and

902   laboratory contexts: The role of performance and contextual factors. Psychology

903   *of Music*, published online October 26, 2016. doi: 10.1177/0305735616670496.

904 Coutinho, E., & Scherer, K. R. (2017). Introducing the GEneva Music-Induced Affect

905   Checklist (GEMIAC): A Brief Instrument for the Rapid Assessment of

906   Musically Induced Emotions. *Music Perception, 34(4),* 371-386.

907 Deshpande, R., Van der Sluis, B., & Myers, C. L. (2013) Comparison of Profile

908   Similarity Measures for Genetic Interaction Networks. *PLoS ONE 8(7):* e68664.

909   doi:10.1371/journal.pone.0068664

910 Egermann, H., & McAdams, S. (2013). Empathy and emotional contagion as a link

911   between recognized and felt emotions in music listening. *Music Perception*, *31*,

912   139–156. doi:10.1525/mp.2013.31.2.139

913 Evans, P., & Schubert, E. (2008). Relationships between expressed and felt emotions in

914   music. *Musicae Scientiae*, *12*, 75–99. doi:10.1177/102986490801200105

915 Gosling, S. D., Rentfrow, P. J., & Swann, W. B., Jr. (2003). A Very Brief Measure of the Big

916   Five Personality Domains. *Journal of Research in Personality, 37,* 504-528.

917   http://dx.doi.org/10.1016/S0092-6566(03)00046-1

918 Hosoya, G., Schindler, I., Beermann, U., Wagner, V., Menninghaus, W., Eid, M., &

919   Scherer, K. R. (2017). Mapping the conceptual domain of aesthetic emotion

920   terms: A pile-sort study. *Psychology of Aesthetics, Creativity, and the Arts*.

921   Advance online publication. http://dx.doi.org/10.1037/aca0000123.

922 Hunter, P. G., Schellenberg, E. G., & Griffith, A. T. (2011). Misery loves company:
923   mood-congruent emotional responding to music. *Emotion, 11(5)*, 1068.

924 Hunter, P. G., Schellenberg, E. G., & Schimmack, U. (2010). Feelings and perceptions
925   of happiness and sadness induced by music: Similarities, differences, and mixed
926   emotions. *Psychology of Aesthetics, Creativity, and the Arts*, *4*, 47–56.
927   doi:10.1037/a0016873

928 Juslin, P. N., Liljeström, S., Västfjäll, D., Barradas, G., & Silva, A. (2008). An experience
929   sampling study of emotional reactions to music: listener, music, and situation. *Emotion*,
930   *8*(5), 668. http://dx.doi.org/10.1037/a0013505

931 Juslin, P. N., & Sloboda, J. A. (2011). *Handbook of Music and Emotion: Theory,*
932   *Research, Applications*. Oxford, United Kingdom: Oxford University Press.

933 Juslin, P. N., & Västfjäll, D. (2008). Emotional responses to music: The need to
934   consider underlying mechanisms. *Behavioral and Brain Sciences*, *31*, 559–575.
935   doi:10.1017/S0140525X08005293

936 Kallinen, K., & Ravaja, N. (2006). Emotion perceived and emotion felt: Same and
937   different. *Musicae Scientiae*, *10*, 191–213. doi:10.1177/102986490601000203

938 Kawakami, A., Furukawa, K., Katahira, K., & Okanoya, K. (2013). Sad music induces
939   pleasant emotion. *Frontiers in Psychology, 4:311,* 1-16. doi:
940   10.3389/fpsyg.2013.00311

941 Kivy, P. (1990). *Music Alone: Philosophical Reflections on the Purely Musical*
942   *Experience*. Cornell, US: Cornell University Press.

943 Konečni, V.J. (2005). The aesthetic trinity: awe, being moved, thrills. *Bulletin of*
944   *Psychology and the Arts 5(2)*, 27–44.

945   Konečni, V. J. (2008). Does music induce emotion? A theoretical and methodological

946   analysis. *Psychology of Aesthetics, Creativity, and the Arts, 2(2)*, 115-129.

947   Konečni, V. J., Brown, A., & Wanic, R. A. (2008). Comparative effects of music and

948   recalled life-events on emotional state. *Psychology of Music, 36(3),* 289–308.

949   Krabbe, J., & Forkmann, T. (2012). Frequency vs. intensity: which should be used as

950   anchors for self-report instruments? *Health and Quality of Life Outcomes, 10,*

951   *107.* http://doi.org/10.1186/1477-7525-10-107

952   Liljeström, S., Juslin, P. N., & Västfjäll, D. (2013). Experimental evidence of the roles

953   of music choice, social context, and listener personality in emotional reactions to

954   music. *Psychology of Music, 41(5),* 579-599.

955   McAdams, S., Vines, B. W., Vieillard, S., Smith, B. K., & Reynolds, R. (2004).

956   Influences of large-scale form on continuous ratings in response to a

957   contemporary piece in a live concert setting. *Music Perception*, *22*, 297–350.

958   doi:10.1525/mp.2004.22.2.297

959   McCrae, R. (2007). Aesthetic chills as a universal marker of openness to experience.

960   *Motivation and Emotion, 31(1),* 5–11.

961   Miu, A. C., & Balteş, F. R. (2012). Empathy manipulation impacts music-induced

962   emotions: A psychophysiological study on opera. *PloS One*, *7*, e30618.

963   doi:10.1371/journal.pone.0030618

964   Scherer, K. R. (2004). Which emotions can be induced by music? What are the

965   underlying mechanisms? And how can we measure them? *Journal of New Music*

966   *Research, 33(3)*, 239-251.

967   Scherer, K. R., & Coutinho, E. (2013). How music creates emotion: A multifactorial

968   approach. In T. Cochrane, B. Fantini, & K. R. Scherer (Eds.), *The emotional*

969 *power of music* (pp. 122–145). Oxford: Oxford University Press, United

970 Kingdom.

971 Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules.

972 In P. N. Juslin & J. A. Sloboda (Eds.), *Music and Emotion: Theory and*

973 *Research* (pp. 361–392). Oxford, United Kingdom: Oxford University Press.

974 Scherer, K. R., & Zentner, M. (2008). Music evoked emotions are different–more often

975 aesthetic than utilitarian. *Behavioral and Brain Sciences, 31*, 595-596.

976 Scherer, K. R., Zentner, M. R., & Schacht, A. (2001-2002). Emotional states generated

977 by music: An exploratory study of music experts. *Musicae Scientiae*, *5*(Suppl.

978 1), 149–171. doi:10.1177/10298649020050S106

979 Schindler, I., Hosoya, G., Menninghaus, W., Beermann, U., Wagner,V., Eid, M., &

980 Scherer, K. R. (2017) Measuring aesthetic emotions: A review of the literature

981 and a new assessment tool. *PLoSONE, 12(6):e0178899.*

982 https://doi.org/10.1371/journal.pone.0178899

983 Taruffi, L., & Koelsch, S. (2014). The paradox of music-evoked sadness: an online

984 survey. *PLoS ONE 9(10): e110490*. https://doi.org/10.1371/journal.pone.0110490

985 Vaitl, D., Vehrs, W., & Sternagel, S. (1993). Prompts-leitmotif-emotion: Play it again,

986 Richard Wagner. In N. Birbaumer & A. Ohman (Eds.), *The structure of emotion:*

987 *Psychophysiological, cognitive, and clinical aspects* (pp. 169–189). Seattle, WA:

988 Hogrefe & Huber.

989 Vuoskoski J. K., & Eerola, T. (2017). The pleasure evoked by sad music is mediated by

990 feelings of being moved. *Frontiers in Psychology, 8, 439*;

991 URL=http://journal.frontiersin.org/article/10.3389/fpsyg.2017. doi:

992 10.3389/fpsyg.2017.00439

993   Wilhelm, P., & Schöbi, D. (2007). Assessing mood in daily life. *European Journal of*

994   *Psychological Assessment*, *23*(4), 258-267. doi: http://dx.doi.org/10.1027/1015-

995   5759.23.4.258

996   Zentner, M., Grandjean, D., & Scherer, K. R. (2008). Emotions evoked by the sound of

997   music: Characterization, classification, and measurement. *Emotion*, *8*, 494–521.

998   doi: http://dx.doi.org/10.1037/1528-3542.8.4.494

999

1000

1001 **Figure captions**

1002 *Figure 1*. Mean *z*-scores for each emotion term during Act I scene 7 (top), Act II scene 5

1003 (middle), and Act IV scene 4 (bottom) of *Macbeth*. The diamonds show the emotions perceived,

1004 and the squares show emotions felt by the listeners.

1005

1006 *Figure 2*. Graphic illustration of the interaction effects between Act and Quality (perceived vs.

1007 felt emotions) in *Macbeth* for four emotion categories (Power, Sadness, Enchantment, and

1008 Tenseness).

1009

1010 *Figure 3*. Mean *z*-score profile for each emotion word in the selected scene (diamonds) and the

1011 whole opera (squares) in *Richard III*.

1012

1013 *Figure 4*. Mean *z*-scores for each emotion term in the three parts: Act II (diamonds), Act III

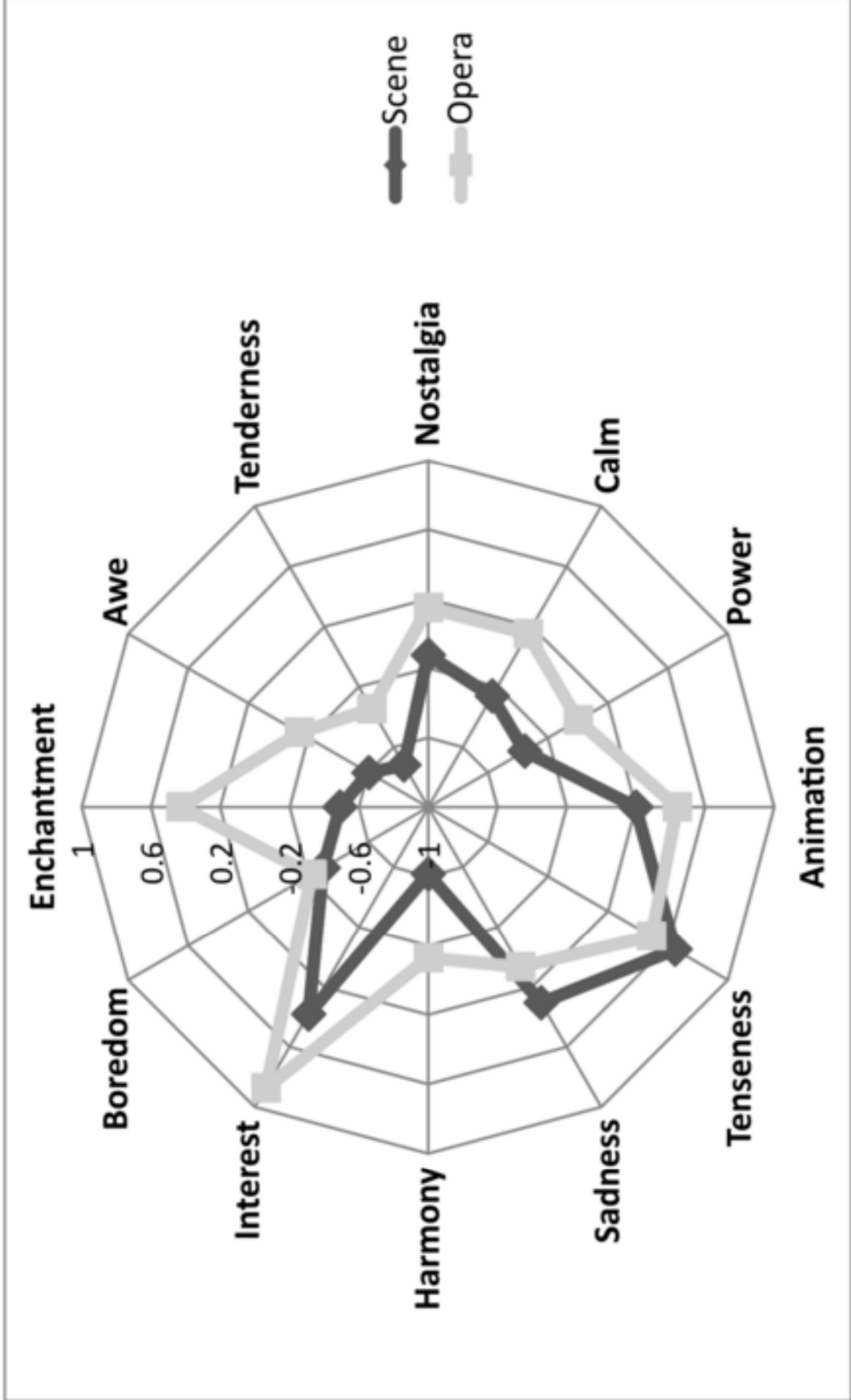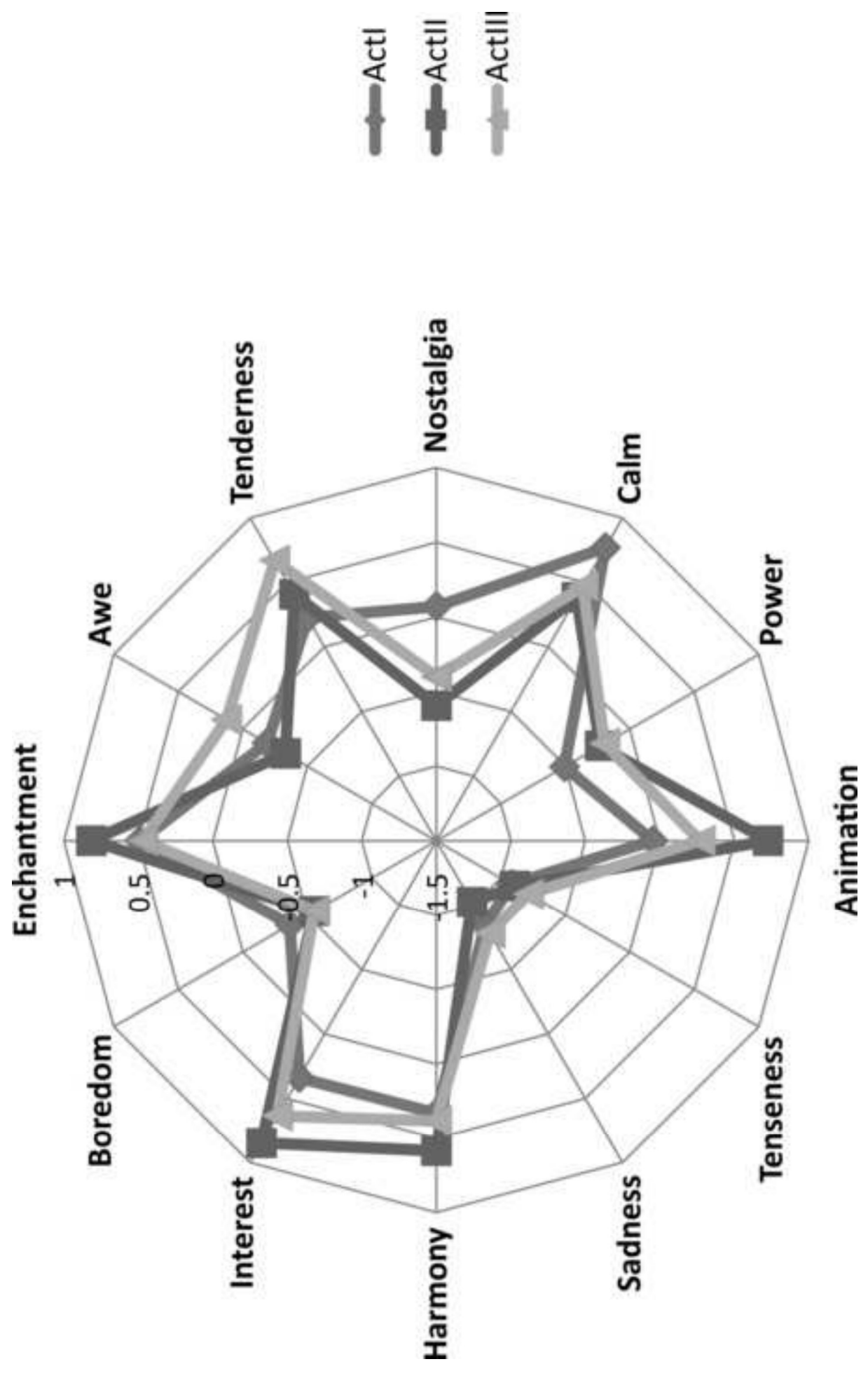1014 (squares), and whole opera (triangles) in *Der Rosenkavalier*.

1015

1016 *Figure 5*. Emotional profiles for the final rating period of the three operas for the emotion

1017 categories: Macbeth (circles), Richard III (diamonds), and Rosenkavalier (triangles).

1018

Act I, Scene 7

Act II, Scene 5

Act IV, Scene 4

Figure

Figure

Figure

Figure

- Macbeth, Act IV
- Richard III, Opera
- Rosenkavalier, Act III

Tenderness
Nostalgia
Calm
Awe
Power
Enchantment
1.2
0.8
0.4
0
-0.4
-0.8
Animation
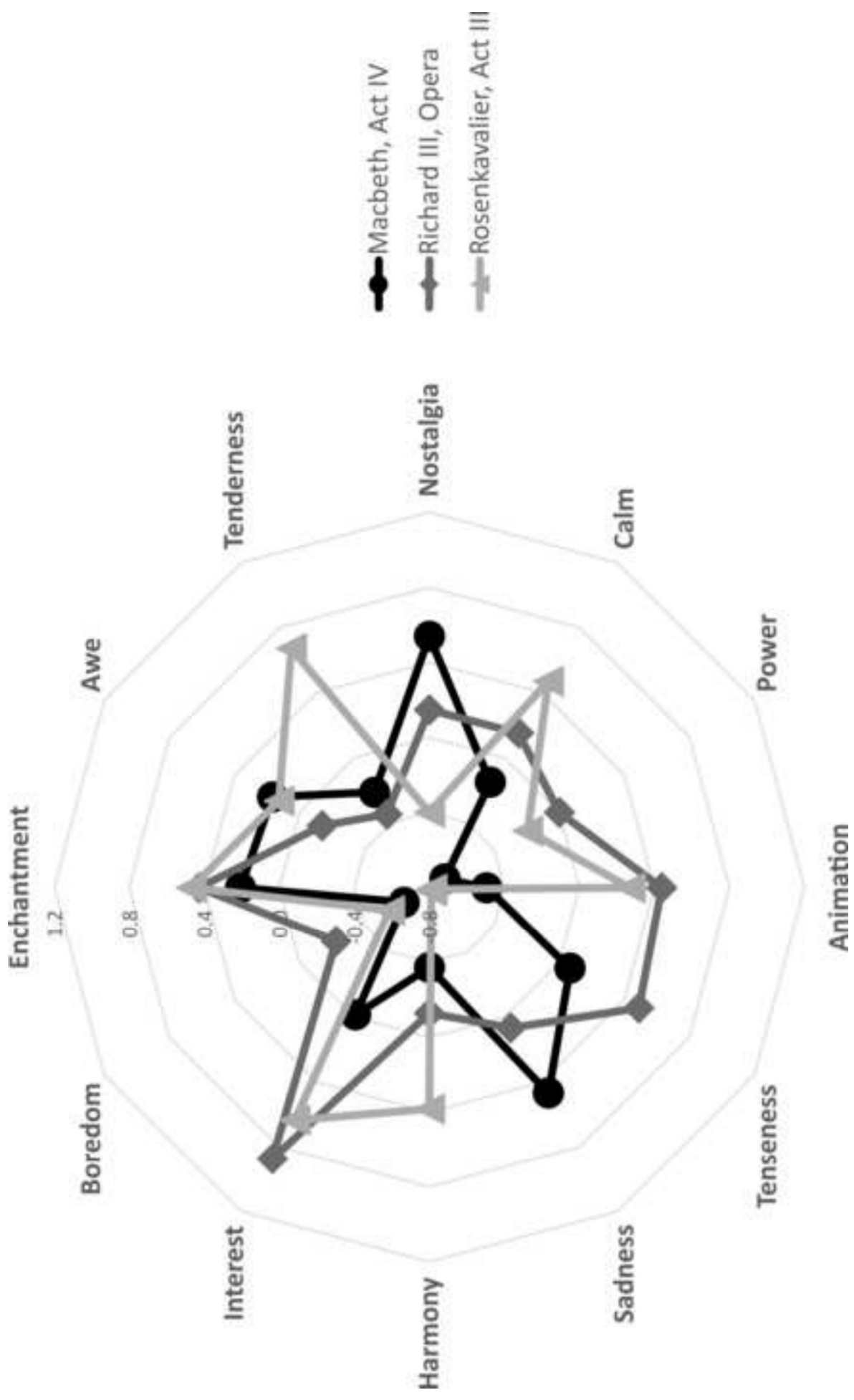Boredom
Tenseness
Interest
Sadness
Harmony
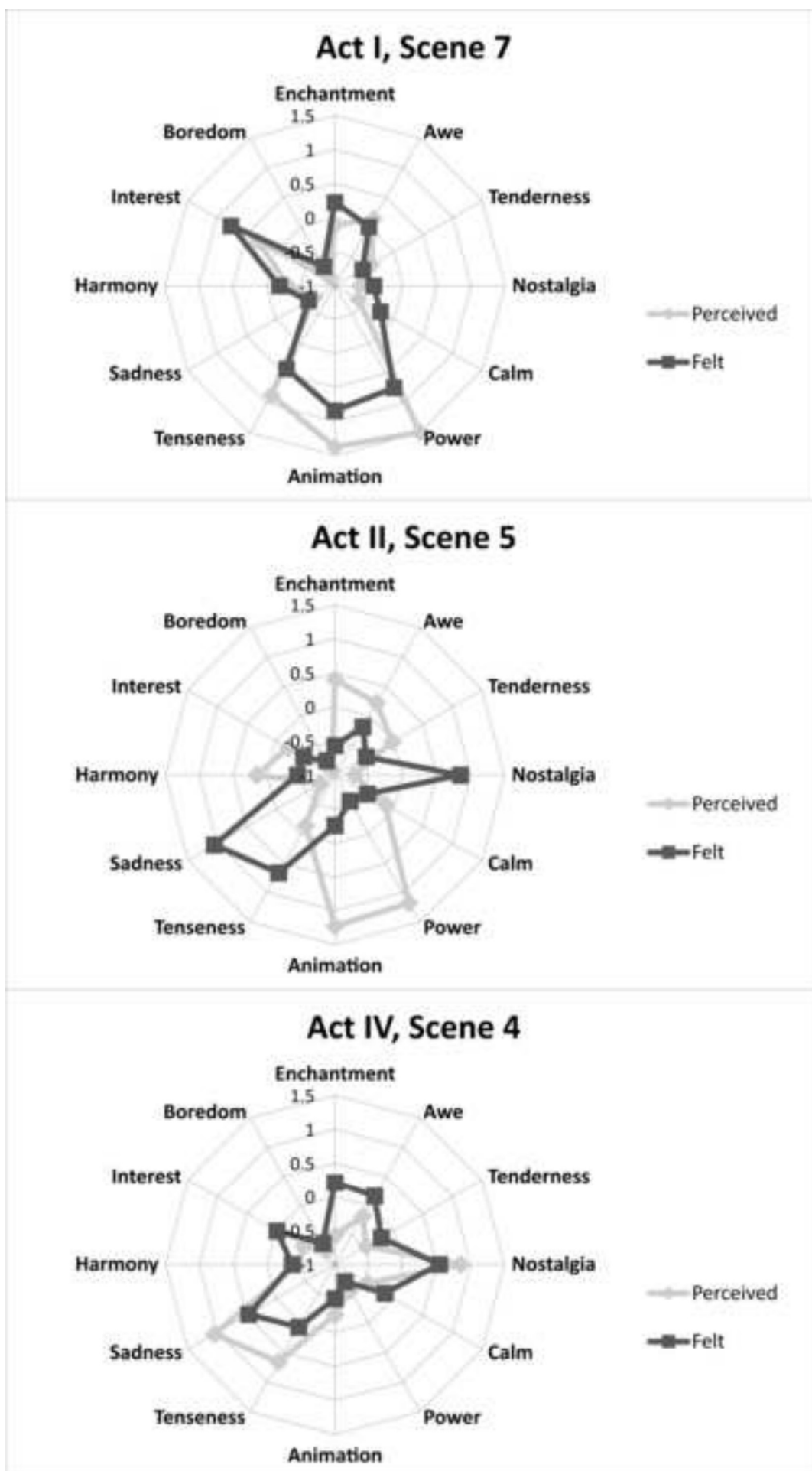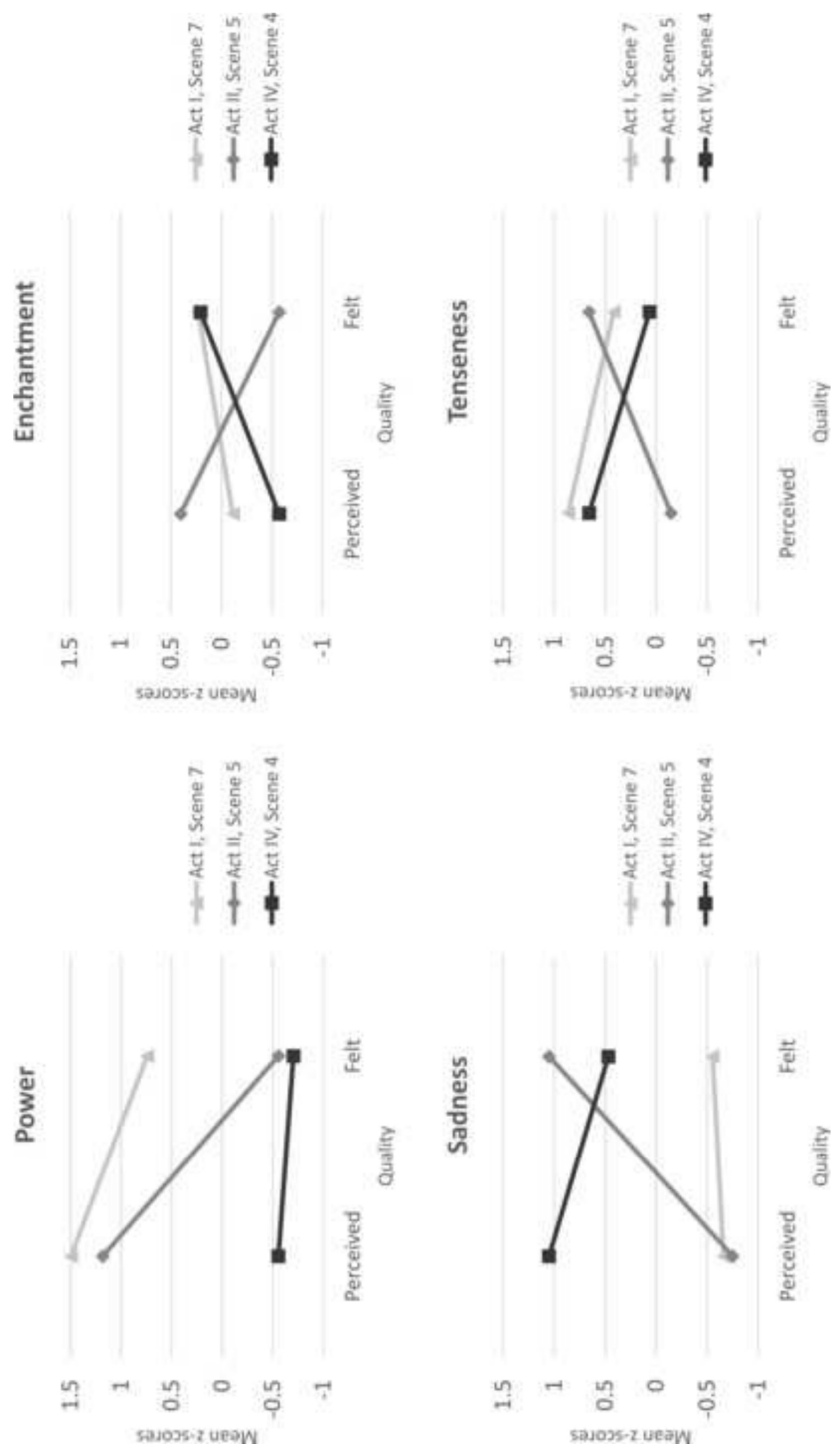
Table

Table 1

Repeated-measures ANOVA: Main effect of Scene/Act on the ratings for the felt emotion categories in Macbeth

Emotion	Scene/Act				Means			Comparison
	F	*df*	*p*	partial η^2	Act I	Act II	Act IV	
Enchantment	13.19	2/76	<.001	.26	0.23	-0.57	0.21	I, IV > II
Awe	1.60	2/76	.208	.04	0.001	-0.18	0.17	
Tenderness	2.32	2/76	.105	.06	-0.53	-0.47	-0.21	
Nostalgia	27.09	2/76	<.001	.42	-0.43	0.85	0.54	II, IV > I
Calm	1.64	2/76	.201	.04	-0.23	-0.45	-0.15	
Power	38.95	1.3/57.5	<.001	.51	0.74	-0.56	-0.71	I > II, IV
Animation	34.56	1.4/54.5	<.001	.48	0.84	-0.26	-0.49	I > II, IV
Tenseness	4.42	2/76	.015	.10	0.42	0.66	0.07	II > IV
Sadness	44.63	2/76	<.001	.54	-0.55	1.05	0.47	II > IV > I
Harmony	1.40	2/76	.25	.04	-0.19	-0.45	-0.37	
Interest	27.96	2/76	<.001	.42	0.76	-0.47	-0.01	I > IV > II
Boredom	0.24	1.7/66.7	.754	.006	-0.67	-0.76	-0.64	

Note. ANOVA = analysis of variance.

Table 2

Repeated-measures ANOVA: (a) Main effects of Scene/Act, (b) Quality, and (c) interaction effect of Scene/Act × Quality on the perceived and felt emotion ratings in Macbeth

a

Emotion	Scene/Act			
	F	df	p	Partial η^2
Enchantment	1.55	2/76	.218	.04
Awe	0.15	2/76	.863	.004
Tenderness	1.64	2/76	.201	.04
Nostalgia	50.92	1.4/54.6	<.001	.57
Calm	0.58	1.8/66.7	.542	.01
Power	81.05	1.6/61,2	<.001	.68
Animation	66.06	1.6/59.9	<.001	.63
Tenseness	3.60	1.5/56.7	.046	.09
Sadness	59.49	1.4/59.5	<.001	.61
Harmony	2.84	2/76	.065	.07
Interest	29.17	1.6/60.1	<.001	.43
Boredom	1.06	1.7/62.8	.341	.03

b

Emotion	Quality			
	F	df	p	partial η^2
Enchantment	0.21	1/38	.648	.01
Awe	0.48	1/38	.493	.01
Tenderness	2.12	1/38	.154	.05
Nostalgia	40.98	1/38	<.001	.52
Calm	1.84	1/38	.183	.05
Power	77.02	1/38	<.001	.67

Emotion	F	df	p	partial η²
Animation	65.96	1/38	<.001	.63
Tenseness	0.67	1/38	.418	.02
Sadness	27.83	1/38	<.001	.42
Harmony	2.46	1/38	.125	.06
Interest	4.03	1/38	.052	.10
Boredom	4.64	1/38	.038	.11

c

	Scene/Act × *Quality*			
Emotion	F	df	p	partial η²
Enchantment	27.18	1.4/23.2	<.001	.42
Awe	3.61	2/76	.036	.09
Tenderness	4.64	2/76	.013	.11
Nostalgia	38.73	2/76	<.001	.50
Calm	4.80	1.3/50.5	.024	.11
Power	20.42	2/76	<.001	.35
Animation	14.60	1.8/67.4	<.001	.28
Tenseness	17.49	2/76	<.001	.32
Sadness	57.19	1.4/57.2	<.001	.60
Harmony	4.81	1.6/60.8	.017	.11
Interest	4.69	2/76	.012	.11
Boredom	0.05	1.7/64.7	.927	.001

Note. ANOVA = analysis of variance.

Table 3

Rotated factor matrix of a PCA analysis of the complete set of ratings on the 12 fuzzy emotion categories

	Components				
	1	2	3	4	5
Calm	0.813				
Tenseness	-0.793				
Sadness	-0.624		0.576		
Harmony	0.526				
Interest		0.766			
Animation		0.725			
Nostalgia			0.786		
Power			-0.693		
Awe				0.846	
Enchantment		0.505		0.636	
Tenderness					0.81
Boredom					-0.689