

The feeling of beauty in music: Relaxing and not confusing

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SUMMARY

Although people throughout the world seek opportunities to participate in music, how and why they experience beauty in music is not well understood. To explore this fundamental aesthetic response, we measured numerous emotional responses to diverse musical excerpts to investigate their intercorrelations. We examined the following hypotheses: 1) that liking or the feeling of beauty (hereafter simply “the feeling of beauty”) is positively predicted by other prototypical aesthetic emotions (e.g., awe or the feeling of being moved); 2) that pleasing emotions (e.g., joy) are also positive predictors; and 3) that negative emotions (e.g., boredom or anger) are negatively correlated with the feeling of beauty. We also hypothesized that the epistemic or knowledge emotions (e.g., interest) are not predictors of prototypical aesthetic emotions. Participants listened to 13 brief musical excerpts. Immediately after listening to each excerpt, the participant rated it using the 42-item Aesthetic Emotions Scale (AESTHEMOS). After summing within related pairs of items to find scores for the 21 subscales, we calculated the means across participants for each song. We found that the means for the feeling of beauty have 1) strong positive correlations with the means of other prototypical aesthetic emotions, 2) positive correlations with some pleasing emotions (notably relaxation), 3) negative correlations with most negative emotions (notably confusion; exception: positive correlation with sadness), and 4) low correlations to epistemic emotions except for a strong negative correlation with surprise. These findings indicate a highly nuanced emotional experience of beauty in music that includes positive, negative, and knowledge-related feelings.

INTRODUCTION

Music has an influential role in our lives. People around the world listen to, play, and enjoy music. Apart from our day-to-day life, music has a plethora of applications in clinical work. Music shapes the human mind and brain, including a broad range of psychological and neurological functions (1-3). Music-based therapies for language impairments, Parkinson's disease, and psychosocial treatment of cancer are among the striking clinical applications of music (4-6). Music also engages numerous brain areas – the auditory cortex, nucleus accumbens, amygdala, hippocampus, and various components of the prefrontal cortex – in processing musical sound and eliciting emotional responses (7).

Music is found to elicit emotions in human listeners through a variety of mechanisms, ranging from reflexive processes in the brain stem to expectations based on learning of musical patterns (8). Beyond these emotional responses, in some circumstances criteria such as the perceived beauty or originality of the music, the skillfulness or expressiveness of the performance, etc. may activate aesthetic judgments. These judgments may in turn evoke feelings – aesthetic emotional responses such as pleasure arising from a judgment of beauty, wonder at the performer's skill, or interest stimulated by the originality of the music (8).

Recent studies have provided evidence that such aesthetic judgments are related to both reported feelings and physiological responses to music (9). Unlike utilitarian emotions, which focus on the past, present, or future utility of a product (music in this case), aesthetic emotions do not reflect a concern with the usefulness of the music but rather an interest in the music itself (10). Similar emotions may also be evoked by literature, art, movies, and various aspects of natural environments. Researchers have shown that music elicits a wide variety of emotions, any of them potentially involved in aesthetic responses to music. Of particular interest is the possible role of sadness in these aesthetic responses since there is considerable evidence that sad music is often

experienced as pleasurable (11).

Since aesthetic responses are highly subjective, they are hard to measure objectively. Despite the high interest in such emotions, there have been few effective tools that can measure them. Thus, characterizing the complex pattern of emotions that arise in aesthetic experiences has not been possible. To address this problem, we used a new instrument for measuring aesthetic emotions, the Aesthetic Emotions Scale (AESTHEMOS), which was developed by Schindler and colleagues and captures the broad range of emotions that occur in aesthetic experiences. The AESTHEMOS is composed of 42 items based upon 5 parts of the emotion process – appraisal, expression, feelings, bodily functions, and action tendencies (10). The 42 items are organized into 21 subscales, each measuring a different emotion. We employed the AESTHEMOS to measure aesthetic emotional responses to music, principal among them being the feeling that accompanies a judgment that the music is beautiful. One item was added to those of the AESTHEMOS to assess the familiarity of the music. Note that the AESTHEMOS is designed to measure felt emotions, not simply perception of the characteristics that are present in the music. Ratings of these two aspects of emotion induced by music are generally similar but not identical (12). Notice that the phrase “feeling of beauty” reflects the focus on felt emotions, not characteristics of the music, for which we would simply use the term “beauty.”

In this study we investigated the four broad categories of emotions measured by the AESTHEMOS: 1) prototypical aesthetic emotions (feeling of beauty, fascination, being moved, awe, enchantment, nostalgia); 2) pleasing emotions (joy, humor, vitality, energy, and relaxation); 3) epistemic emotions (surprise, interest, intellectual challenge, and insight); and 4) negative emotions (feeling of ugliness, boredom, confusion, anger, uneasiness, and sadness) (10). While these terms are operationally defined by the items used to assess them (see Materials and Methods for examples), some additional descriptive information may help clarify their meaning (10). Scholars regard the prototypical aesthetic emotions as genuinely aesthetic in that they entail explicit aesthetic evaluation although they are not necessarily always pleasing, as the inclusion of nostalgia in this category suggests. However, pleasing emotions such as those listed above may also contribute to the aesthetic emotional experience. Yet another category of emotions that may shape aesthetic experience, referred to above as the epistemic emotions, are those involving a search for meaning and a feeling of insight or knowing. Finally, the AESTHEMOS includes the negative emotions listed above, which may also contribute to aesthetic evaluations and feelings.

Though emotional responses to music have been the subject of numerous studies, there has been little agreement on which particular categories of emotion can be elicited by music. A recent large-scale study of 2777 participants responding to 1841 brief music samples extracted 13 separate emotion dimensions (13). We employed the 13 music

samples that received the highest ratings on the 13 scales of Cowen et al. (13). This approach provided a highly diverse set of musical excerpts with respect to their ability to evoke emotions, maximizing our likelihood of finding relationships among the different emotions of the AESTHEMOS. Our goal was to determine which of the many emotions elicited by music are most closely correlated with the feeling of beauty. We hypothesized positive correlations of the feeling of beauty with other prototypical aesthetic emotions and with pleasing emotions, and negative correlations with negative emotions. In addition, we examined how being moved is similar to and different from the feeling of beauty.

Our results indicated that the feeling of beauty, while strongly related to the other prototypical aesthetic emotions, had a strong positive association with relaxation and a strong negative association with confusion. Being moved had stronger associations with sadness and insight and a weaker association with joy than did the feeling of beauty.

RESULTS

Descriptive Statistics on Individual Emotions

Summaries were calculated for each of the 21 emotions of the AESTHEMOS, each emotion score being the sum of scores for the two items pertaining to that emotion; 13 summaries were calculated for each emotion – one for each song. Variation among responses of individual participants was large, often encompassing the full range of possible scores from the minimum of 2 to the maximum of 10. While it is not feasible to provide summaries for all 21 emotions, a summary for the feeling of beauty is shown as an example (Table 1).

Song	min	Q1	median	Q3	max	mean	sd
A	2	4	5	7	10	5.29	2.22
B	2	3	3	4	10	3.76	1.87
C	4	7	8	10	10	8.24	1.67
E	2	3	4	6	10	4.52	2.18
F	2	4	5	7	9	5.52	2.14
G	4	5	6	7	10	6.38	1.53
H	6	8	9	10	10	8.67	1.46
I	3	8	9	10	10	8.52	1.89
J	3	7	8	10	10	8.00	1.95
K	2	3	3	4	10	3.48	1.78
L	2	2	2	4	6	3.05	1.40
M	3	5	6	7	10	6.10	1.84

Table 1: Descriptive statistics for the 13 songs on the scores for Feeling of Beauty/Liking. Note that scores for individual participants varied widely, occupying the full possible range from a minimum of 2 to a maximum of 10 for some songs. 21 participants completed the rating for all songs. Abbreviations: min = minimum, Q1 = lower quartile or 25th percentile, Q3 = upper quartile or 75th percentile, sd = standard deviation.

Correlates of the Feeling of Beauty

We examined the hypothesized relationships between the feeling of beauty and other emotions in the four broad categories measured by the AESTHEMOS. The relationships among emotions were investigated using Pearson correlations (r) and scatterplots based on the mean ratings across the 21 participants. Thus, each plot displays a point

for each of the 13 songs employed in the study (Figures 1 and 2). In addition, a visualization of the correlation matrix for all 21 emotions was created (Figure 3).

In general, our data show that the feeling of beauty had a strong, positive correlation with all the prototypical aesthetic emotions. From weakest to strongest, the correlations between prototypical aesthetic emotions and the feeling of

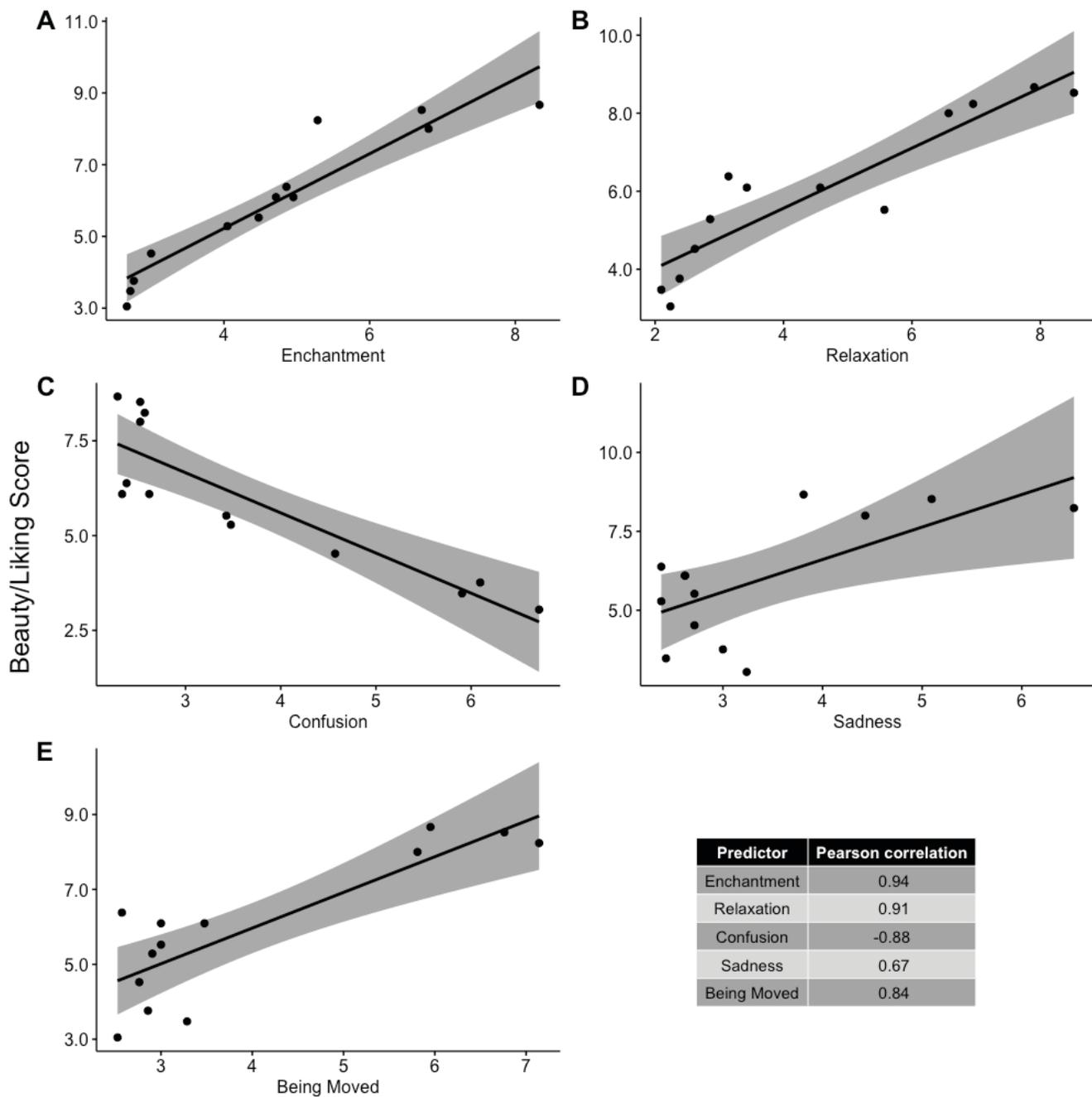


Figure 1: The linear relationship between the feeling of beauty/liking and five other emotions measure by the AESTHEMOS. Pearson correlations corresponding to each scatterplot are shown in the table at the lower right. The gray area around each regression line represents a 95% confidence band. Each point represents the mean ratings across 21 participants of one of the 13 songs. Note that three of the correlations exceeded the Bonferroni-corrected criterion value, $r = 0.85$, the correlation with being moved is slightly below the criterion, and the correlation with sadness is considerably below the criterion. Note also that scales for different plots are not the same.

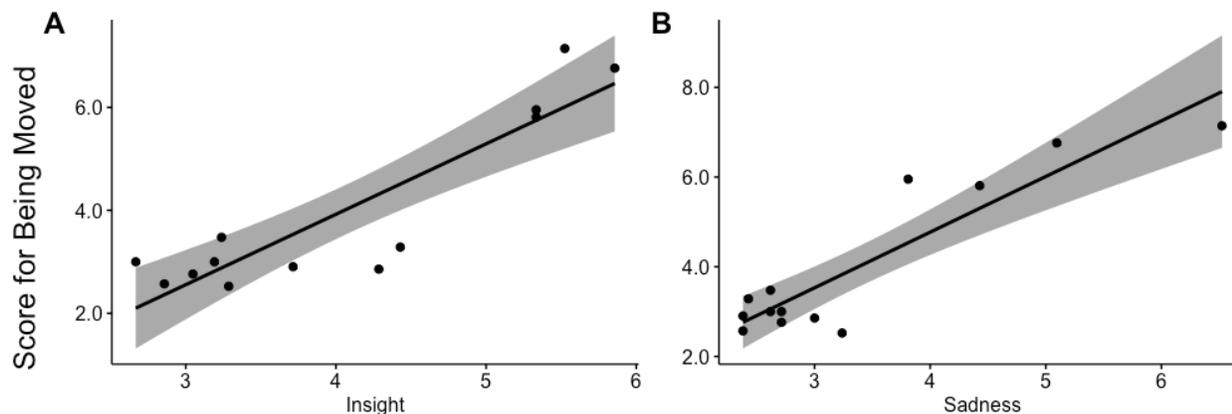


Figure 2: The linear relationship between being moved and two other emotions measured by the AESTHEMOS. The gray area around each regression line represents a 95% confidence band, and each point represents the mean ratings across 21 participants of one of the 13 songs. A: $r = 0.90$; B: $r = 0.91$. Comparison with **Figure 1** reveals that sadness correlated more strongly with being moved than with the feeling of beauty. Note that the scales for the two plots are not the same.

beauty as the response variable were the following (values of r in parentheses): being moved (0.84), awe (0.88), nostalgia (0.89), fascination (0.90), and enchantment (0.94; **Figure 1**). Note that with $n = 13$, an r value of 0.56 or greater is required to attain the conventional two-tailed, uncorrected 0.05 p -value (15); the Bonferroni-corrected (16) 0.05 p -value (0.05/210 correlations = 0.00024) requires an r of at least 0.85. All the prototypical aesthetic emotions were correlated with each other (shown in the first 6 rows and columns, upper left, **Figure 3**). In this matrix of 15 correlation coefficients among these 6 emotions, there were only 4 correlations smaller than $r = 0.80$ — nostalgia with fascination (0.69), being moved with fascination (0.73), being moved with enchantment (0.75), and nostalgia with enchantment (0.77). Thus, we observed at least moderate positive correlations among all the prototypical aesthetic emotions.

In contrast, we found that the feeling of beauty had highly variable correlations, some of them negative, with the pleasing emotions (shown in the rows for these emotions, **Figure 3**). From weakest to strongest, the correlation coefficients were -0.10, -0.44, -0.45, 0.77, and 0.91 for humor, vitality, energy, joy, and relaxation, respectively. Note that for the pleasing emotions, only joy and relaxation (**Figure 1B**) had a correlation with the feeling of beauty that attained the conventional statistical significance level, while humor had only a very weak relationship with the feeling of beauty.

We observed similarly variable correlations between the feeling of beauty and the epistemic emotions (**Figure 3**). The correlation of the feeling of beauty with intellectual challenge was 0.05, with interest was 0.34, with insight was 0.60, and with surprise was -0.94. Most of these correlations were positive, with surprise being the only negatively and strongly correlated emotion. In contrast, we found a correlation near 0 between the feeling of beauty and intellectual challenge.

The feeling of beauty was negatively correlated with most of the negative emotions (**Figure 3**), quite strongly so in

several instances: -0.20 for boredom, -0.80 for uneasiness, -0.87 both for feeling of ugliness and for anger, and -0.88 for confusion (**Figure 1C**). Thus, negative emotions evoked by music may diminish the feeling of beauty. However, a noteworthy exception is sadness, which showed a modest positive correlation of 0.67 with the feeling of beauty (**Figure 1D**).

Correlates of Being Moved

While all the prototypical aesthetic emotions were strongly correlated with each other, they could still differ in their relationships to other emotions. It is not possible in a brief paper to examine the patterns of emotions accompanying each of the prototypical aesthetic emotions. However, one can begin to appreciate the differences among them by contrasting the pattern of the feeling of beauty with that of being moved (**Figure 3**). In spite of the close relationship between these two emotions (**Figure 1E**), the pattern of other emotions when there was a feeling of being moved was noticeably different in at least three respects: 1) a considerably more modest correlation with joy ($r = 0.35$) than we found for the feeling of beauty (0.77); 2) a stronger correlation with insight (0.90) as compared to 0.61 with the feeling of beauty (**Figure 2A**); and 3) a stronger correlation with sadness (0.91) versus 0.67 for the feeling of beauty (**Figure 2B**).

Familiarity

Familiarity ratings displayed weak correlations with the emotions of the AESTHEMOS ranging from $r = -0.37$ (for boredom) to $r = 0.41$ (for humor). The correlation coefficients between familiarity and the feeling of beauty and between familiarity and being moved were both very weak: 0.08, and 0.06, respectively. Thus, there is little evidence that the relationships described above might be attributable to variations in familiarity of our participants with the musical excerpts employed in this study (**Figure 3**).

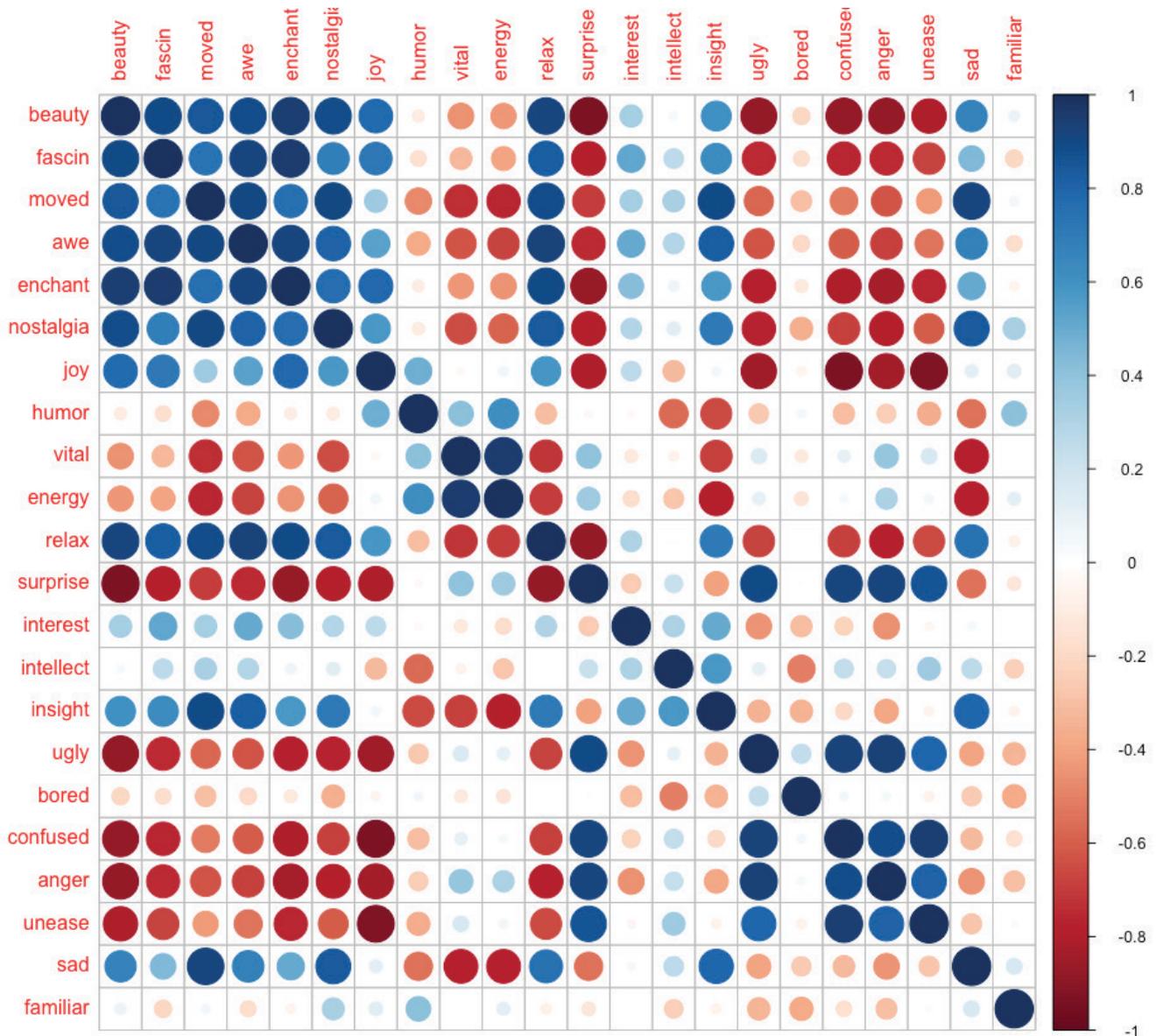


Figure 3: A visualization of the correlations among all the emotions measured in the study, along with familiarity. The prototypical aesthetic emotions are shown at the upper left (from beauty, i.e., feeling of beauty to nostalgia). The pleasing emotions are shown immediately below them (joy to relax, i.e., relaxation). The epistemic emotions (surprise to insight) are shown next. The negative emotions (ugly, i.e., feeling of ugliness to sad, i.e., sadness) are shown near the bottom. Correlations with familiarity are shown at the bottom and on the right. The maximum correlation of 1 is seen along the diagonal from upper left to lower right, representing the perfect correlation of each emotion with itself.

DISCUSSION

The brief musical excerpts employed in this study elicited a broad range of emotional responses that displayed a complex pattern of interrelationships. Central to this pattern were strong positive correlations between the feeling of beauty and each of the other prototypical aesthetic emotions, as classified by Schindler *et al.* (10). The prototypical aesthetic emotions were all found to be highly intercorrelated, supporting their being grouped together as a core aspect of aesthetic responses to music.

We found that the feeling of beauty was strongly

associated with several other emotions from the categories of pleasing, epistemic, and negative emotions. The strongest positive associations were with relaxation and joy (pleasing emotion category) and with sadness (negative emotion category). There was little evidence for a positive association with epistemic emotions except for insight, which had a moderate positive correlation with the feeling of beauty. We observed strong negative associations of the feeling of beauty with most of the negative emotions and with surprise, classified as an epistemic emotion by Schindler *et al.* (10). The prototypical aesthetic emotion of being moved displayed

a pattern of associations with other emotions that was quite similar to that for the feeling of beauty. However, it differed in having a considerably weaker correlation with joy and stronger correlations with both insight and sadness. None of these findings appeared attributable to our participants' familiarity with the musical excerpts.

Our results are largely consistent with other recent research. Aesthetic emotions are closely linked to evaluative judgments and are biased toward the positive feelings that accompany liking (17). We also observed this pattern in the positive correlations of the feeling of beauty with relaxation and joy and the numerous negative correlations with negative emotions. Menninghaus *et al.* also noted that, despite this general positivity bias, there may be contributions of negative emotions to the overall aesthetic experience as well, as demonstrated in our study by the positive correlations of sadness with the feeling of beauty and with being moved (17).

The association between relaxation and the feeling of beauty was also suggested in recent work on the effects of mindfulness meditation on aesthetic responses to music (18). In this study, a group of participants who had just received a 10-minute mindfulness training rated music as more beautiful than did untrained control participants, suggesting that relaxation can enhance the feeling of beauty. Thus, it is possible that relaxation in our participants increased the feeling of beauty.

There is sizable literature on the phenomenon of liking sad music, and various hypotheses to explain it have been proposed (11). Sadness in music may be enjoyed as an opportunity to understand one's own feelings, as a tool to regulate one's mood, or to empathize with others. It has also been suggested that the enjoyment of sadness in music occurs especially in an aesthetic context (11). Hence, the judgments and feelings that a piece of music is beautiful might be experienced simultaneously with sadness but not because of the sadness. An alternative is the possibility that some emotions, such as sadness, may act indirectly to produce prototypical aesthetic emotions, *i.e.*, by eliciting some other emotion that in turn affects the aesthetic emotion (17). This possibility is especially pertinent to our study because there was a rather strong positive correlation ($r = 0.74$) between sadness and relaxation, which may be causally linked to the feeling of beauty, as discussed above.

The contributions of the negative emotions other than sadness to the feeling of beauty in our study were largely to counteract it, as shown by the strong negative correlations of several negative emotions with the feeling of beauty. The most strongly negative correlation was found for confusion ($r = -0.88$). Some researchers classify confusion as an epistemic emotion rather than a negative one, along with surprise (19). Each of these emotions was predicted by performance on a trivia task that was followed by immediate feedback to trigger an emotional response. Surprise and confusion were positively correlated in that study, as indeed they also were in ours ($r = 0.92$). The analysis of Vogl *et al.*

indicates that making an error on a response for which one has high confidence leads to surprise and, in turn, to confusion (19). A similar sequence of events may occur in response to unexpected patterns of musical sound and account for the strong negative correlations of both surprise and confusion with the feeling of beauty.

The emotion of being moved is categorized as a prototypical aesthetic emotion, though it need not necessarily be linked to aesthetic evaluation in profound everyday life events, such as funerals or weddings (17). Being moved is an emotion that promotes connectedness with others and is associated with a variety of other feelings, including sadness and insight (17, 20). Thus, the strong correlations of each of these emotions with being moved in our study are consistent with what others have found. Previous studies have also found that joy may be an aspect of being moved although it may be mixed with sadness (20). Thus, the modest correlation between joy and being moved in our study is not unexpected.

The relationships among emotions in our study do not appear to be mediated by the degree of familiarity with the music, especially considering that the correlations of familiarity with the prototypical aesthetic emotions were quite low. Nonetheless, repeated listening (increased familiarity) has been demonstrated to enhance liking of music regardless of how complex the music is; even at the first listening, liking is higher for music that is similar to music one has heard before (20). Furthermore, repeated listening has been found to enhance music-elicited pleasure and emotional arousal (21). Thus, familiarity may play some role in aesthetic emotions even though our findings provide no evidence that it modifies the relationships among the emotions that are elicited.

Thus, the use of the AESTHEMOS, together with brief musical excerpts that were known from previous work to produce highly diverse emotional responses, allowed us to show strong relationships among emotions that occur in aesthetic responses to music. In particular, we have been able to characterize in considerable detail the rich pattern of emotions accompanying the feeling of beauty. This study shows how the wide array of emotions that accompany aesthetic judgments may be combined in the experience of beauty in music. These findings suggest the possibility of similar relationships, not only in other music but also in other aesthetic experiences, such as the appreciation of visual artworks or the beauty of nature. The AESTHEMOS was designed to be applicable to various domains of experience, thus facilitating future investigations of these possibilities (10).

Several aspects of our study and analysis limit the generality of our conclusions. First, note that the patterns reported here do not address individual differences in participant responses. Our data summaries showed wide variations between participants (**Table 1**). Thus, the patterns reported here show common features of responses despite substantial evidence that individual participants responded in their own, unique way, and in spite of our rather small sample size. Further analysis using linear mixed models might allow

characterization of individual patterns of response. Although a larger sample of participants will likely be necessary, future studies might investigate whether there are consistent differences in patterns of response among personality and/or gender groups. Age is unlikely to have been a significant factor in the present study since all participants were in a rather narrow age range, but comparison with other age groups in future studies might reveal interesting differences. However, in the present context it is worth reemphasizing our findings of consistent common response patterns over and above these individual variations.

As with any study involving responses to music, it is possible that the music employed produced peculiar responses that are quite different from those one would have obtained with other music. This issue is somewhat mitigated by the extensive sample of excerpts from which our music was selected and their demonstrated diverse characteristics in a prior study (13). A particular limitation of these excerpts is their brevity (5 seconds). Some emotional responses may require more listening time to emerge. Thus, there is a need for further studies in which participants listen to lengthier excerpts.

The relatively small sample size employed in this study suggests that, despite the strong associations shown, the patterns of intercorrelation among emotions may not be replicated with a larger sample size, even with the same excerpts of music. However, a replication with a larger sample is already underway in our laboratory, and preliminary results suggest a very similar pattern of associations among emotions. However, future work is needed to investigate the generalizability of our findings.

Our study demonstrates the feasibility of using the AESTHEMOS to study relationships among emotions and the diverse aspects of aesthetic responses to music. Our analysis focused on the feeling of beauty and showed its strong positive relationship with other prototypical aesthetic emotions as well as with relaxation, joy, and (to a lesser extent) sadness. Our data also show strong negative relationships with surprise, confusion, and several negative emotions. Being moved differed from the feeling of beauty, especially by stronger relationships with insight and sadness. Further studies are needed to confirm these relationships in a larger sample of participants and with longer excerpts of music.

MATERIALS AND METHODS

Participants

The participants were 21 students (20 high school, 1 college student assistant; 15 female, 6 male; ages 14–20) attending the Bethel College Summer Science Institute (North Newton, KS) for high school students.

Procedure

Participants listened to 13 five-second instrumental, non-vocal song excerpts. Immediately after listening to each excerpt, they recorded their emotions using the AESTHEMOS,

presented as a Google form (10). Each song was rated on a five-point scale from “not at all” to “very” for 42 different emotional response items. Some examples of these items include: “I found it beautiful,” “Felt confused,” “Made me aggressive,” “Made me feel nostalgic,” and “Felt awe.” After participants rated their emotional responses, they also rated the familiarity of each piece of music from “not at all familiar” to “very familiar” on a five-point scale. Each participant listened to the excerpts in a different, randomly chosen order to avoid any systematic effect of the order in which the songs were heard. Participants were asked to rest between excerpts to avoid fatigue and confusion. The study was approved by the Bethel College Institutional Review Board.

Data Analysis

All data were imported into RStudio (14), version 1.3.1093, and R (23), version 4.0.3, for analysis (see Appendix for R code). First, the 42 different emotion categories or subscales were condensed into 21 AESTHEMOS subscales, each consisting of the sum of ratings on two items. For example, the data from “Amused me” and “Was funny to me” were summed for each participant and each song into the subscale “Humor” and data from “Liked it” and “I found it beautiful” were combined into the subscale “Feeling of beauty/liking.” Once the 21 subscale scores were created for each participant, means across the 21 participants were calculated for each of the 13 songs and for each emotion subscale. Then correlations between emotion subscales, based upon the means across participants, were calculated, and scatterplots for pairs of emotions were created. Confidence intervals were also calculated and displayed on the scatterplots to show the variability in the data and our confidence level in the relationship. Finally, a correlogram was created to allow visualization of the entire matrix of correlations.

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APPENDIX

R code used in the analysis of data and creation of graphs:

```
# Load packages
```

```
library(mosaic)
```

```
library(readr)
```

```
library(ggpubr)
```

```
library(scales)
```

```
# Import data
```

```
all_data <- read_csv("Filename.csv")
```

```
all_data <- select(all_data, Participant : Familiarity )
```

```
# Create a variable for each Aesthemos subscale
```

```
all_data2 <- mutate(all_data, Feeling_of_beauty_liking = Liked_it +
```

```
  I_found_it_beautiful,
```

```
  Fascination = Was_impressed + Fascinated_me,
```

```
  Being_moved = Felt_deeply_moved + Touched_me,
```

```
  Awe = I_found_it_sublime + Felt_awe,
```

```
  Enchantment = Felt_something_wonderful + Was_enchanted,
```

```
  Nostalgia = Made_me_feel_nostalgic +
```

```
  Made_me_feel_sentimental,
```

```
  Joy = Delighted_me + Made_me_happy,
```

```
  Humor = Amused_me + Was_funny_to_me,
```

```
  Vitality = Spurred_me_on + Invigorated_me,
```

```
  Energy = Motivated_me_to_act + Energized_me,
```

```
  Relaxation = Calmed_me + Relaxed_me,
```

```
  Surprise = Baffled_me + Surprised_me,
```

```
  Interest = Made_me_curious + Sparked_my_interest,
```

```
  Intellectual_challenge =
```

```
  Challenged_me_intellectually + Was_mentally_engaged,
```

```
  Insight = Felt_a_sudden_insight + Sensed_a_deeper_meaning,
```

```
  Feeling_of_ugliness = I_found_it_distasteful +
```

```
  I_found_it_ugly,
```

```
  Boredom = Felt_indifferent + Bored_me,
```

```
Confusion = Felt_confused + Was_unsettling_to_me,  
Anger = Made_me_aggressive + Made_me_angry,  
Uneasiness = Worried_me + Felt_oppressive,  
Sadness = Made_me_sad + Made_me_feel_melancholic)
```

```
# Data numerical summaries and boxplots for 21 participants,  
# 21 Aesthemos subscales + familiarity, 13 excerpts  
# Output means to dataframe
```

```
favstats(Feeling_of_beauty_liking ~ Song, data=all_data2)  
bwplot(Feeling_of_beauty_liking ~ Song, data=all_data2)  
beauty <- mean(Feeling_of_beauty_liking ~ Song, data=all_data2)  
beautydf <- as.data.frame(beauty)  
beautydf <- tibble::rownames_to_column(beautydf, var = "song")
```

```
favstats(Fascination ~ Song , data=all_data2)  
bwplot(Fascination ~ Song, data=all_data2)  
fascin <- mean(Fascination ~ Song, data=all_data2)  
fascindf <- as.data.frame(fascin)  
fascindf <- tibble::rownames_to_column(fascindf, var = "song")
```

```
favstats(Being_moved ~ Song, data=all_data2)  
bwplot(Being_moved ~ Song, data=all_data2)  
moved <- mean(Being_moved ~ Song, data=all_data2)  
moveddf <- as.data.frame(moved)  
moveddf <- tibble::rownames_to_column(moveddf, var = "song")
```

```
favstats(Awe ~ Song, data=all_data2)  
bwplot(Awe ~ Song, data=all_data2)  
awe <- mean(Awe ~ Song, data=all_data2)  
awedf <- as.data.frame(awe)  
awedf <- tibble::rownames_to_column(awedf, var = "song")
```

```
favstats(Enchantment ~ Song, data=all_data2)
```

```
bwplot(Enchantment ~ Song, data=all_data2)
enchant <- mean(Enchantment ~ Song, data=all_data2)
enchantdf <- as.data.frame(enchant)
enchantdf <- tibble::rownames_to_column(enchantdf, var = "song")
```

```
favstats(Nostalgia ~ Song, data=all_data2)
bwplot(Nostalgia ~ Song, data=all_data2)
nostalgia <- mean(Nostalgia ~ Song, data=all_data2)
nostalgiadf <- as.data.frame(nostalgia)
nostalgiadf <- tibble::rownames_to_column(nostalgiadf, var = "song")
```

```
favstats(Joy ~ Song, data=all_data2)
bwplot(Joy ~ Song, data=all_data2)
joy <- mean(Joy ~ Song, data=all_data2)
joydf <- as.data.frame(joy)
joydf <- tibble::rownames_to_column(joydf, var = "song")
```

```
favstats(Humor ~ Song, data=all_data2)
bwplot(Humor ~ Song, data=all_data2)
humor <- mean(Humor ~ Song, data=all_data2)
humordf <- as.data.frame(humor)
humordf <- tibble::rownames_to_column(humordf, var = "song")
```

```
favstats(Vitality ~ Song, data=all_data2)
bwplot(Vitality ~ Song, data=all_data2)
vital <- mean(Vitality ~ Song, data=all_data2)
vitaldf <- as.data.frame(vital)
vitaldf <- tibble::rownames_to_column(vitaldf, var = "song")
```

```
favstats(Energy ~ Song, data=all_data2)
bwplot(Energy ~ Song, data=all_data2)
energy <- mean(Energy ~ Song, data=all_data2)
energydf <- as.data.frame(energy)
energydf <- tibble::rownames_to_column(energydf, var = "song")
```

```
favstats(Relaxation ~ Song, data=all_data2)
bwplot(Relaxation ~ Song, data=all_data2)
relax <- mean(Relaxation ~ Song, data=all_data2)
relaxdf <- as.data.frame(relax)
relaxdf <- tibble::rownames_to_column(relaxdf, var = "song")
```

```
favstats(Surprise ~ Song, data=all_data2)
bwplot(Surprise ~ Song, data=all_data2)
surprise <- mean(Surprise ~ Song, data=all_data2)
surprisedf <- as.data.frame(surprise)
surprisedf <- tibble::rownames_to_column(surprisedf, var = "song")
```

```
favstats(Interest ~ Song, data=all_data2)
bwplot(Interest ~ Song, data=all_data2)
interest <- mean(Interest ~ Song, data=all_data2)
interestdf <- as.data.frame(interest)
interestdf <- tibble::rownames_to_column(interestdf, var = "song")
```

```
favstats(Intellectual_challenge ~ Song, data=all_data2)
bwplot(Intellectual_challenge ~ Song, data=all_data2)
intellect <- mean(Intellectual_challenge ~ Song, data=all_data2)
intellectdf <- as.data.frame(intellect)
intellectdf <- tibble::rownames_to_column(intellectdf, var = "song")
```

```
favstats(Insight ~ Song, data=all_data2)
bwplot(Insight ~ Song, data=all_data2)
insight <- mean(Insight ~ Song, data=all_data2)
insightdf <- as.data.frame(insight)
insightdf <- tibble::rownames_to_column(insightdf, var = "song")
```

```
favstats(Feeling_of_ugliness ~ Song, data=all_data2)
bwplot(Feeling_of_ugliness ~ Song, data=all_data2)
ugly <- mean(Feeling_of_ugliness ~ Song, data=all_data2)
```

```

uglydf <- as.data.frame(ugly)
uglydf <- tibble::rownames_to_column(uglydf, var = "song")

favstats(Boredom ~ Song, data=all_data2)
bwplot(Boredom ~ Song, data=all_data2)
bored <- mean(Boredom ~ Song, data=all_data2)
boreddf <- as.data.frame(bored)
boreddf <- tibble::rownames_to_column(boreddf, var = "song")

favstats(Confusion ~ Song, data=all_data2)
bwplot(Confusion ~ Song, data=all_data2)
confused <- mean(Confusion ~ Song, data=all_data2)
confuseddf <- as.data.frame(confused)
confuseddf <- tibble::rownames_to_column(confuseddf, var = "song")

favstats(Anger ~ Song, data=all_data2)
bwplot(Anger ~ Song, data=all_data2)
anger <- mean(Anger ~ Song, data=all_data2)
angerdf <- as.data.frame(anger)
angerdf <- tibble::rownames_to_column(angerdf, var = "song")

favstats(Uneasiness ~ Song, data=all_data2)
bwplot(Uneasiness ~ Song, data=all_data2)
unease <- mean(Uneasiness ~ Song, data=all_data2)
uneasedf <- as.data.frame(unease)
uneasedf <- tibble::rownames_to_column(uneasedf, var = "song")

favstats(Sadness ~ Song, data=all_data2)
bwplot(Sadness ~ Song, data=all_data2)
sad <- mean(Sadness ~ Song, data=all_data2)
saddf <- as.data.frame(sad)
saddf <- tibble::rownames_to_column(saddf, var = "song")

favstats(Familiarity ~ Song, data=all_data2)

```

```
bwplot(Familiarity ~ Song, data=all_data2)
familiar <- mean(Familiarity ~ Song, data=all_data2)
familiardf <- as.data.frame(familiar)
familiardf <- tibble::rownames_to_column(familiardf, var = "song")
```

```
# Combine means into a single dataframe
allmeans <- merge(beautydf, fascindf, by = "song")
allmeans <- merge(allmeans, moveddf, by = "song")
allmeans <- merge(allmeans, awedf, by = "song")
allmeans <- merge(allmeans, enchantdf, by = "song")
allmeans <- merge(allmeans, nostalgiadf, by = "song")
allmeans <- merge(allmeans, joydf, by = "song")
allmeans <- merge(allmeans, humordf, by = "song")
allmeans <- merge(allmeans, vitaldf, by = "song")
allmeans <- merge(allmeans, energydf, by = "song")
allmeans <- merge(allmeans, relaxdf, by = "song")
allmeans <- merge(allmeans, surprisedf, by = "song")
allmeans <- merge(allmeans, interestdf, by = "song")
allmeans <- merge(allmeans, intellectdf, by = "song")
allmeans <- merge(allmeans, insightdf, by = "song")
allmeans <- merge(allmeans, uglydf, by = "song")
allmeans <- merge(allmeans, boreddf, by = "song")
allmeans <- merge(allmeans, confuseddf, by = "song")
allmeans <- merge(allmeans, angerdf, by = "song")
allmeans <- merge(allmeans, uneasedf, by = "song")
allmeans <- merge(allmeans, saddf, by = "song")
allmeans <- merge(allmeans, familiardf, by = "song")
```

```
# Correlations among means of songs across participants
allmeans2 <- select(allmeans, beauty : familiar)
round(cor(allmeans2), digits = 3)
```

```
# Selected scatterplots of means
# Figure 1
```

```
be <- ggscatter(allmeans, x = "enchant", y = "beauty", add = "reg.line",
               conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Enchantment", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))
```

```
be2 <- annotate_figure(be, fig.lab = "A", fig.lab.size = 18,
                     fig.lab.face = "bold")
```

```
br <- ggscatter(allmeans, x = "relax", y = "beauty", add = "reg.line",
               conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Relaxation", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))
```

```
br2 <- annotate_figure(br, fig.lab = "B", fig.lab.size = 18,
                     fig.lab.face = "bold")
```

```
bc <- ggscatter(allmeans, x = "confused", y = "beauty", add = "reg.line",
               conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Confusion", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))
```

```
bc2 <- annotate_figure(bc, fig.lab = "C", fig.lab.size = 18,
                     fig.lab.face = "bold")
```

```
bs <- ggscatter(allmeans, x = "sad", y = "beauty", add = "reg.line",
               conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Sadness", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))
```

```
bs2 <- annotate_figure(bs, fig.lab = "D", fig.lab.size = 18,
                     fig.lab.face = "bold")
```

```
bm <- ggscatter(allmeans, x = "moved", y = "beauty", add = "reg.line",
               conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Being Moved", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))
```

```
bm2 <- annotate_figure(bm, fig.lab = "E", fig.lab.size = 18,
```

```

fig.lab.face = "bold")

## Table of correlations for plot
# Open table created in spreadsheet
cor_table <- read_csv("Table_Fig1_JEI.csv")

# Summary table plot, medium black theme
cor_table.p <- ggtexttable(cor_table, rows = NULL,
  theme = ttheme("mBlack"))
## Graphs and table together
fig1_5 <- ggarrange(be2 , br2, bc2, bs2, bm2, cor_table.p,
  ncol = 2, nrow = 3)

annotate_figure(fig1_5,
  left = text_grob("Beauty/Liking Score", color = "black", rot = 90, size = 18)
  )

# Figure 2
mi <- ggscatter(allmeans, x = "insight", y = "moved", add = "reg.line",
  conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Insight", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))

mi2 <- annotate_figure(mi, fig.lab = "A", fig.lab.size = 18,
  fig.lab.face = "bold")

ms <- ggscatter(allmeans, x = "sad", y = "moved", add = "reg.line",
  conf.int = TRUE, cor.coef = FALSE, cor.method = "pearson") +
  labs(x = "Sadness", y = " " ) +
  scale_y_continuous(labels = label_number(accuracy = 0.1))

ms2 <- annotate_figure(ms, fig.lab = "B", fig.lab.size = 18,
  fig.lab.face = "bold")

```

```
fig6_7 <- ggarrange(mi2, ms2,  
  ncol = 2, nrow = 1)  
  annotate_figure(fig6_7,  
    left = text_grob("Score for Being Moved", color = "black", rot = 90, size = 18)  
  )
```

```
# Figure 3
```

```
library(corrplot)
```

```
cormat <- cor(allmeans2)
```

```
corrplot(cormat, method = "circle")
```