The Smell of Jazz: Crossmodal Correspondences Between Music, Odor, and Emotion

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Abstract

People can systematically match information from different senses, and these matches are known as crossmodal correspondences. Most work on these correspondences has explored how they might arise through neural mechanisms, statistical covariance in the environment, or semantic associations (e.g., Spence, 2011). Recently, Palmer, Schloss, Xu, & Prado-León (2013) demonstrated that at least some color-music correspondences can be explained by emotional mediation. The present study investigates the emotion mediation hypothesis for correspondences between odor and music, testing whether the strength of odor-music matches for particular odors and musical selections can be predicted by the similarity of the emotional associations with the odors and music. We found that perceived matches were higher when the emotional responses were similar and that a model including emotional dimensions captured a significant amount of the variance of match scores. These results provide new evidence that crossmodal correspondences are mediated by emotions.

Keywords: crossmodal; odor; music; emotion

Introduction

Listening to music or smelling a flower may seem to be sense-specific, but most experiences are multisensory. For instance, visual cues can influence how music is perceived (e.g., Hodges, Hairston, & Burdette, 2005; Platz & Kopiez, 2012). Similarly, when encountering an odor, other senses influence the interpretation of that odor and thus the nature of people's experience with it (e.g., Gottfried & Dolan, 2003; Seo & Hummel, 2011).

Questions about commonalties and integration across the senses have been of interest to scholars from Aristotle onward (Marks, 1978), and the study of crossmodal correspondences has been robust in recent years. Spence (2011) distinguished three types of correspondences: structural, statistical, and semantic. In his classification, structural correspondences arise because of similarities in the information being provided by the different senses; for instance, magnitude may be represented by neural mechanisms that are common across modalities (e.g., bright lights might be matched to louder sounds because they both cause higher firing rates in the brain). Statistical correspondences, however, arise via statistical learning; regularities in the environment, such as the fact that larger objects tend to create louder sounds, would cause a corresponding internal link between senses. Semantic correspondences are also learned, but relate to language; for instance, "high" pitches and "high" elevations use the same terminology, which could thus lead to an association between pitch and elevation. Thus both statistical and semantic correspondences are learned, but may arise through different processes. However, it may be that semantic correspondences also stem from statistical covariance in the world; for instance, Parise, Knorre, & Ernst (2014) showed that the use of the term high for pitch reflects the statistics of natural scenes. Thus, as Spence, noted, more than one of these three factors may contribute to a particular crossmodal correspondence.

While this tripartite model explains a number of different correspondences, Palmer, Schloss, Xu, & Prado-León (2013) demonstrated that, for color and music, crossmodal correspondences seem to be emotionally-mediated. They argue that emotional mediation provides a more parsimonious explanation for the correspondences they find between color and music, color and emotional faces, and music and emotional cases. They give three main reasons: (1) all three correspondences yielded very high correlations via their emotional associations, (2) the music-to-color correspondences were highly consistent across two different cultural groups, and (3) there is no compelling evidence that the specific correspondences (such as between fast, major music and saturated, light, yellowish colors) actually relate to covariance of the those stimuli in the world. Palmer, Langlois, & Schloss (2015) extended these results by demonstrating the strong role of emotion for color and music associations with very precisely controlled single-line melodies. Albertazzi, Canal, & Micciolo (2015) also found that emotional adjectives such as "calm" and "happy" played a role in associations between art and music. Thus emotion may be a fourth factor important to understanding crossmodal correspondences, consistent with suggestions by Schifferstein & Tanudjaj (2004).

Some studies have already examined the link between music and odors. For instance, Seo, Lohse, Luckett, & Hummel (2013) found that music (such as Christmas carols and the song "Y.M.C.A.") and background sounds (such as beach sounds and toothbrushing) could be matched with specific odors and that those sounds could increase the odor's pleasantness when the sound and odor were considered congruent. Crisinel & Spence (2012) showed that participants consistently match odors such as candied orange to musical notes with higher pitches than they do odors such as coffee, and that some odors were preferentially matched to notes created by particular musical instruments. Crisinel, Jacquier, Deroy, & Spence (2013) further investigated correspondences between olfactory stimuli and the pitch and instrumental class of sound stimuli and found that stimuli that were judged as happier and more pleasant were consistently associated with higher pitches. They noted the potential importance of emotional dimensions for crossmodal correspondences, particularly those involving odor. Taken together, these studies provided evidence that people with normal perception can make consistent, non-arbitrary associations between musical sounds and odors. However, these studies used few actual musical selections; Crisinel & Spence (2012) and Crisinel et al., (2013) primarily used single notes as stimuli. Crisnel et al., (2013) did have three musical selections specifically composed to match specific odors, but participants only selected the intended music as a match for one of their three pairings. Moreover, they only considered a relatively limited set of emotions (pleasantness, relaxing, and happy). In the present study, we examine the nature of music-odor associations, using a broad range of music and odor selections and assessing several emotional dimensions to determine whether the crossmodal correspondence is linked to shared emotional associations.

Methods

Participants

40 undergraduate students at Occidental College participated in the study and were compensated with a total of $20. All gave informed consent and the Occidental College Human Subjects Research Review Committee approved the protocol.

Materials

Music Stimuli We used 15 different musical selections from the 34 used by Whiteford, Schloss, & Palmer (2013) in their investigation of music-color associations. These selections were deliberately chosen to be as diverse as possible in the nature of the emotions they elicited and represented a broad array of musical genres. We reduced the number of selections because smelling odors takes longer than viewing colors, and we wanted to ensure the experiment could be conducted in a reasonable amount of time. To choose those 15, we used participant ratings of each music excerpt along 10 semantic/emotional dimensions provided by Whiteford et al. (2013). We excluded one of their samples at the recommendation of the authors, and we used ratings (n=15) to conduct a k-means analysis to cluster the music that had similar ratings, as was done by Langlois, Peterson, & Palmer (2014). We generated 15 clusters and then selected the genres that were closest to the centroid of each cluster. When there were two selections in a cluster, we selected the genre that we thought would be better known to our population. The samples we used were from the genres called Bach, Balkan Folk, Bluegrass, Blues, Classic Rock, Dixieland, Eighties Pop, Funk, Gamelan, Heavy Metal, Hindustani Star, Jazz, Piano, Psychobilly, and Reggae (as labeled by Whiteford et al.; the specific music samples can be provided upon request). Each selection was 15 seconds in duration.

Odor Stimuli We used 15 Sniffin' Stick pens imported from Germany. These included both pleasant and unpleasant familiar odors and have been previously used in other psychophysical research (e.g., Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997; Schloss, Goldberger, Palmer, & Levitan, 2015). The odors tested in this experiment were apple, banana, cinnamon, cloves, coffee, fish, garlic, leather, lemon, licorice, orange, peppermint, pineapple, rose, and turpentine.

Dimensions We used 8 dimensions to rate each odor and each music selection: Preference (Like vs. Dislike), Familiarity (Familiar vs. Unfamiliar), Intensity (Strong vs. Weak), Anger (Angry vs. Not Angry), Pleasantness (Pleasant/Harmonious vs. Unpleasant/Disharmonious), Romance (Romantic/Sensual vs. Not-Romantic/Not-Sensual), Energy (Energizing vs. Calming), and Happiness (Happy vs. Sad). We used a continuous scale and descriptors of each dimension were provided at each extreme. The dimensions were derived by reviewing past studies on color-music associations (Palmer et al., 2011), the Geneva Emotion and Music Scale (Zentner, Grandjean, & Scherer, 2008) and the Universal Emotion and Odor Scale (Ferdenzi et al. 2013), and then selecting dimensions likely to apply to both music and odors.

Procedure

Participants completed three tasks over the course of two consecutive days. On Day 1 they completed the music-odor matching task, in which they rated the degree of match between each of the 15 odors and 15 musical selections. On Day 2 they completed the music-emotion and odor-emotion rating tasks, rating each musical selection and each odor on the 8 dimensions listed above, in random order.

Music-Odor Matching Ratings We first presented participants with each of the odors and each of the musical selections so they could familiarize themselves with the stimuli. We then presented each of the 15 odors paired with each of the 15 musical selections (225 odor-music pairs). For each pair, participants rated how much the odor and music matched each other using a continuous scale from "very poorly" matched, to "very well" matched. The musical selections would autoplay and loop until participants made their rating. The combinations were blocked by odor with the order of the odors randomized. Within each odor block, the order of the musical selections was randomized. Participants sniffed their arm after each odor to neutralize its scent before sniffing the next odor. An air purifier ran continuously throughout the experiment and overnight to eliminate residual odor from the air.

Music and Odor Dimensional Ratings On the second day, participants rated each musical selection and each odor on each of the 8 dimensions. There was one block for music ratings and another for odor ratings, and the order of the blocks was randomized, as was the order of the musical selections and the odors within the blocks. The musical selections would autoplay and loop until the participant made their ratings.

Results and Discussion

The primary question of interest is whether emotions might mediate the matches between odors and music. Thus, we compared the match ratings and the similarity of ratings on the 8 different dimensions. For each pairing, we calculated the mean association score across all participants as well as the mean similarity for each of the 8 ratings for the two stimuli (see below). The highest mean match rating was between cloves and Hindistani Sitar and the lowest mean rating was between fish and Bach. We therefore expected that cloves and Hindistani Sitar would be rated relatively similarly on the relevant dimensions, whereas fish and Bach would be rated quite differently on those dimensions. We were particularly interested in which dimensions were the best predictors of the match scores. Figure 1 depicts the match scores for each of the 225 odor-music combinations.

Table 1: Multiple regression on reduced set of factors.

Dimension	Beta	Significance
Preference	0.187	0.009
Familiarity	0.014	0.756
Intensity	-0.129	0.014
Anger	0.410	< 0.0005
Romance	0.294	< 0.0005
Energy	0.066	0.196
Happiness	0.184	0.001

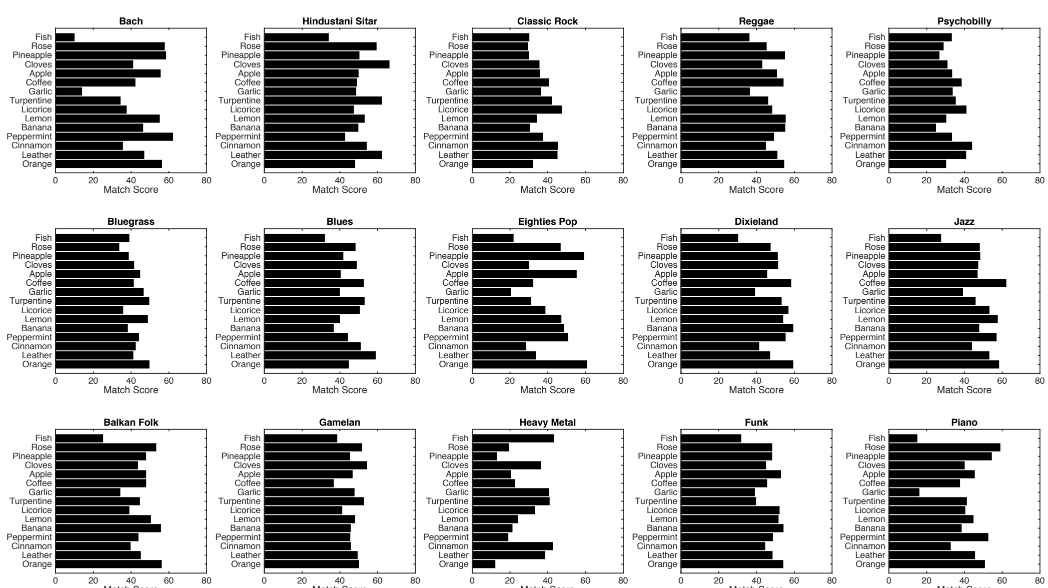

Figure 1: Mean match scores for each odor and each musical selection.

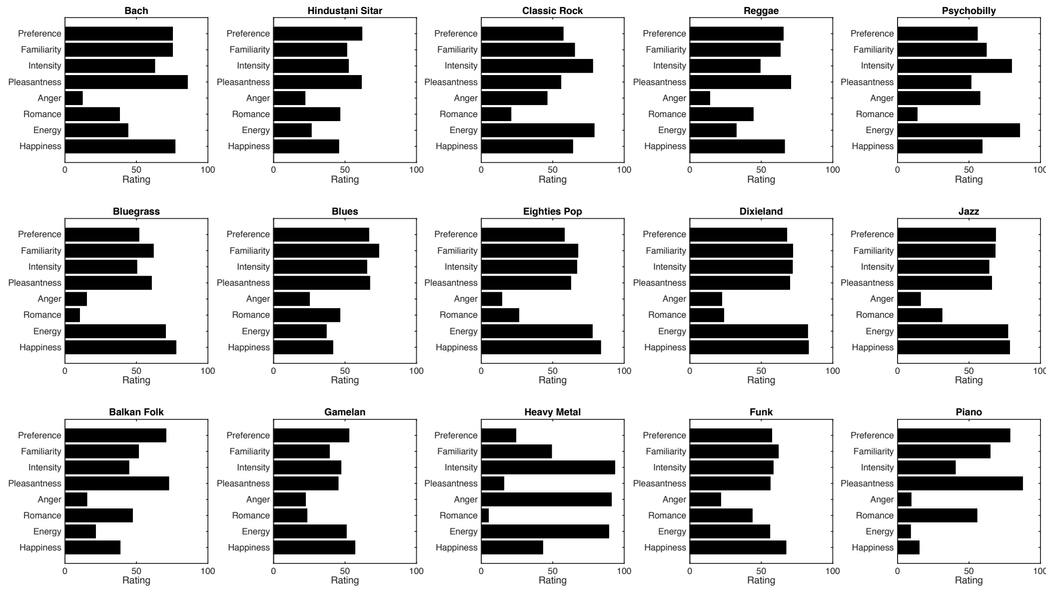

Figure 2: Mean dimensional ratings for each musical selection.

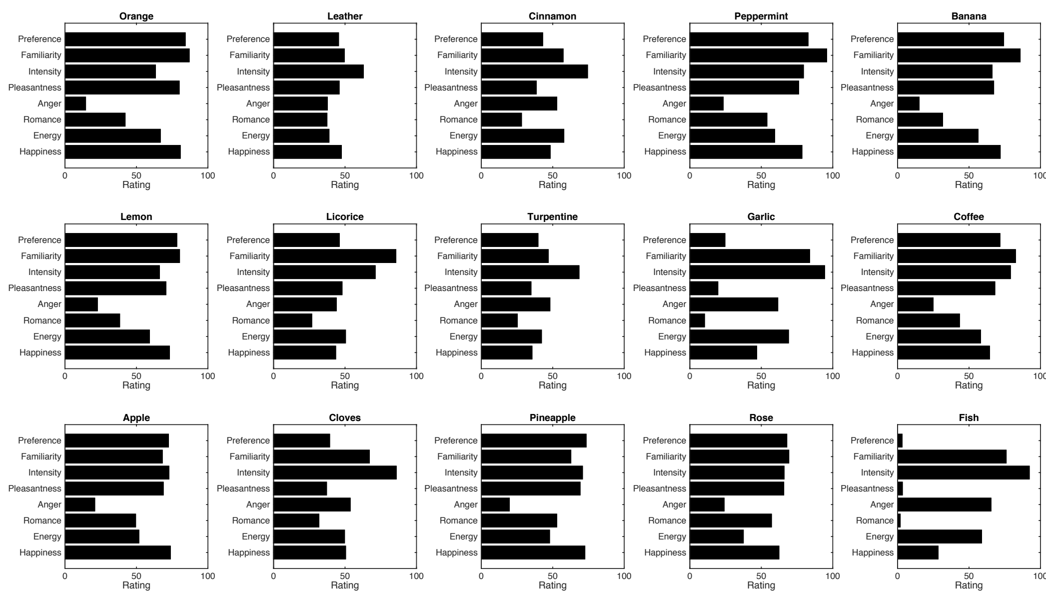

Figure 3: Mean dimensional ratings for each odor.

We then conducted a multiple regression with the match scores as the outcome measure and the similarity scores on the 8 different dimensions as the predictor variables. Figures 2 and 3 show the mean dimensional ratings for each musical selection and odor. For each dimension, we calculated the similarity in rating for each odor-music combination as 100 minus the absolute value of the difference in the two ratings. Of those 8 dimensions, we found that there was collinearity between preference (VIF = 8.255) and pleasantness (VIF = 10.701); we also found that these two variables were significantly correlated with each other, $r = 0.923$, $p < 0.0005$. All other VIF values were less than 3. Thus we decided to remove pleasantness from the model, but allowed the other 7 dimensions to remain (though many of these were also significantly correlated). The multiple regression analysis on the reduced set of factors showed that the model was able to capture a significant amount of the variance, with an overall $R^2 = 0.578$; $F(7,217) = 42.491$, $p < 0.0005$. Table 1 gives the Beta weights and significance of each of the reduced dimensions, 5 of which were statistically significant: anger, romance, happiness, preference, and intensity. Energy and familiarity were not statistically significant. These results demonstrate that similarity in emotional response predicts the strength of the match between objects and odors. The negative weight of intensity is likely due to all of the factors entering the model together, as the correlation between similarity in intensity and match score was positive. We therefore examined the correlations separately between the similarity in each of the 8 features and the match scores, as shown in Figure 4. With the exception of familiarity, all of the factors were significantly correlated with match score (all $p < 0.0005$). However, the odors we used were all relatively familiar; a study including unfamiliar odors might uncover a greater role for familiarity. Odor learning can be very rapid (e.g., Li, Luxenberg, Parris, Gottfried, 2006), however, so it is possible that emotional responses to new odors could change over the course of an experiment.

Overall, our results were consistent with the emotional-mediation hypothesis. However, there were some notable differences between our results and past work on color and music associations. Whiteford et al. (2013) had participants rate colors and musical selections on 10 dimensions, several of which overlapped with our dimensions. They found highly significant correlations between color-music matches and similarity of emotional content for 9 of their dimensions (Appealing vs. Disgusting, Calm vs. Agitated, Complex vs. Simple, Happy vs. Sad, Harmonious vs. Disharmonious, Loud vs. Quiet, Spicy vs. Bland, Warm vs. Cool, Whimsical vs. Serious) but only a slight correlation for preference. In contrast, we found that preference ratings for music and for odor were strongly correlated with music-odor matches and did contribute to the regression model. Moreover, preference ratings were highly correlated with harmonious/pleasantness ratings in the present data. Why the relationship among preference, harmoniousness, and match ratings should differ for color-music and odor-music correspondences remains an open question.

Further investigation of the nature of preferences may help illuminate such questions. Odor preferences and color preferences both can serve the important goal of helping us determine what objects to approach/avoid (e.g., Herz, Beland, & Hellerstein, 2004; Palmer & Schloss, 2010), and typically one likes objects that one finds pleasant and harmonious. However, for complex stimuli such as music, this relationship may be more complex; some people, particularly experts, prefer music that they do not consider harmonious (Palmer & Griscom, 2013). While there may be some evolutionary reasons for preferring some types of music over others (e.g., Gill & Purves, 2009), music and emotion are closely linked (Blood & Zatore, 2001; Hunter & Schellenberg, 2010).

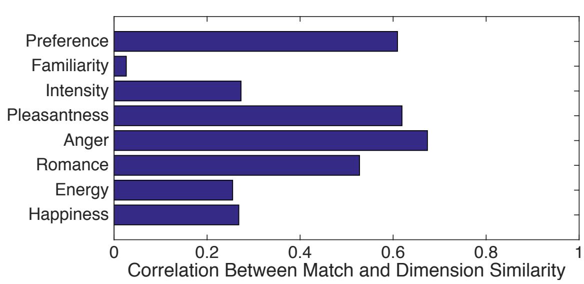

Figure 4: Correlations between match scores and similarities in each of the 8 dimensions.

Because our musical selections differed dramatically on many dimensions, we cannot address what particular musical features influence the emotional responses and the crossmodal correspondences that we measured. Using carefully controlled stimuli, as done by Palmer et al. (2015), could allow precise tests of how musical features, such as mode and tempo, influence crossmodal associations.

Previous studies have been rather mixed on the universality of crossmodal correspondences; studies of color-odor associations (Levitan et al, 2014) and color-music associations (Palmer et al., 2013) have found similarities across cultures, but for visual-taste correspondences, substantial differences across cultures have been identified (Wan, Woods, van den Bosch, McKenzie, Velasco, & Spence, 2014). It is likely that emotional responses to music and odors are, at least in part, culturally specific. If so, the emotional-mediation hypothesis would predict that the crossmodal matches would differ depending on the underlying emotions elicited by the music and odor selections.

In summary, crossmodal correspondences between odors and music are likely to be mediated by emotion. These results thus strengthen the possibility that affective correspondences constitute a fourth type of crossmodal correspondence.

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