DISSIMILARITY MEASURES AND EMOTIONAL RESPONSES TO MUSIC

POSTER #605

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INTRODUCTION

A common method for studying emotional responses to music is to have listeners describe their internal states using words. Given that emotionally descriptive words are used constantly in everyday life to convey internal states to other people, we can see how they would be useful in describing responses to non-linguistic stimuli. Many studies, however, constrain the listener to one or two valenced dimensions. Empirical results, as well as introspective experience, suggests that emotional responses to music are much more elaborate and oftentimes conflicting. The goal of this study was to develop a more nuanced method of measuring emotional response to musical excerpts. We explored self-report by having subjects choose from a large subset of descriptors, exploring the data gathered using a variety of dissimilarity metrics and machine learning techniques.

METHODS

Ten people (seven women) participated in the experiment, with ages 18 to 49 (M = 25 years). All but one had some musical experience (M = 17, range = 4 - 43), defined as prior training on an instrument or voice. We presented twenty-three excerpts of around thirty seconds to a minute-and-a-half; the excerpts represented non-famous pieces from the classical repertoire from the eighteenth- through the twentieth-century, as well as some non-famous, non-"classical" pieces from contemporary genres. Following each excerpt we asked the listener to select the word(s) from a list of twenty-one that described their emotional response to the piece. (Note this is *induced* emotion, as opposed to *perceived* emotion.) We also asked the listeners to rank, in order, the strength of the words chosen, allowing ties. Earlier experiments used a strength rating scale; we found that subjects had difficulties deciding on baselines; as well, we had the challenge of comparison of subjective "strength" values across subjects.

DISTANCE METRICS

Euclidean	$d_{ij} = \sqrt{\sum_p \lvert x_i - x_j \rvert^2}$	Jeffrey Divergence	$d_{ij} = \sum_p \left(x_i \log \frac{x_i}{m} + x_j \log \frac{x_j}{m} \right), m = \frac{x_i + x_j}{2}$
Hamming	$d_{ij} = \sum_p \lvert 1 - \delta(x_i, x_j) \rvert$	Chi-Squared Statistic	$d_{ij} = \sum_p \frac{(x_i - m)^2}{m}, m = \frac{x_i + x_j}{2}$
Manhattan	$d_{ij} = \sum_p \lvert x_i - x_j \rvert$	Weighted Manhattan	$d_{ij} = \sum_{p \in \{P_{\text{common}}\}} \lvert x_i - x_j \rvert + \frac{1}{\lvert \{P_{\text{non-common}}\} \rvert} \sum_{p \in \{P_{\text{non-common}}\}} \lvert x_i - x_j \rvert$
Common	$d_{ij} = \sum_{p \in P_{\text{common}}} \lvert x_i - x_j \rvert$		
Levenshtein	minimum number of operations needed to transform one string into another		

The choice of distance metric is vitally important; with your choice of metric, you import all of the assumptions of the distance measure into your model. For example, Euclidean distance is symmetric, while most psychological similarity measurements are non-symmetric. As well, many metrics that are used in histogram comparisons fail to take into advantage the contribution of neighboring bins. Earth mover's distance (EMD) attempts to get around this problem; later iterations of this work will incorporate this measure.

WORD FREQUENCIES ACROSS SUBJECTS

Words in red represent the "basic" emotion category for the same excerpt in Kallinen, 2005

DISTRIBUTIONS

Combining responses across all subjects, the graphs show the distribution of emotional descriptors after applying each labeled distance metric. We used standard multi-dimensional scaling (MDS) methods to produce these spatial distributions. We also performed k-means clustering to discover any underlying group structure. The optimal number of clusters was chosen using the gap statistic. Colors indicate group membership.

STIMULI

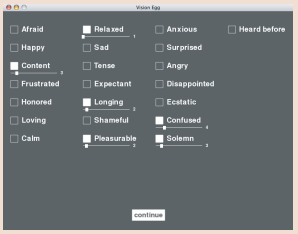
Beethoven, Ludvig Van • Symphony No. 4, First Movement
Bernstein, Leonard • Serenade for Solo Violin, Strings, Harp, and Percussion
Bloch, Ernest • Suite für Bratsche und Klavier: Lento/Allegro/Moderato
Bruch, Max • Violin Concerto No. 1 in g Minor, Third Movement
Bridge, Frank • Allegro appasionatto
De Lucia, Paco • Cositas Buenas
Debussy, Claude • La Cathedrale Engloutie
Explosions in the Sky • First Breath After Coma
Fauré, Gabriel • Piano Quartet No. 2 in G Minor, Op. 45 - Allegro molto moderato
Feldman, Morton • Why Patterns?
Haydn, Joseph • Symphony No 90, First Movement
Kammerflimmer Kollektief • Shibboleth
Kline, Phil • The Blue Room
Lang, David • How to Pray
Mendelssohn, Felix • Song Without Words Op. 62, No. 3
Mozart, Wolfgang Amadeus • Symphony No 36, Second Movement
Puccini, Giacomo • Crisantemi
Rachel's • Water From The Same Source
Saint-Saëns, Camille • Carnival of the Animals, Finale
Schumann, Richard • Symphony No. 4 in d Minor - Lebhaft
Schumann, Richard • Symphony No. 4 in d Minor - Romanze
Shostakovich, Dimitri • Symphony No. 6 in b Minor, Op. 54, First Movement
Stravinsky, Igor • Symphony No. 1 - Largo
Vaughan Williams, Ralph • In the Fen Country

WORDS

Afraid	Honored
Angry	Longing
Anxious	Loving
Calm	Pleasurable
Confused	Relaxed
Content	Sad
Disappointed	Shameful
Ecstatic	Solemn
Expectant	Surprised
Frustrated	Tense
Happy	

We chose words at the intersection of two previous large-scale studies (Juslin and Laukka, 2004; Gabrielsson, 2001). We presented the words in a random order for each subject to help prevent order effects.

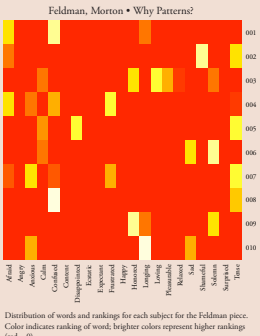
INTERFACE



STATISTICS

- All subjects chose, on average, more than one emotional descriptor (all $p < 10^{-6}$)
- In ⅓ of the pieces, small correlation between age and number of words chosen
- In ⅓ of the pieces, small correlation between years of musical experience and number of words chosen
- Strong ($p < 0.0005$) correlation between age and years of musical experience
- Small ($p < 0.05$) correlation between years of musical experience and theory training, but not years of theory training

DISTRIBUTION OF RANKINGS



Distribution of words and rankings for each subject for the Feldman piece. Color indicates ranking of word; brighter colors represent higher rankings (red = 0).

CONCLUSIONS

- Listeners' emotional responses are quite wide-ranging, and any attempt to collapse into smaller number of categories hides important variability
- No evidence for "basic" emotional responses; nearly all responses were multivariate
- The choice of distance metric strongly determines the results of analysis

Background image created using Emotional Found by Jared Tarbell