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MUSICAL STYLE PERCEPTION BY A LINEAR AUTO-ASSOCIATOR MODEL AND HUMAN LISTENERS

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ABSTRACT

The present research adapts to musical style perception a simulation approach previously used with visual stimuli (i.e., faces), which can handle a variety of tasks such as identification, recognition and categorization. A linear auto-associator was trained with musical excerpts of three composers (Bach, Mozart, and Beethoven). Based on its learned representation, a linear classifier (i.e., Adaline) was trained and its ability to categorize new excerpts from these three composers was evaluated. A subset of the excerpts used to train the linear models is currently tested in free and constrained classification tasks with human listeners.

1. INTRODUCTION

Musical Style Perception

When turning on the radio and listening to a musical excerpt, we can easily guess its musical style (i.e., classical music, rock, or country music) or even evaluate finer stylistic differences (e.g., baroque, classical, or romantic periods). Despite the apparent ease of perceptual classification, musical style is a complex multidimensional concept for which a wide range of descriptions has been proposed in musicology. Musical style has been defined as a "distinguishing and ordering concept" that "groups examples of music according to similarities between them" (1). The defining characteristics of style include recurring phrases, specific forms, melodic, harmonic or rhythmic features, timbre, typical textures and formal organization (2, 3). Musical style thus creates a paradox: listeners easily and rapidly recognize the style of an historical period or of a composer, but theoretical descriptions have difficulties to capture the characteristics of musical style.

Musical style perception can be seen as one example of sophisticated implicit learning processes that lead to non-verbal knowledge just by mere exposure to individual items. Comparable to implicit learning of language or tonal music, listeners seem to become sensitive to structural regularities underlying style. The question remains to specify the level of information on which the learned knowledge is based: Do listeners learn higher-level abstractions (i.e. rules, prototypes) or are specific episodes stored in memory based on perceptual characteristics (i.e., low-level representations)?

Parallel to Face Perception

For the visual modality, an example of a complex perceptual classification task is face perception. Previous research has shown that linear auto-associative memories (also known as Principal Component Analysis PCA models) operating on faces can handle a variety of tasks such as identification, recognition and categorization (i.e., 4, 5).

The present research proposes to consider musical style perception as a task similar to face perception, and applies a computational approach that has been successfully used for face perception and categorization. Faces are complex visual stimuli that are easily categorized (i.e., in terms of gender, race) or recognized (i.e., being classified as familiar or not). Despite the ease of face perception, the description of specific, multidimensional features that form the basis of the categories is rather complex and not well defined in terms of geometrical features. From this point of view, face processing can be seen as a perceptual task comparable to musical style processing. Several face perception models have been proposed in the literature, they are based on either explicit features of the faces coding separately elements (e.g., nose, mouth, eyes) or low-levels based on intensities in each pixel of the image. The low-level pixel-based code has been extensively used for neural network modeling (see 6, for a review). The most popular networks are based on linear auto-associative memories and are often used in combination with some classifiers (i.e., perceptron, ADALINE). Recent research applied this PCA approach to style perception in paintings, notably to simulate the performance of pigeons having learned to classify visual artworks in stylistic categories (i.e., Monet, Picasso) (7), and also to the classification of musical excerpts of two composers (8).

Overview

Our present work applies the principal component analysis approach to identify the style of short musical pieces. Musical excerpts by Bach, Mozart and Beethoven were used to train a linear auto-associator in combination with a linear classifier. The same musical excerpts were used in free and constrained classification tasks with human listeners.

2. SIMULATIONS

A linear auto-associator was trained with musical excerpts of Bach, Mozart, and Beethoven. The training material consisted of 10-second excerpts of piano works. Stimuli were prepared as midi files with a "piano" timbre, and their output recorded as .wav files. The musical excerpts were concatenated in a stimulus matrix. Two simulations were performed differing in the application of a first preprocessing step. This preprocessing step consisted in applying a Fast Fourier Transformation (FFT) to the sound files. The auto-associator model simulated the storage of the sound patterns, and gave for each excerpt its projections on the eigenvectors (i.e. principal components) computed from the training set. This processing step consisted in subjecting the data matrices to a Principal Component Analysis that decomposes the stimuli into eigenvectors, which are stored in a second matrix. The projections of the musical excerpts on these eigenvectors were then used to train a linear classifier (i.e., ADALINE) to categorize the musical excerpts into three groups. The simulations were in fact testing how far musical style classification can be performed on the basis of acoustic information only (9).

The linear classifier showed perfect performance for pieces it had learned. A jackknife (i.e., a "leave-one-out") approach was used to evaluate its generalization performance. The memory was able to categorize correctly new musical excerpts of the learned style with high level of accuracy, and this independently of the preprocessing.

3. HUMAN LISTENERS

A subset of the musical excerpts used in the simulations was presented to human listeners using two classification tasks. With the help of visual icons on the computer screen, 21 excerpts (7 for each of the three composers) were represented in the experimental session. The icons were linked to the wav-files and double-clicking caused the computer to start playing the excerpt via its 16-bit soundboard, over high-quality stereo equipment, presenting the stimuli via loudspeakers at comfortable levels. Clicking once on the icon would interrupt playing, and icons could be dragged and dropped to any part of the computer screen.

In a first experimental phase, excerpts were presented on the screen in a random arrangement, and participants had to group together excerpts "having the same musical style," with "musical style" defined as characterizing excerpts "that might have been created by the same composer." In a second experimental phase, they were informed that only three composers had been creating these excerpts, and they were asked to regroup their previous groupings into just three groups. The experimenter saved the file containing the participant's groupings after each of the two sorts, and data were retrieved from the saved files. We are currently running the behavioral experiments. The first data from the free classification task suggests that listeners show some sensitivity to the historical pattern of musical style.

4. DISCUSSION

The present research proposes to combine both computational and behavioral approaches to further our understanding of musical style perception. The computational approach applied the PCA approach previously used for face processing to musical style processing. The simulations with musical excerpts presented here and in (8) suggest that the acoustic signal of musical excerpts contains sufficient information to capture stylistic differences and that stylistic processing of musical information might be based on simple, perceptual processes in link to memory storage. Low-level processing might be the basis to define the complex phenomenon of musical style perception as a rather simple, linearly separable problem. Interestingly, previous data have shown that even pigeons seem to be able to differentiate musical styles and to classify Bach with Scarlatti and Stravinsky with other contemporary composers (10). Similar musical discrimination performance has been reported for fish (11). The outcome of the behavioral approach, still in progress, will be compared to the performance of the computational model.

5. REFERENCES

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