Individual Differences and the Interpretation of Auditory Graphs: Cognitive Abilities and Demographics

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Abstract

Auditory graphs exploit pattern recognition in the auditory system but questions remain about the relationship between cognitive abilities and sonification interpretation. Ss completed magnitude estimations relating sound dimensions to data dimensions. Multiple regression indicates some support for demographics, Ravens, and n-back predicting interpretation of sounds. Details and implications are discussed.

Summary

In many laboratories and classrooms researchers analyze large, multidimensional, and dynamic data sets. New sonification and auditory graphing techniques are being used to exploit the exceptional pattern recognition capabilities of the human auditory system (Walker, 2002). Unfortunately, there remain many unanswered questions in auditory display design, and in particular the relationship between cognitive abilities, demographics, and the interpretation of sounds used to represent data.

The limited research in this area has found some differences between groups of individuals, such as sighted and visually impaired listeners (Walker & Lane, 2001), and in one case musical novices and musical experts (Neuhoff et al., 2002). This indicates that there may be individual differences in variables that affect the way people interpret auditory information. However, there has not been any systematic evaluation of the relationship between a variety of variables and auditory graph interpretation. Further, to our knowledge, cognitive abilities such as working memory and spatial reasoning have not been considered for their influence.

Walker (2002) points out that, in order to develop useful and effective auditory displays, the designer must determine (1) the optimal display dimension or sound attribute to represent the data dimension, (2) the polarity of the mapping, and (3) the scaling or slope of the mapping. The focus of the present study is on the last of these design considerations, namely the amount of change of a data dimension (e.g., temperature) that a listener perceives given a certain change in a sound dimension (e.g., frequency). Our concern is whether we can predict the listener's interpretation based on working memory, spatial reasoning, and other cognitive and demographic variables.

Georgia Tech students participated in an auditory magnitude estimation task involving frequency, tempo, or spectral brightness. The 10 data dimensions used in the study were size, temperature, pressure, velocity, number of dollars, urgency, proximity, danger, attractiveness, and mass. The participants heard a series of sounds presented one at a time in random order and were asked to assign each sound a value that represented its magnitude for a particular data dimension. For example, "What 'Number of Dollars' does this sound seem to represent?" We also collected data on demographics and on the Ravens Progressive Matrices and n-back working memory task.

Using multiple regression, we investigated the influence of these potential predictor variables on the interpretation of auditory graphs, specifically the scaling of the individual mappings and the R-squared values of those mappings. We found some support for each of our independent variables contributing to the prediction of how listeners interpreted the sounds they heard. For example, in some cases spatial reasoning ability contributes to the prediction of slope and R-squared values. There was less support for using the n-back as a predictor of auditory graph interpretation. Full details of these findings will be discussed in the talk. These results may be useful in designing more effective auditory displays and sonifications, or in selecting personnel for tasks that involve auditory displays. However, we caution that many questions remain and require further study.