Comprehension of Sonified Weather Data Across Multiple Auditory Streams

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ABSTRACT

Weather data has been one of the mainstays in sonification research. It is readily available, and every listener has presumably had some form of experience with meteorological events to draw from. When we want to use this type of complex data in a scenario such as in a classroom, we need to be sure that listeners are able to correctly comprehend the intended information. The current study proposes a method for evaluating the usability of complex sonifications that contain multiple data sets, especially for tasks that require inferences to be made through comparisons across multiple data streams. This extended abstract outlines a study that will address this issue by asking participants to listen to sonifications and then respond with a description of general understanding about what variables changed, and how said changes would physically be represented by real weather conditions.

1. INTRODUCTION

Making small talk about the weather is more than just an easy way to start out a conversation with someone. Weather is something that we can all physically experience through one or more perceptual modalities on a daily basis. Furthermore, studying weather and forecast data is a great introduction for many students into the scientific processes of observation and data collection. This is especially advantageous because weather data is something that is often and widely collected, making it readily available through many services [1]. The sonification of weather data is nothing new to the ICAD community. Over the past decade there have been various proceedings that discuss the merit of sonifying meteorological data for uses such as broadcasting over the radio [2], for creating dynamic art installations [3], or for the purpose of presenting historical data through a non-visual modality to create new exploratory experiences [4]. At this point there is less of a question of how the sonification of meteorological data should be designed, but instead a question of how it could or should be implemented. In a science classroom, for instance, exploring weather data through a non-visual modality can be useful for many students, especially those with a visual impairment who may have no other effective way to explore data.

For sonifications of weather data to be truly useful in a classroom setting, they need not only to sound good, but also be informative to listeners by providing usable information for making predictions, comparisons, and inferences. For a sonification to be informative in this manner, the information must be not only perceivable but also comprehensible [5]. This means that listeners need to be able to explore data and make informed decisions based on what they hear. Meteorological data contains multiple variables that interact and require comparison or considerations to be made between them. This would require weather sonifications to be designed with concurrent or nearly concurrent presentation of weather variables (i.e., temperature and humidity). However, the successful presentation of simultaneous information or messages across separate audio streams is still an aspect of sonification that needs to be addressed further [6] [7]. This is an issue because of a limitation on the number of auditory streams usable by sonification consumers, which may be linked to a component of Auditory Scene Analysis where stream segregation has a potential upper bounds of no more than five, but closer to three, concurrent auditory streams being the more ideal for listeners to utilize [5][8][9].

With a suggested limit on the number of concurrent auditory streams that a listener can utilize, we must consider design techniques like *sonification configuration*, or the loading of information onto specific auditory streams [10]. The current study seeks to examine this using real weather data. Participants will be presented with three or five variables of weather data for a specific day. These variables will be presented in each trial in one of three variable presentation formats. These formats are the serial (one right after another) presentation of each weather variable, parallel presentation of all three or five variables simultaneously, or the sonification configuration condition with up to five weather variables presented across three concurrent auditory streams.

1.1 Hypothesis

Comprehension is operationally defined as the participants' ability to correctly identify what the sonified data represents in relation to the physical variables that drive it. For instance, if a sonification of temperature data displays a trend in the temperature rising over the course of a day, a participant can show they comprehend this by responding that the temperature has gone up. Response time will also be measured as a factor of comprehension. As the number of weather features being presented increases from three to five, it is predicted that listeners will have a harder time comprehending the information being provided. This is predicted to result in lower accuracy in

identifying weather patterns and longer response times when participants answer questions about the weather data being sonified.

Comprehension is predicted to be the least accurate during the parallel presentation condition due to an overlapping of auditory streams. The serial presentation variant is expected to result in increased accuracy and response time as it will be more taxing on working memory. The sonification configuration condition is expected to result in higher accuracy as well as faster response times due to the strategic mapping of data variables to sound parameters that will intentionally stream together in useful ways during auditory scene analysis.

2. METHOD

The proposed method for the upcoming study consists of presenting sonifications of real weather data, with either three or five physical weather variables represented. These will be presented in serial, parallel, or the sonification configuration conditions. Participants will then be asked to answer comprehension-based questions about what the sonifications represent in terms of the related physical weather conditions.

2.1. Stimuli Design

The goal of this study is to determine listeners' ability to comprehend information within sonifications that contain multiple data sets. The stimuli for this study will use real weather data obtained from Weather Underground's historical data archive [1]. These streams of auditory content will be designed in PureData and saved to 2-channel stereo WAV files. Weather data will be narrowed to five major variables: air temperature, humidity, wind speed, wind direction, and cloud cover. The auditory streams for each will be designed to reflect its physical dimension as closely as possible. For example, temperature will be expressed in frequency of a presented tone, which relates to the increase in molecular movement at increasing temperatures. This will be done with positive polarity, where high temperatures map to high frequencies. Humidity will be expressed as the tempo or inter-stimulus interval (ISI) between tones, with positive polarity for tempo and negative polarity for ISI, in that high humidity results in a fast tempo or short ISI. Wind speed will be represented by intensity of pink noise added to the stimulus, with positive polarity where high wind speeds map to high pink noise intensity. Wind direction will be represented spatially. The pink noise source will match the cardinal direction of wind, while staying on the horizontal plane. Finally, cloud cover will be expressed via the wet/dry mix of additional reverberation applied to the signal. This is also done with positive polarity, where high cloud cover or overcast conditions map to a highly reverberant signal.

2.2. Current Procedure

Participants will be presented a randomized version of the weather data sonifications falling into either the three or five weather variables category as well as one of the three possible presentation conditions (serial, parallel, or sonification configuration). Following the stimuli presentation, listeners will be asked to give, in their own words, an explanation of the physical weather conditions for the day's data being sonified. This is to gauge listeners' general understanding of what variables changed and in what direction. For example, a listener will be presented a day's worth of weather data and then respond with something like "It got hotter at the end of the day, the humidity seemed to stay constant. There was also a light wind from the east for most of the morning." Response time will be measured and these responses will be scored for comprehension level according to the operational definition in our hypothesis.

3. CONCLUSION

By implementing an operational definition for comprehension, we can begin to quantify the relative usability of sonifications containing multiple data streams. Doing so will allow for these auditory displays to be better developed and deployed in a variety of scenarios, such as lessons on meteorology in a science classroom of both sighted and visually impaired students.

4. REFERENCES

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