**Rochester Institute of Technology**

**B. Thomas Golisano College**

**of**

**Computing and Information Sciences**

**Master of Science in Human Computer Interaction**

**~ Project Proposal Approval Form ~**

Student Name: Shuishi Fang

Project Title: Using Sound Cue to Improve Time Perception Accuracy in Data Sonification

Project Area(s): Application Dev. Database Website Dev.

(√ primary area) Game Design √ HCI eLearning

Networking Project Mngt. Software Dev.

Multimedia System Admin. Informatics

Geospatial Other

## ~ MS Project Committee ~

Name Signature Date

Chair

Committee Member

Committee Member (optional)

Approved: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_/\_\_\_\_/\_\_\_\_ electronic copy received

Using Sound Cue to Improve Time Perception Accuracy in Data Sonification

By

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This capstone proposal is submitted in partial fulfillment of

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Using Sound Cue to Improve Time Perception Accuracy in Data Sonification

HCI MS Capstone Project Proposal

Shuishi Fang

# Abstract

Formal research showed that people’s perception of time is significantly less accurate compare to perception of pitch while listening to a sonified data chart. In this work, I propose adding a repeating sound cue to the data signification. Such sound cue serve as a reference to people’s perception over time while listening to a sonified data chart, similar to grids serve as a reference to people’s perception over space in visual modality. Also, I will use within subject experiments to test if this design approach could improve people’s perception of time while hearing a sonified data chart.

# 1 Introduction and Background Information

Although the Web Content Accessibility Guideline suggests to represent dataset to blind and low vision user using screen reader by reading out the numeric table directly[6], usability test revealed such approach to be “time-consuming” and “take enormous cognitive effort”[25]. And the history of creating accessible data charts can be traced back to the 90s[16], trying to allow visually impaired user somehow perceive data charts more effectively, as data visualization techniques developed rapidly at the end of last century[15].

There are mainly four categories of accessible data chart: Sonification[22] [13] [12] [4] [5] [24] trying to map the vision variables into acoustic variables as pitch, timbre, loudness, and audio icon. Haptic[17][19]is trying to map them into different levels and types of vibrations. Tactile[2] [14] [21] approach trying to allow users to touch the data chart a similar way as braille keyboard and screens. While natural language[9] [10] [11] [8] [25] [18] trying to communicate the key attributes of a data chart with users through descriptive sentences. And there is hybrid method [8] [25]trying to combine multiple modalities and remedy the short come of each.

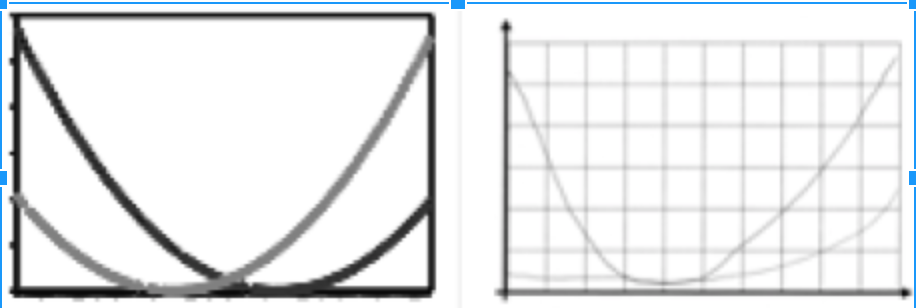


Figure 1: the original chart(left) and a typical participant drew chart(right) [4]

When trying to sonify the two axes of visually represented data charts, time naturally is utilized to represent the x-axis, as historically people mostly use x axis to represent time[15]. However, some experiments[4] show people’s perception over time is not very accurate(Figure 1). And although large in number, most of the modern sonification methods are designed for combine usage with visualized data by sighted people utilize people’s perception ability over sound modality to reveal abnormal in a data set which can’t be perceived by eyes[3] [23], or used to represent real time data. Thus researchers never actually address this time accuracy problem as it is less significant in their usage of sound sonification.

Nowadays brain neurologists and psychologists argues that the perception of time is not controlled by certain independent brain part, but the result of some “sequence of events” and experiments show that people’s sense of time is different for each sense, and synchronized by some mechanism often, thus not very reliable[20].

In this work, I’m planning on improve people’s time perceiving accuracy by playing the sound of a second hand (<https://www.youtube.com/watch?v=zHIVeWhCMU8>) between a certain time interval, say one second, thus create something similar to a grid in user’s perception of time to make it more possible for comparison of different part of a sonic chart in mind. And evaluate this new design approach of sonification by within-subject experiment.

As for recruiting participants, since I’m simply trying to test a design approach to remedy a certain known problem in an earlier published design, instead of claim this is a part of the ultimate solution for data sonification, so any person with the hearing ability is eligible. As demonstrated[8], I can recruit sighted people to evaluate the effectiveness of this new design by showing them similar sonification chart with or without the time grids sound and ask sighted participants to draw down what they heard, and compare to the original chart[4].

# 2 Motivations and Goals

## 2.1 Problem/Purpose and Significance

## During some earlier research of sonification, the result shows that due to the inaccuracy of time perception, participants might have a skewed perception of the original chart. As the shape and most other properties of the data sonification captured and drew out by participants, there is a skew in the x-axis, which is represented by the time during the experiment(Figure 1). And this inaccuracy is more significant than the similar inaccuracy in other potential dimension, say pitch. As the usage of two non-time dimension to represent a data chart has been proved worse[4], be able to improve the perception accuracy of the time dimension (x-axis) is vital to improve the usability of data sonification in representing non real time data chart on its own.

## 2.2 Research Questions

Research Question 1:

Whether or not including a referential sound which slice time equally in signification improves people’s accuracy of the axis represented by time?

Research Question 2:

Whether or not including a referential sound which slice time equally in signification deteriorate people’s accuracy of the other dimension represents y axis?

Research Question 3:

Will the property of the referential sound (Loudness? Pitch? Timbre?) interfere with its effectiveness? If so, how?

## 2.3 Research Objectives

Design a within subject experiment to compare the participants time perceive accuracy difference between sonification chart with or without referential sound component.

Obtain IRB approval.

Create several data sonification charts, with and without referential sound component.

Recruit participants to conduct the test.

Analyze the data and write the final report.

## 2.4 Potential Contributions and Benefits

# As time is commonly used in sonification to represent x-axis, if we could increase people’s accuracy perceiving the time, we would be able to make data sonification one step closer to being a standalone data representing method and serve as a form of accessible data chart to blind or low vision users using a screen reader. This is more of a design contribution.

# 3 Prior Work

Different attempts have been made to code visual variables into acoustic variables by using timbre, pitch, loudness, audio icon.

Other researches show the capacity of acoustic modality. For example, one research shows there might be three or four acoustic sounds people could track simultaneously, there are other works determine how many audio icon can people recognize at a time [13].

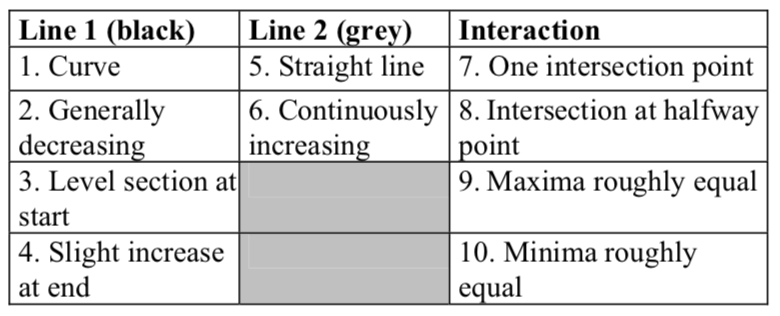


Figure 2: Attributes of a curve[4]

The earliest research of using time to represent x-axis is done by Mansur in 1984, and later in Brown and Brewster’s work “Drawing by ear”[4], the researchers sonificated a series of line charts of two data series, using time to represent x-axis, and pitch to represent y-axis. The researchers had a different such sonification for each major mathematic attributes (Figure 2). The researchers patch the two different data series in each sonification into different ears of a headphone, provided a few control function for participants to probe the sonification, like forward and backward, and overview. 12 Sighted participants would probe the sonification for two minutes, and were asked to draw down what they heard. Then drew pictures were compared their drawings with the original data charts. The researchers coded the original curve by the attributes they have, like a curve drop down, a line going up, or something like that. At the end of each session, each participants was given a NASA TLX scales [26] to determine their subjective workload experienced.

On the other hands, Abu and others’ work on Microsoft Excel Accessibility [1] used similar ways to “Draw by Ear” to exam how much information about the data could a participant absorb after explore the accessible data chart provided by research. Moreover, they showed a set of tasks contextually related to data usage. They argue that there are three kind of cognitive process happening while a sighted user is perceiving a visualized data chart: First is “Question-Answering”, which uses data to perceive certain facts in the dataset. Second is “Knowledge Synthesis”, which is using the data set to create an idea. The third one is “Knowledge Acquiring” which focus on the generating of long term memory about certain ideas created by visualized data set. And in their work, they also measured the ability of 9 sighted participants to reproduce the data chart to see how well their alternative data representing works. Unlike Brown and Brewster’s work only compare how much attributes of the different curves participants captured, Abu and his colleagues also tested participants ability to identify the crossing points and mutual positions of different lines within the same chart. And measured the time participants takes to find out that fact. In my work, I would also adopt this technique to compare the skew on two different sonification dimensions (time and pitch).

As for how to generating the sonification, Bearman and Brown[3] mentioned five different special designed systems which has previously used by researchers to generated snoificiation in 2012. They are SuperColider, Pd, Max/MSP, Csound, and ChucK. And they also mentioned some researchers used build in MIDI tool or pre recorded their sonification. I’ll check those tools out and see how to generate informations using one of them.

# 4 Methodology

## 4.1 Plan of Work

Design a within-subject experiment to compare the participants time perceive accuracy difference between sonification chart with or without referential sound component.

Things being tested here are participants’ accuracy in perceiving the data sonification. I will test it by measuring how well a sighted participant could reproduce the image. “How well” here is defined by the same attributes table provided by Brown and Brewster (Figure 2). I will match the attributes captured by participants during the reproducing. For each attribute, I will use statistic methods to see if participants could replicate it or not. On the other hand, certain questions will be asked to the participants, to measure the information they perceived from the data chart.

During the test, the participants will be shown three different charts: one data visualization chart, one data sonification chart without the sound cue, and then another data signification chart with the sound cue to separate the time equally. Each chart will be shown to the participants for 2 minutes, during which participants could probe the data chart (forward, backward, listen again, etc for the sonified data chart, or however they would like to for the visualized data chart). After the 2 minutes probing time, the chart will be taken away, and participants will be provided with dotted paper to draw down what they saw or heard.

After the drawing, some questions will be asked to the participants, for example to estimate the mean of one data set. Or to estimate how much is the highest subtracted by the lowest. Things like that. I’m still working on the questions.

The reasons I provide the data visualization chart are to let participants getting familiar with the task, and to have a base line of how good data reproduce works when perceiving the data is not a problem.

To balance out the result, there will be two different datasets being sonified, and for some participants, dataset A have the sound cue, and for others, dataset B will have the sound cue.

Submit the IRB form and obtain IRB approval.

Learn how to use one of the tools and create several data sonification charts. Design iteration may occur here.

Right now I’m planning to use the sound of a watch second hand “Ticking” sound (<https://www.youtube.com/watch?v=zHIVeWhCMU8>) as the sound cue, which could avoid unnecessary complicates in designing the sound cue as people are familiar with this sound. A few informal usability tests will be conduct to determine the proper loudness and time interval of this sound cue. As I suspect if the sound cue is too loud, it will attract participants attention from the sonified dataset, and if there are too much sound cues in a sonified data chart, participants would lose track of it.

Recruit sighted participants and conduct the test.

Analyze the data and write the final report.

## 4.2 Challenges or Barriers

Right now I’m not yet familiar with how a real data sonification should sound like and how different choice of sound cue would influence the outcome is not clear yet. It would take a few informal design and test iterations to tune it before actually perform the within subject test.

## 4.3 Limitations

Due to both logistic and realistic reason, I’m going to recruit sighted user instead of blind and low vision user to perform the task, so they could redraw the data chart they heard and provide data for analyze. Real blind and low vision users are not able to re generated that chart in another form, then I would be limited to asking indirect question, and unable to probe details of participants’ perception. However this choice of participants could potentially skew the result because sighted users would have more experience with data charts, thus have a higher graph literacy[7] then blind and low vision user. It could also be a good thing as it eliminates a potential independent variable. Still, without actually test the design with blind and low version users, only the potential of an accessible data chart approach could be determine by this work.

Also, another potential source of skew in the research is bringing by the referential sound itself. The iterate design process would only be able to find one or two usable sound cues from unusable ones, if possible. But probably not be able to have a clear idea of how the loudness, the pitch and the timbre of that sound could potentially interfere with participant’s perception with the sonified data sets. Also, I’m not sure it would be better that the sonified data and the sound cue are more different to each other, or more similar to each other. And I’m not aim to test them all out.

## 4.4 Deliverables

The final report of the Capstone project.

The original dataset acquired of from the experiment.

# 6 Timeline for Proposed Work

12 Week Plan:

Before semester begins, obtain approval from committee members and forward to Tracy, get enrolled in the capstone.

5 Weeks: Design the within subject test. Develop questionnaire and a sample sonification Submit IRB form for exempt. Conduct the informal within subject test to get a suitable sound cue.

2 or 3 Weeks: Seeking potential participants, finish sonification.

3 Weeks: Book usability test lab and conduct within subject test.

4 Weeks: Analyze data and writing the final report.

2 Weeks: Book and conducting the project defend with the committee.

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