Audio Perception and Interface Design

ISYE 348 Fall 2024 Lab 2

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This lab assignment is due by 23:59 on 2024-09-24. If you have any questions or need clarification, please reach out to me via email or during office hours. The report will be graded on **20 points** based on the following criteria:

Criteria	Points
Introduction (your own words; 50-100 words)	1
Methods (your own words; 100-200 words)	2
Results	6
Discussion	6
Improvements	2
Conclusion	3

Submission: Please submit your report as a PDF file on Canvas. Make sure to include your name and your partner's name at the beginning of the report. Include any code, plots, or tables as needed to support your answers. Make sure to answer all questions thoroughly and provide detailed explanations where necessary. Cite any external sources used. Submit one single pdf file with all the answers.

Collaboration with your classmates is encouraged, and you will work in pairs for this lab to complete the report. Each group should have data for part 1 (audiogram) from at least one member and part 2 (audiocons) data from all members. Please list your partner's name at the beginning of the report. Only one submission per group is required. Must include data from both partners in the report.

Late submissions will be penalized by a 1 point deduction every hour past the deadline.

Please read the course policy on academic integrity and collaboration on the course syllabus. If you have any questions about what is permissible, please ask before submitting your work.

Introduction

This lab explores two key aspects of audio perception and its application in interface design: basic audiometry and earcon recognition. These experiments will help us understand human hearing capabilities and how auditory cues can be effectively used in user interfaces.

Objectives

1. To generate a basic audiogram and understand the relationship between frequency and hearing thresholds.
2. To investigate how well participants can learn and recall associations between earcons (non-speech audio cues) and their meanings in a user interface context.

Safety Considerations

- Ensure audio levels are comfortable and safe for extended listening.
- CAUTION: higher volume levels can cause hearing damage. Keep the volume at a comfortable level. Higher volume levels even for inaudible frequencies can cause damage to the ear or the headphones. To be safe, note the volume level that allows you to listen to a 1,000 Hz tone without discomfort and do not stray too far above this level, even if you can't hear much.

Equipment

- Computer or smartphone with:
  - Pure tone generator (e.g. https://www.szynalski.com/tone-generator/)
  - NIOSH Sound Level Meter app (or AirPods with iPhone)
- Headphones
- A quiet room for testing
- Set of 10 distinct earcons (audio files) with list of 10 corresponding interface actions or notifications

Part 1: Pure tone audiogram generation

Procedure

1. Form pairs. One person will be the subject, and the other will be the tester.
2. Generate the audiogram:
   - The tester will play pure tones at the following frequencies: 250 Hz, 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz.
   - For each frequency:
     a. Start at a very low volume and gradually increase until the subject can just barely hear it.
     b. Record the sound level (decibel) using the NIOSH app (or use decibel values identified in the iphone).

- Repeat the process for each ear separately.

3. Create your audiogram:
    - Plot the hearing thresholds (in dB) for each frequency on a graph.
    - Use different symbols or colors for left and right ears.

Results

Record your results here:

1. Audiogram data table:

Frequency (Hz)	Right Ear (dB HL)	Left Ear (dB HL)
250		
500		
1000		
1500		
2000		
3000		
4000		
6000		
8000		

2. Insert your audiogram graph here (X-axis: Frequency in Hz, Y-axis: Hearing Level in dB). Refer to https://soundhearing.org/2024/06/25/pure-tone-audiometry-explained/ for more details.

(also include any other data/plots that you may have collected)

Discussion

1. Describe the overall shape of your audiogram and any notable findings.
2. How might age, gender, or noise exposure affect an audiogram?
3. What are the implications of your findings for designing auditory displays or alarms?
4. How could background noise in different environments affect the ability to hear certain frequencies?
5. What are some limitations of this simple audiogram test compared to professional hearing tests?
6. [optional] If you and your partner both collected audiograms, compare and discuss any differences or similarities.

Part 2: Earcon Recognition and Learning

Procedure

1. Earcon Learning Phase

- Introduce participants to the concept of earcons.
- Present each earcon paired with its corresponding action/notification.
- Play each earcon-action pair 3 times.
- Allow participants 5 minutes to review and memorize the pairs.

2. Immediate Recall Test
   - Randomize the order of earcons.
   - Play each earcon once.
   - Ask participants to identify the corresponding action/notification.
   - Record accuracy and response time for each earcon.
3. Distractor Task
   - Have participants complete a simple, unrelated task (e.g., Psychomotor Vigilance Task https://nimrobotics.com/pvt/ + basic math problems (3 digit addition)) for 10 minutes.
4. Delayed Recall Test
   - Repeat steps from Part 2 with a new randomized order.

Results

1. Calculate overall accuracy for each test phase.
2. Compare accuracy between immediate recall and delayed recall.
3. Analyze response times across test phases.
4. Identify any patterns in which earcons were easier or harder to remember.
5. Note if the participant has familiarity with the earcons or the interface actions.
6. Include any tables or plots to support your results.

Discussion

1. Discuss the key findings from the earcon recognition experiment.
2. Were some earcons consistently easier or harder to remember? Why might this be?
3. How might these findings inform the design of audio interfaces?
4. What factors could affect a person's ability to learn and remember earcons?
5. Compare the results in your group. Were there any differences or similarities in the learning and recall of earcons?

Improvements

How could you improve the experimental design or procedures to gather more accurate data or better understand the underlying mechanisms of audio perception and earcon recognition? Or what would you do differently if you were to repeat this experiment?

Conclusions

Include a brief summary of your findings and any insights you gained from this lab. What did you learn about human hearing capabilities and the use of auditory cues in interface design?

References

1. National Institute for Occupational Safety and Health. (2019). NIOSH Sound Level Meter App. https://www.cdc.gov/niosh/topics/noise/app.html
2. Szynalski, T. (n.d.). Online Tone Generator. https://www.szynalski.com/tone-generator/