VIRGINIA COMMONWEALTH UNIVERSITY

Exploration of Multi-fingered Access to 2D Spatial Information

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ABSTRACT

Typically, the use of touchscreen devices with tactile and/or auditory feedback to provide access to refreshable graphics uses a single finger, limiting the perceptual field of view and, potentially performance. Preliminary results using feedback to multiple exploring fingers, either through vibration feedback or sonified (non-speech sounds) feedback suggests that the benefit of multi-fingered feedback may depend on modality, user characteristics and the question asked.

INTRODUCTION

Many different research groups have examined the use of vibrotactile cues with auditory labels as feedback for a single exploring finger for providing nonvisual access to various types of diagrams on smartphones and tablets. However, exploration is often slow and difficult.

- ***Can performance improve if simultaneous feedback for multiple exploring fingers is used?*** Previous work in our laboratory have given conflicting results. ***Does this depend on the type of diagram and questions asked?***

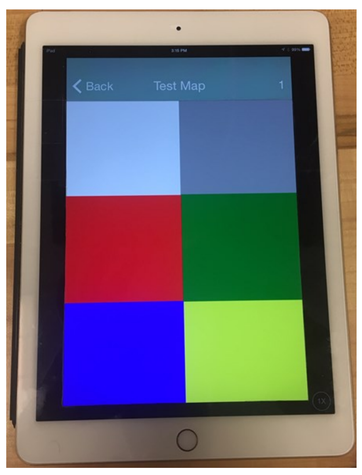
Few groups have considered sonified cues in place of vibrotactile cues, despite advantages of less power consumption in generating the cues.

- ***Can we achieve at least the same performance if sonified cues replace the vibrotactile cues for multiple exploring fingers?*** We are unaware of any previous work on this topic. However, we do know from auditory perceptual processing that sounds are pre-attentively grouped based on timbre and spatial location. ***Can we use either or a combination of these grouping principles to provide feedback for more than one exploring finger simultaneously? And does this result in a performance benefit?***

- In this study, we focus on providing feedback to 2 fingers, but the principles are the same for multiple fingers

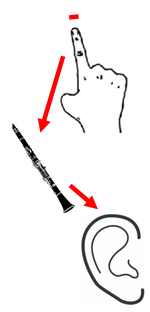
Feedback Methods

- Colors contacted by a finger mapped to a set of 6 notes/vibrations
- Seven different feedback methods examined



Audio Cues (notes: 55, 196, 466, 880, 1760, -)

1.



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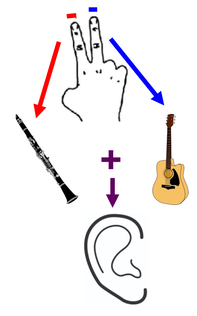

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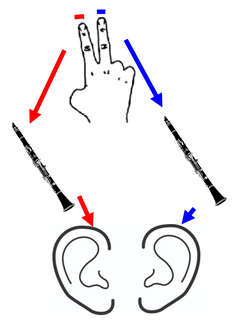

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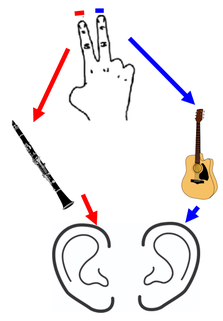
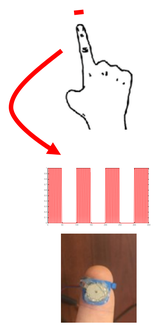


Tactile Cues (on-off vibrations: 490/10, 250/50, 75/50, 50/50, 10/21, -)

5.



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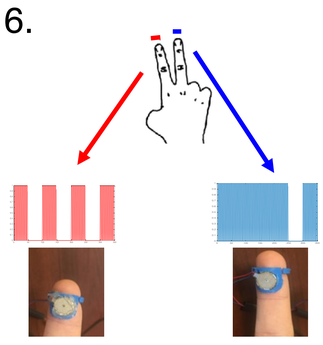

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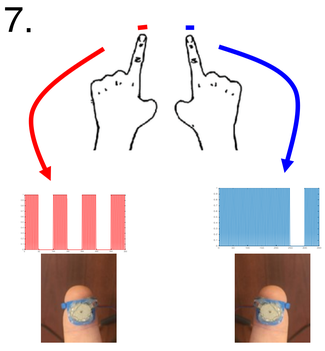
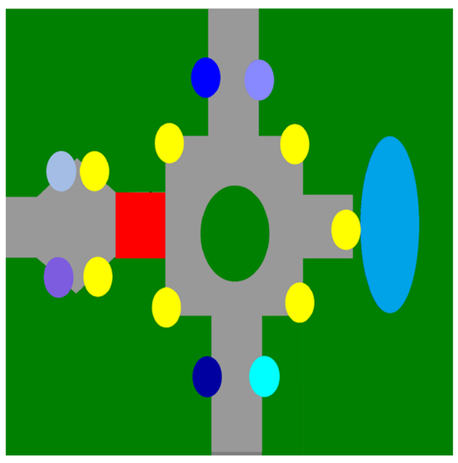


- Parameters chosen by extensive pilot testing

Diagram/Map Representation

- Representation on tablet
- Colors indicate features
- Diagrams for exploring botanical gardens
  - Two types of maps

Overview Map of Garden Areas + Buildings



Individual Garden Area

- Questions varied in the type of spatial information needed

OVERALL MAP: _____

1: Buildings are indicated by the color white. How many buildings are there in the map?

2: What is the overall shape of the _____ garden?

3: Is the _____ garden _____ than the _____ garden?

4: Is the _____ garden next to the _____ garden?

5: Which garden is closer to the _____ garden, the _____ garden or the _____ garden?

6: How many gardens are to the _____ of the entire _____ garden?

7: How many gardens are _____ the entire _____ garden?

8: You are somewhere in the _____ garden. Which garden(s) MUST you pass through to go directly to the _____ garden?

9: Which gardens are between the _____ garden and the _____ garden.

10: What is the overall shape of the _____ garden?

INDIVIDUAL GARDEN MAP: _____

1: Benches are indicated by the color yellow. How many benches are on the map?

2: Buildings are indicated by the color white. How many buildings are there in the map?

3: Which path(s) have the most _____ ?

4: How many _____ are adjacent to _____ ?

5: What points of interest _____ the _____ ?

6: Following paths that is to say, no stepping on the grass or flowers but assuming buildings are one large room, if you are at the _____ corner, find the closest _____ .

7: Following paths that is to say, no stepping on the grass or flowers but assuming buildings are one large room, if you are at the _____ corner, find the closest _____ IF you cannot use the stairs.

8: Following paths that is to say, no stepping on the grass or flowers but assuming buildings are one large room, how many direct paths are there to get from _____ to _____

9: The next two questions will simulate your potential usage of the map while you are exploring the gardens. If you will allow me to, I will move one of your fingers to a point of interest. Imagine that this is like you have found the YOU ARE HERE SYMBOL on the map. This could be like you were exploring the garden without a map and now want to see what is around you.

Could you tell me what is nearby the _____ point of interest on the pathway(s).

10: We are going to do the same thing but in a different location.

Could you tell me what is nearby the _____ point of interest on the pathway(s).

PRELIMINARY RESULTS

Based on:

- 2 study participants who were visually impaired
- 1 participant was congenitally blind and somewhat familiar with tactile diagrams
- 1 participant was adventitiously blind and never used tactile diagrams before
- All participants blindfolded
- Methods counterbalanced
- Measured number of questions correct, response time to answer all questions for a map correctly

Summary of *preliminary* results:

Users had more correct answers:

- using auditory cues rather than vibrotactile cues
- using two fingers with auditory feedback compared to one finger
- only for some types of questions using two fingers with vibrotactile feedback compared to one finger

- Method 4 appeared to produce the best performance

- There does not appear to be a difference in response times between methods

CONCLUSIONS

Preliminary results suggest that the use of sonified (non-speech sounds) feedback, particularly with two fingers, is more effective than using vibrotactile feedback (one or two fingers). This also involves hardware that is more comfortable/easier to use than multi-fingered vibrotactile feedback and has lower power consumption than vibrotactile feedback.