Serpentine

Serpentine is a highly stretchable self-powered sensing material that can recognize human input based on deformations of its shape.

- Can **sense** human gestures
- **Flexible** and can be embedded into various objects
- Cylindrical shaped cord allows several **intuitive** and playful interactions.
- Easy to **manufacture** with readily available materials
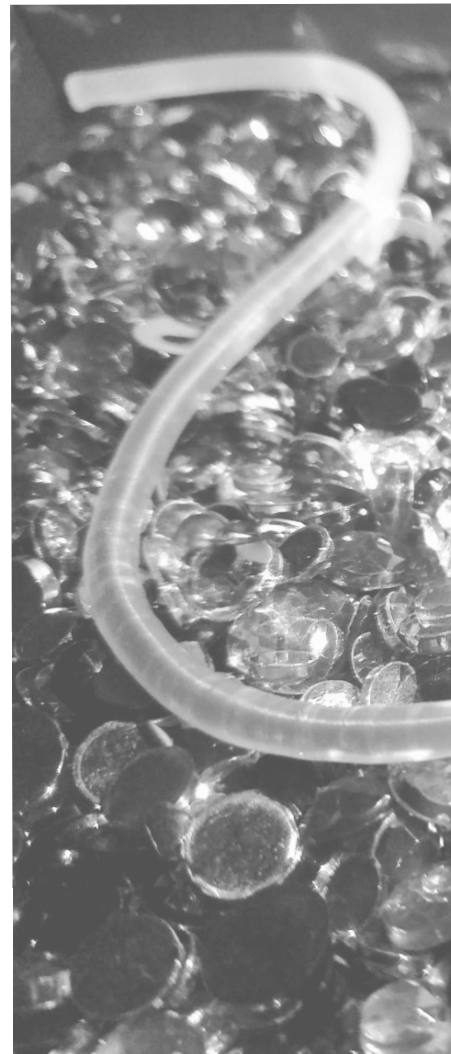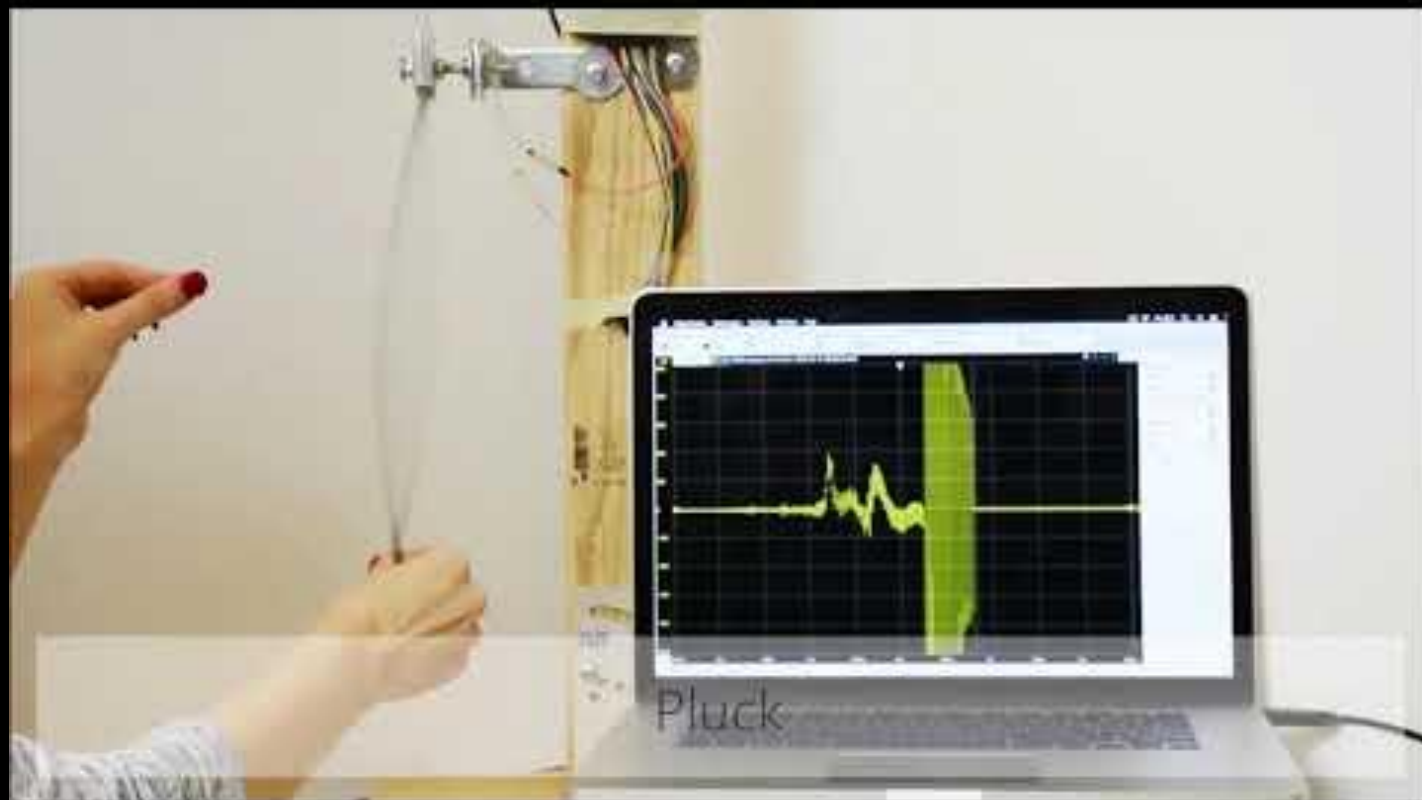
Pluck

Gestures

The gestures that serpentine has been established to sense and classify.

| Double Pinch | Twirl | Pluck | Stretch | Twist | Wiggle |

Process

Potential Gestures

Potential Solutions

Evolve

Use Cases, Form factors, Gestures

Co-design

Literature review

Flexible and organic interfaces

Technical capabilities

Understanding the technology

Brainstorming gestures

Manufactured 2 form factors

Manufacture

Data collection and Testing

Tested with n=4

Plotted confusion matrices and accuracy scores

Research

Expert and user interviews

Literature Review

Analyse and Define

Affinity Mapping

Scenarios

Design and develop

Watch Screen Mockups

Test and Refine

Wizard of Oz

Usability Test setup

Literature

- Design of organic interfaces and vision of claytronics.
- Alternate interaction techniques with wearables (tapskin, watchout, whoosh)
- Flexible interfaces (paperphone, Foled, flex stylus, morphees, Bendflip)
- Interactions for rollable displays, Foldable interactions
- Sensing technologies
- Research methods
- Prototyping techniques
- Evaluation procedures

Co-design exercises

Aim

To determine
- intuitive and natural gestures
- contexts and use-cases
- form factors
- social acceptable locations to wear/interact with the technology

Method

Groups of 3-4 participants (typical users) were given sensors of different diameters and lengths.
Probes: Cards with different domains/themes printed on them.

Insights from lit review and co-design

- **Wrist** and fingers were the most preferred places for wearing the band.
- Users prefer basic and simple gestures.
- Ability to **customize** the actuation.
- The interactions with the band are most relevant in **eyes-free contexts.**
- Participants wanted to look like an accessory and expressed concerns regarding the look and feel.
- **Wrist** and Spine are best for the body to sense haptic feedbacks
- The themes **safety**, health tracking and gaming had the most number of contexts generated within them.

Wrist worn Contexts

What gestures can serpentine sense when worn on the wrist?

1) Ideated 12 unique gestures

2) Experiment 1

Description
- 4 users Performed gestures (n=10/20) in a random order which were classified.
- Plotted Accuracy scores and confusion matrices.
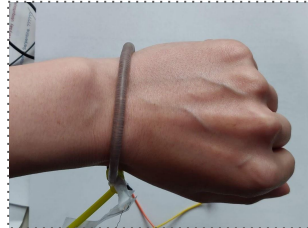
Results
6 out of 12 gestures were eliminated because of low voltage values, low accuracy scores and low intuitiveness to users.

Pluck
Stretch
Tap
Double tap
Pinch
Double pinch
Slide
Twist
Bend
Roll
Roll and leave
Knot

3) Manufactured 2 form factors

Manufactures in-house 2 types of sensors similar in shape and size, but with different sensing zones.

One single sensing zone

4 sensing zones

Advantage:
- Greater range of gestures
- Several combinations of locations and patterns
- Number of fingers used can also be sensed.

4) Experiment 2

Description
- Performed the same set of ideated gestures on the band
- Plotted V/t graphs to determine the shape of the signal shape
- 6 gestures produced significant differences in signal shapes

DOUBLE TAP
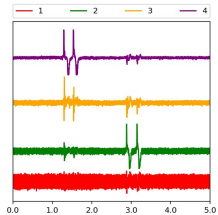
PINCH
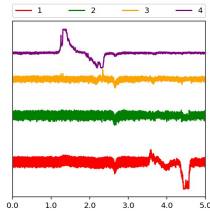
SLIDE
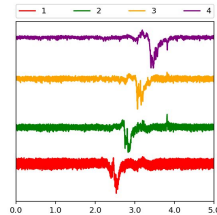
SINGLE TAPS
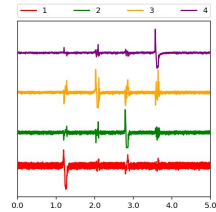
PLUCK
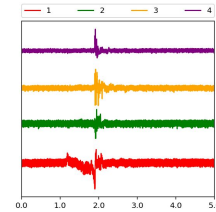
SLIDE WITH 2 FINGERS
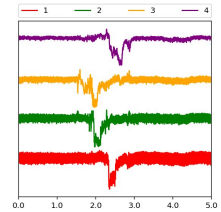
Alternate input methods

For partially visually impaired users

For normal vision users in eyes-free contexts

Goal

To design alternate + multimodal interactions with smartwatches by using serpentine as the strap of a smartwatch.

My User Group

Users with Moderate Vision Impairment

    Snellen visual acuity = 20/70 to 20/160

Users with Severe Visual Impairment

    Snellen visual acuity = 20/200 to 20/400
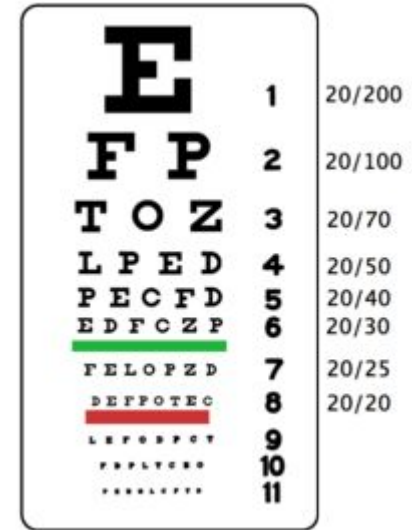
Snellen Visual Acuity from the standard eye testing chart

Research

- Literature review | Assistive wearables for visually impaired users

  Major Finding: Alternate/Multimodal interactions for generic devices such as smart watches/Fitbits have not been addressed.

- 2 expert interviews
  Director of CVI, Dr. Rasheeda Wilkins and Ph.D student from the Sonification Lab

- 2 user interviews
  Partially visually impaired staff and a client at CVI

What is the partially visually impaired user like?

- **Weak** Vision
- **Weak night vision** or no vision at nights
- Can perceive presence of **light**, color and direction of light
- Some require **high contrast in colors** to identify an object
- Rely on voice based outputs and inputs
    - Always have their **earphones** on.
- Don't want to be **recognized** as visually impaired.

*The participants at CVI might not be average of all partially visually impaired users.

TECH USAGE

NON-TECH
- Canes

ASSISTIVE TECH
- Fusion - Screenreader
- JAWS (Tells what you are pressing)
- Be my eyes - for knowing attires of people, names of products in grocery stores and their expiry dates
- BlindSquare for navigation

DEVICES
- Laptop, iphone, android tablet, braille reader
- Tablets and iphones
- iPhone, mp3-player, GPS, Smart fitness tracker (steps, activity, water and meals)
- DEVICES: Bluetooth earphones
- Prefer iPhone - since it has good accessibility features

APPS
- Screenreaders, Color Invert, Magnifier
- Rotor - Depends on what she is working on
- E-commerce apps, email, gmail, Navigation: Waze, Google Maps,
- Gmail, Text, JW Library, JW.ORG, Audiobooks, BARD (Audiobooks), Maps, Voiceover, Large Letters (Magnification)

FEATURES
- Keyboard shortcuts instead of mouse
- Brightness features Zoom in features
- GPS

PAINPOINTS WITH APPS
- Screenreaders come with their on issues. It says "BUTTON" but does not read out the text on the button.

INFORMATION ACCESS
- The watch needs to act as a backup source if I forget my phone.

- Blind solitaire, Bar Audible, C and AI, K and Fb Reader, Scan, Victor trek, Victor screen reader
- Victor Reader Trek
- Use screenreaders and magnifiers mainly
- JAWS, Zoomtext, Opentext, Braille Write

SAFETY AND SECURITY

OUTDOOR SAFETY
- Uses fake names for the number 911 in stealth mode
- Have somebody with her to go out at nights
- Dont want to draw attention and be noticeable that I am blind
- Don't want to pull out your phone in threatening situations to call 911.

- Doesn't go out at nights due to safety concerns
- Safety hinders mobility
- Tries to be always aware of surroundings
- Send distress signal

- Doesn't use the cane all the time. They act as identifiers and the blind person can be targeted.
- Refuses to make herself a target
- Act like she is looking around
- This can help in child safety.

SECURITY
- Lock doors with this gesture.
- Don't like to open bags to pull out phones in public transport
- Like to keep hands free while in public spaces - safety and security purposes

- Unlock phones in public situations
- This will help me send distress signal in stealth

- Safety hinders mobility

MOBILITY

FITNESS
- Use Fitbits for tracking mobility
- Only run in daylight

- Blind people are encouraged to be active.
- The band can help me cut/answer calls while exertion

- Exercises only indoors

NAVIGATION
- Navigate using common landmarks or ask people
- Difficult to read street signs

- While describing locations, it is important to be very specific and provide all details.
- Want the watch to help me navigate

- I wish the navigation apps are more interactive
- Voice input for address

- She wants to get the cross street and the main street

USE CASES

- Playack screenreaders
- Different gestures mean different signals.
- Invisible Switches - blend into the room. Not on specific button.

- 5 important things to do: Call, SMS, SOS, Find keys, TV Remotes, Turn Alexa(On /Off)
- Use it while in Trek50w signal areas) for communication, because it uses less power.
- Protects privacy in ATMs

- Helpful in situations where voice I/O is not possible: MEETING, DOCTORS', THEATRE
- Use it as Morse code generator

- Can be used as oth input and output device
- Mouse or Keyboard

- Lights on/off
- Open doors using the stretch interaction

- No numpad in ATMs - Use a pattern of interactions on serpentine as the pin.
- Code, own pattern to open a safe

PRODUCT-IVITY
- Check time and weather (1-2 times a day)
- Will want the watch to give alarms and reminders. That is more useful that just text/ messaging.
- Can be used for finding things
- Unlock your phone

EYES-FREE
- Visually impaired
- Cut calls when phone starts ringing.
- Helps during presentations
- Feedback for sports people.

HEALTH AND FITNESS
- Healthcare purposes- Track body parameters
- In the shoe/ankle guard to protect ankle injury
- Stress Buster - If data is used for something else, then I can use it.
- Displays a happy face that lights up whenever I press the stress ball multiple times.

GAMING and FUN
- Music instruments
- String controller | Change form and change gesture. Combinations of gestures and form factors.
- Having something physical in the hand that can be deformed gives more feedback. More fun.
- Game controller | Archery game
- Know how much pressure I am putting

FORM FACTOR
- Made something which is used universally and can be comfortably used by the blind audience.
- Haptic Feedback - Wrists and Spine best for detecting vibrations
- Wrist Band or Ring
- Does not look so good now, maybe if it looks good, then I will use it.

- Want something flat - which is comfortable to wear.
- Jewellery can be masked too.
- Wrist Band or Ring looks more accessory and can be well masked.
- Want to use it as accessory

- Will prefer having it as a band rather having it as a strap of a wrist watch.
- Will want a different form factor - a more flat band.
- Want to use phone as a computational device
- Unique. Always on the hand.

PAINPOINTS WITH TECH
- Using fitbit is alsa a challenge
- Want a more pronounced way to dial an SOS call so as to prevent false triggers.
- Lighting outdoors requires me to adjust the lighting on the screen several times a day
- Learnability of gestures might be an issue but with practice they get pretty fast.

- Need a speaker on the smartwatch, most outputs on the smartwatch are visual
- Visual outputs are not blind friendly
- Watch has a very small screen space

- The reminders buzz the fitbit but due to low screenspace she cannot tell what those reminders are.

INTERACT-IONS

VOICE I/O
- Hearing in public spaces is an issue- due to ambient noise
- Voice input is also troublesome esp while inputting punctuations.
- I dont want to talk.

- Comfortable using Voice I/o in public spaces - avoids voice I/O for something private

WANTS/ DESIRES
- Want to be more independent.
- Went it to pair with existing devices.

- The watch will be more useful if it can also help him visualize
- Fit into the ecosystem of existing devices

LIFESTYLE
- Digital divide and dependence leads to less participation work/education.

ORGANIZING
- Organized in storing stuff.
- Prefers compartmentalized bags

- Misplacing stuff makes a huge difference.
- While describing location of a particular item, it is important to be specific

CUSTOMIZA-TION
- I want to customize what the gesture will actuate.
- Want basic and simple gestures

- The needs vary from person to person. Hence, a way to customize these features will be good.
- The needs vary from person to person. Hence, a way to customize these features will be good.

OTHER
- Filing forms on paper is tough
- Blind users: Good spatial memory

- At nights, I need a flashlight
- Like that the interaction is fixed end the location is not.

Technology they use

Frustrations with wrist wearables

Devices
Laptops, Tablets, Mobile Phones
Fitbits, Earphones

Assistive Softwares
Screen readers softwares
Magnification softwares
Blind Friendly Maps
AI apps that tell the
visualize/recognise objects before
them.

- Low screen space
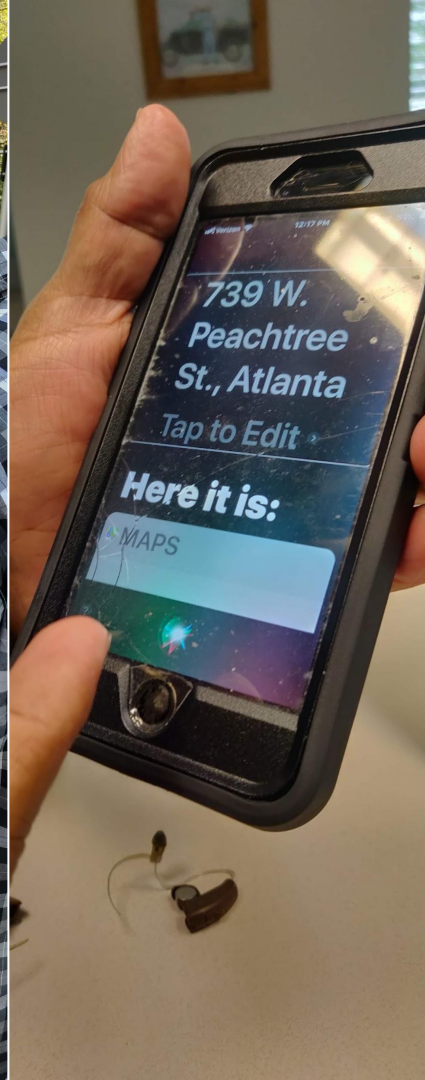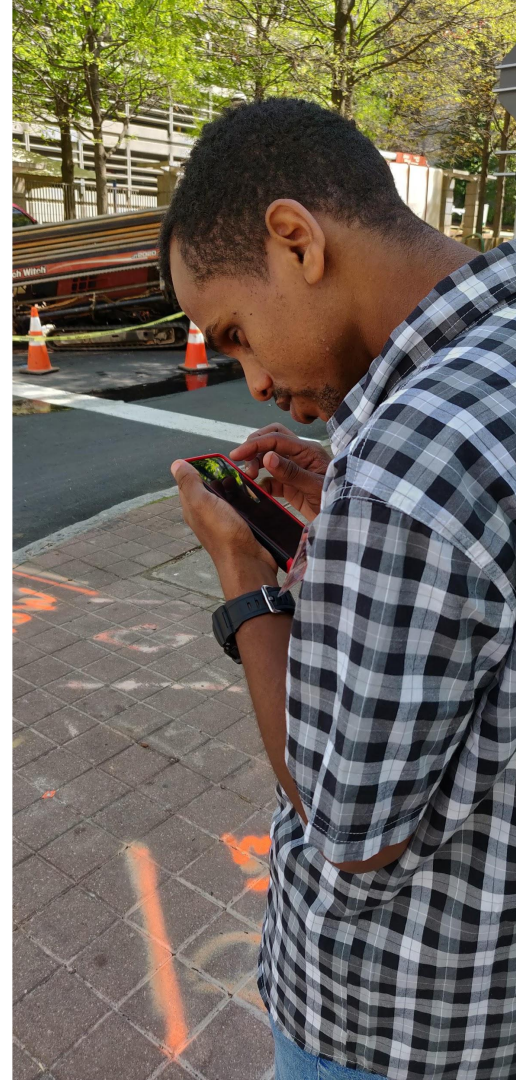- Limited space for interaction
- Smaller font sizes and smaller graphics

Insights and Solutions

Navigation, Information Access and Safety

Navigation

1 Knowing the current location

2 Repetition of the navigation instruction.

3 Adjusting Brightness and inverting colors

4 Ambient Noise in public spaces hinders voice Input

DIRECTIONS ON THE MAP

Double Tap to restate the direction to walk in.
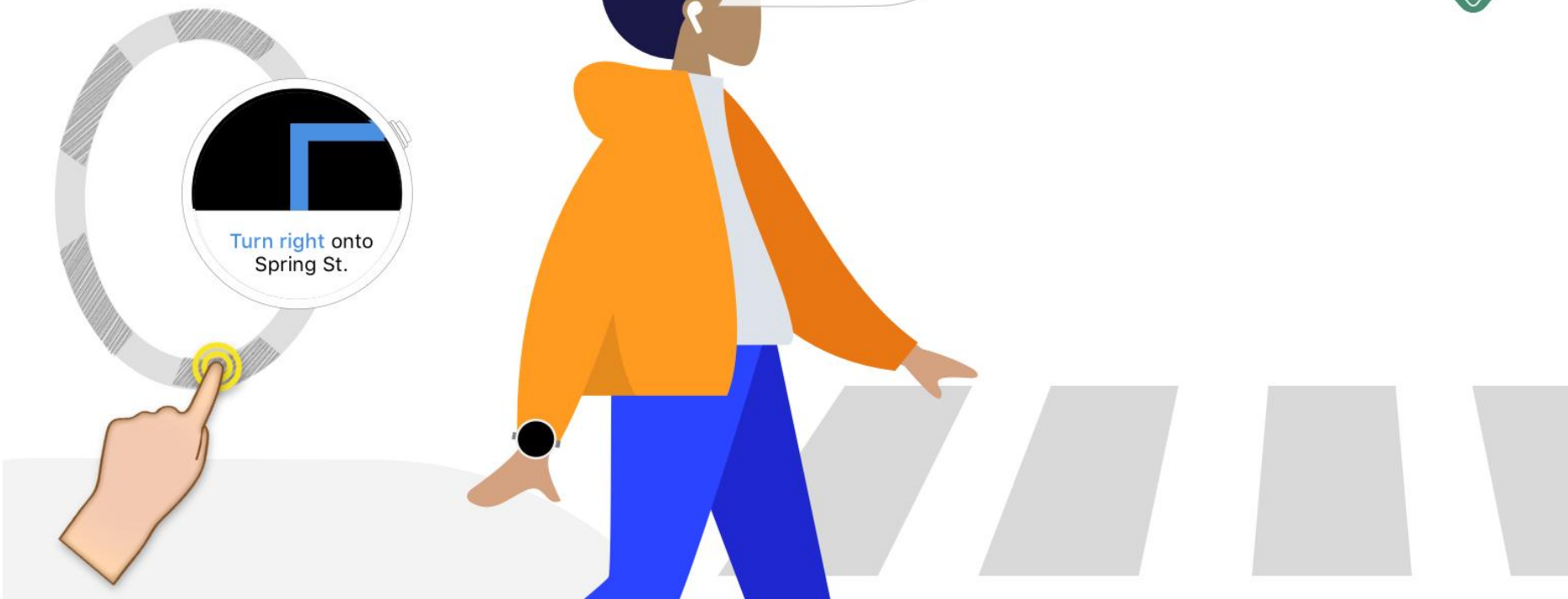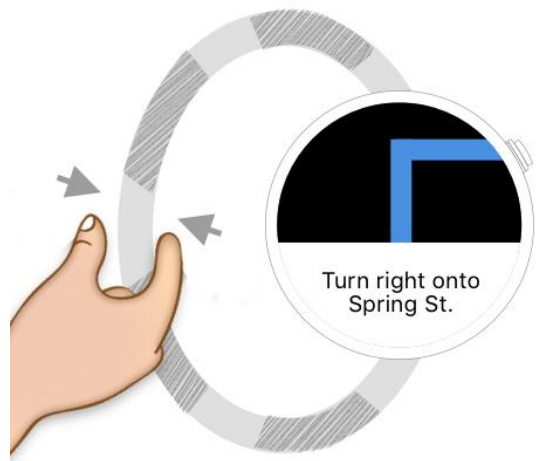
Safety

"I want to be more independent"

"I want to be able to dial 911 quickly and in stealth "

1 Directly Hinders Mobility

2 Low confidence and dependent on others

3 Refrain at home during nights

4 Afraid of being a target in public spaces

5 Want to dial SOS in stealth.

6 Stick to indoor fitness activities

SAFETY

Pinch in a pattern you set to dial 911.
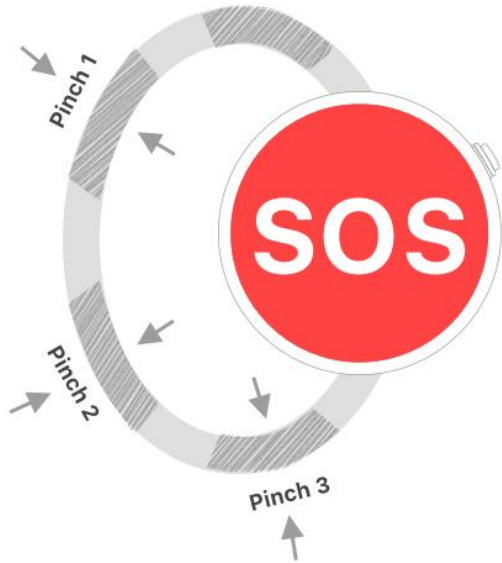
Need for a complex interaction to prevent errors

Information Access

1 Every app is not designed for equitable use

2 Different Apps work best in different color modes.

3 Small Screen Space on watches

4 Accessibility features in phones/watches are hidden inside the menu trays.

5 Audio feedback and Voice I/O is not suitable for all contexts
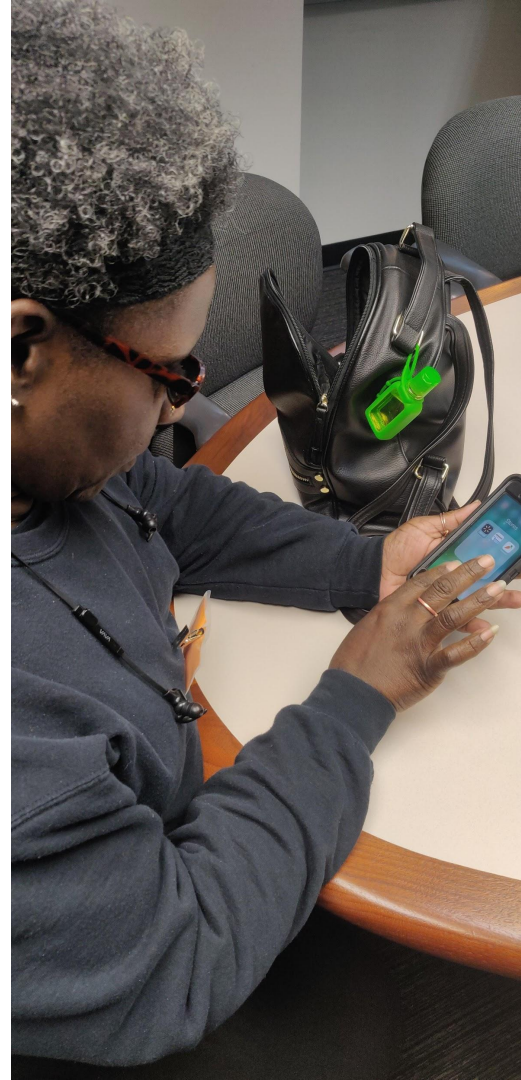
COMMUNICATION: CALLS

Plucking cuts the call.

Pluck here
to cut the call

Sarah

Pluck here to
pick call
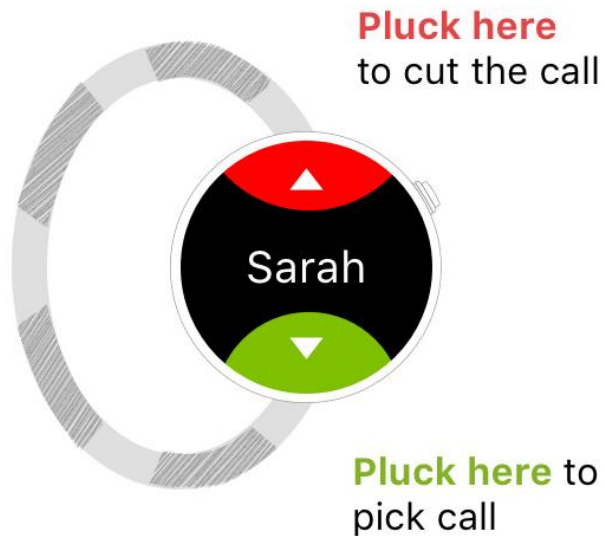
Other scenarios include churches,
meetings.

INFORMATION ACCESS: TEXT MAGNIFICATION

Swiping outward with 2 fingers zooms in the text

Swiping inward with 2 fingers zooms out the text
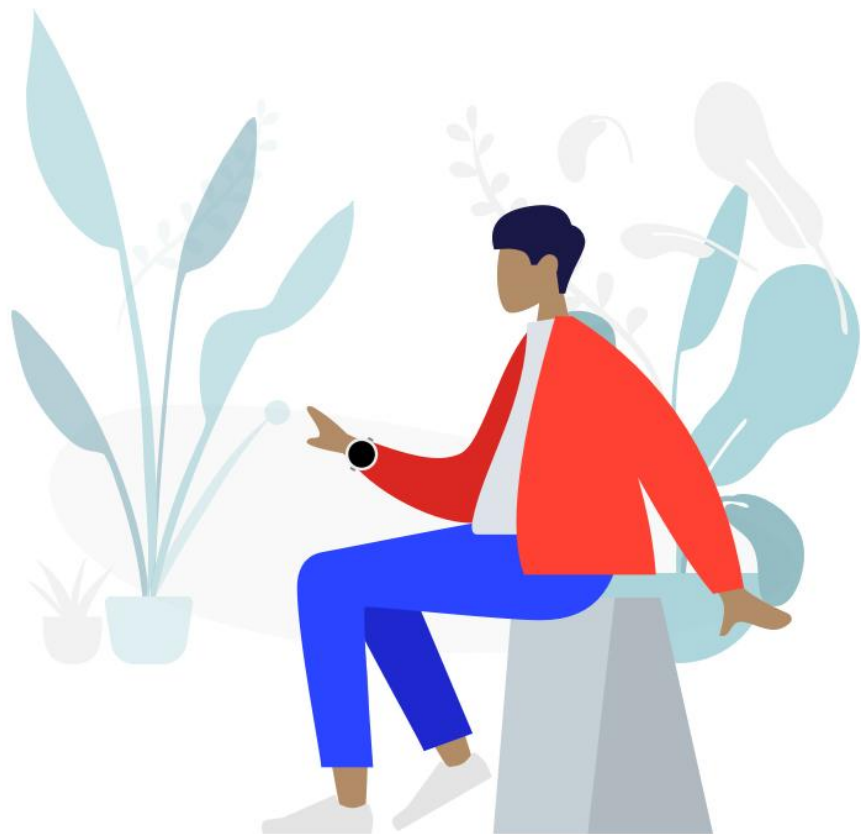
INFORMATION ACCESS: SCREENREADER

Double Tap to turn on the screenreader
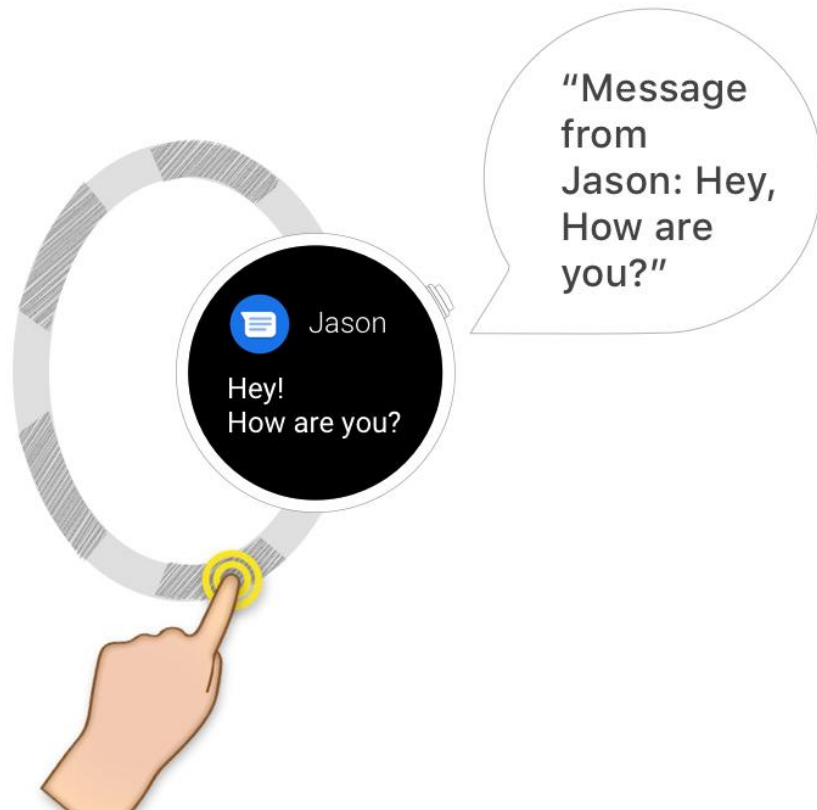
INFORMATION ACCESS: COLOR INVERT

Pinch to smart invert colors back and forth.
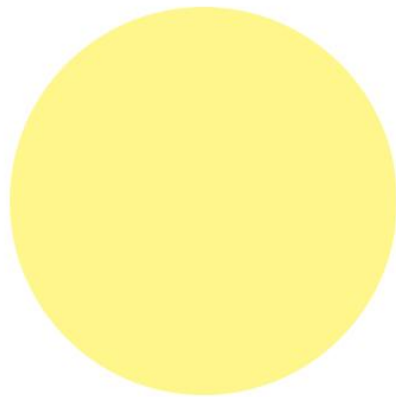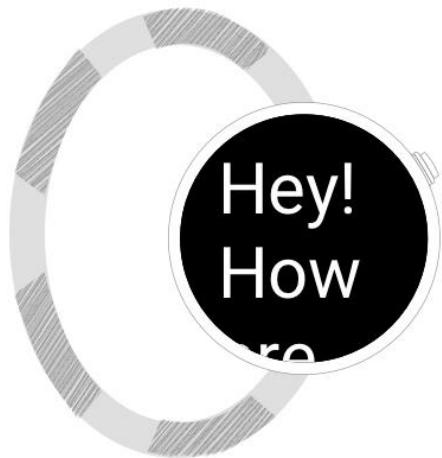
INFORMATION ACCESS: SCREENREADER

Double Tap to turn on the screenreader

Usability Testing

Wizard of OZ with 6 partially visually impaired users

Unstructured feedback with normal vision users

Goal

To validate the concepts
To test the learnability of interactions and usability of the designs
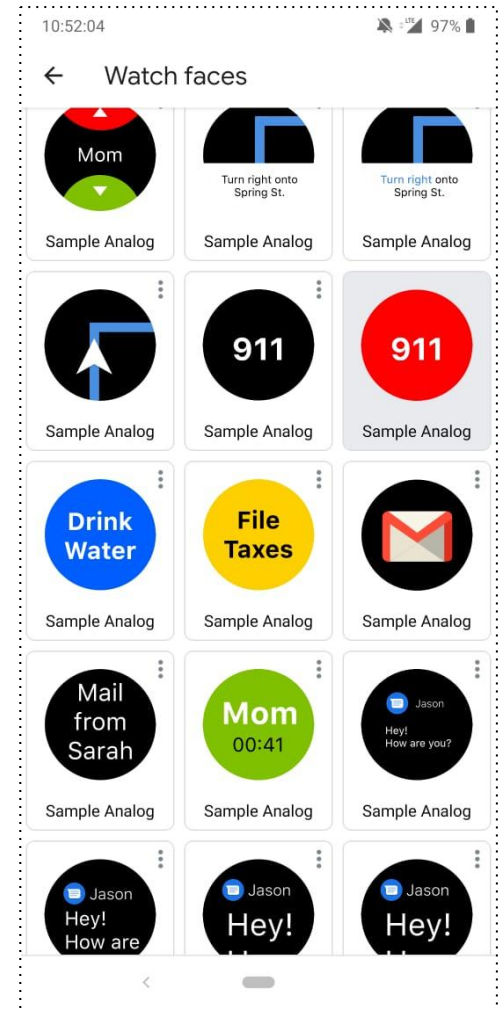To know the perceived value of the product.

Method

Wizard of Oz
- scenario based questions
- modified SUS questionnaire.

The setup

Participants (average age: 49) were asked to wear the watch and were asked to perform interactions based on scenarios.

Remotely controlled watch screens by building the android watch face extension

Major Findings from Wizard of Oz

- Users felt that the watch added to their **convenience**
- Users wanted to be able to **customize** certain actuations.
- Users liked that the device prevents other people to notice that they are blind.
- **Cost** was a concern
- The testing also surfaced certain interface issues that were addressed.

87

SUS Score

High learnability index

Low perceived mental and physical demand

Conclusion

The **multimodal interactions** combined with the **ubiquity** of the smartwatch can make several phone interactions more accessible.

The generic nature of the device adds to increased **social acceptance** of a smartwatch as an assistive device.

Future Work

Customization

Building interaction scenarios for more contexts

Work towards making the design more universal

Thank you

Madhuri Bhavana | MS-HCI (IC)

Advisor: Dr. Gregory Abowd