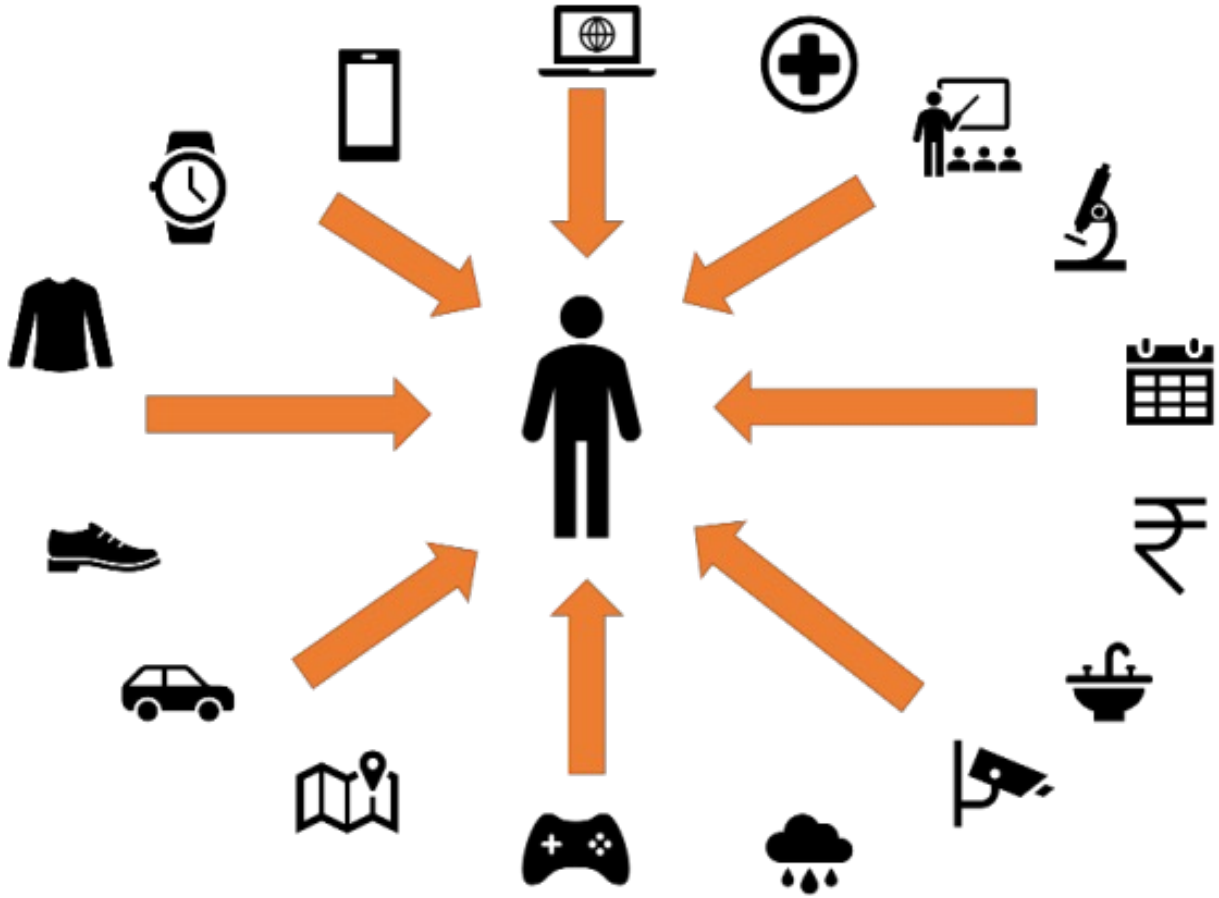
Interfaces for Pervasive Systems

COMP5047 – Lecture 11

Zhanna Sarsenbayeva

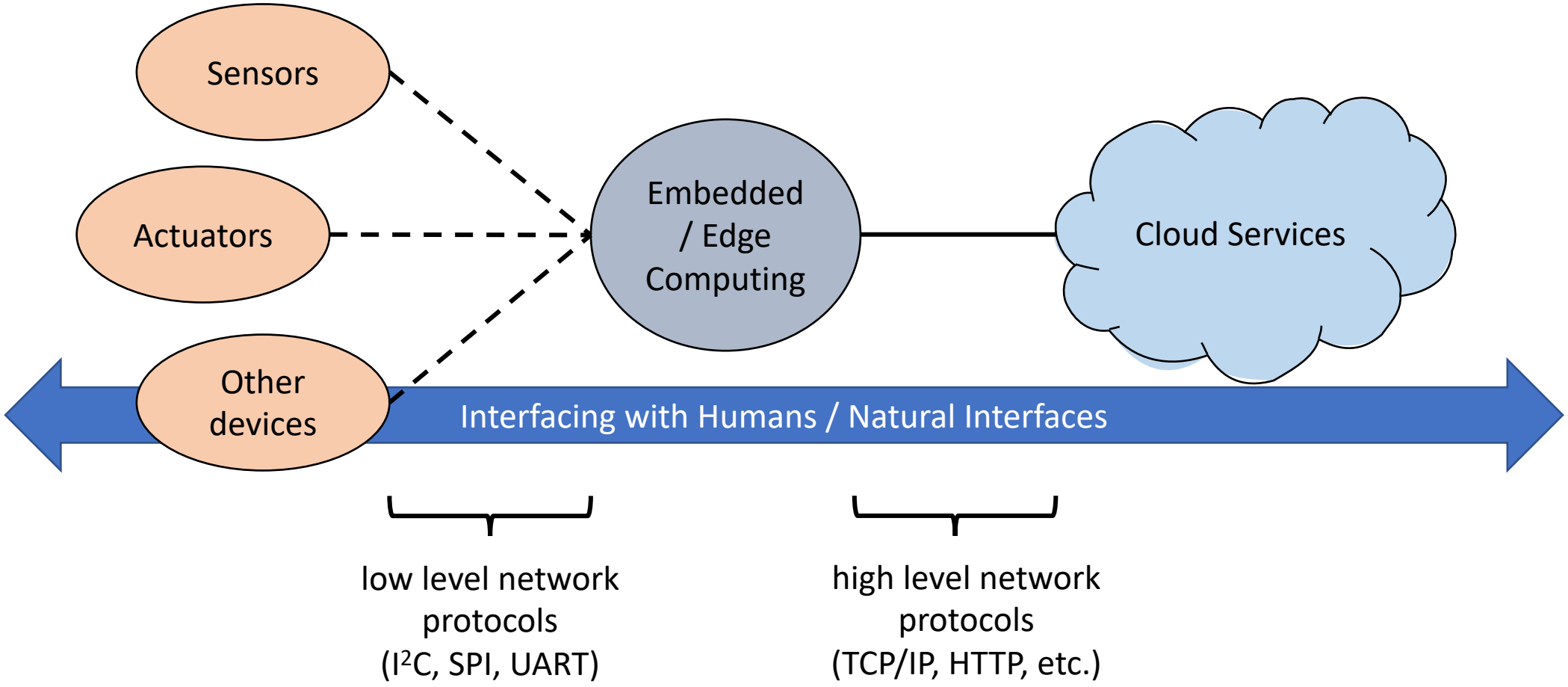
The School of Computer Science
The University of Sydney

Interfacing with Pervasive Systems



https://www.nic.in/blogs/pervasive-computing/

A Simple Overview



Why User Interface is Important

Why User Interface is Important?

Three Mile Island Disaster

- Control panel light to show the status of the relief valve that prevents the reactor from overheating.
  - Light's on, valve's open;
  - light's off, valve's closed.
- It was designed to operate on user action, not to actually sense the valve condition

https://www.cracked.com/article_19776_6-disasters-caused-by-poorly-designed-user-interfaces.html

Usability Goals

- Effective to use (effectiveness)
- Efficient to use (efficiency)
- Safe to use (safety)
- Having good utility (utility)
- Easy to learn (learnability)
- Easy to remember how to use (memorability)

User Experience (UX)

- Going beyond usability
- Felt experienced and emotions
  - Satisfying, Helpful, Fun Vs. Boring, Unpleasant, Frustrating

Interaction Types

- Provide means to conceptualize the design space using interactions
- We will discuss five (5) main types
  - Instructing
  - Conversing
  - Manipulating
  - Exploring
  - Responding

Instructing

- User instruct the system
- Tell the system what to do
- Examples
  - Typing in commands
  - Selecting Menus
  - Speaking commands
  - Gesturing
  - Pressing buttons
  - Combination of function keys

Instructing: Examples

https://cdn.pixabay.com/photo/2017/08/06/12/40/soda-2592159_960_720.jpg

- A frequently used model
  - Terminal
  - Text editor

Conversing

- Users have a dialog with a system
- Similar to how we talk to each other
- System acts as the partner
- Simple menu-based dialogues to complex voice recognition
- Audio or text-based dialogues
  - Apple - Siri, Amazon – Alexa
- Virtual Agents

https://i.pinimg.com/originals/74/5b/da/745bdab2d5542e6a35624b8de6d9cc35.jpg

Manipulating

- Rely on manipulating objects
  - Moving, selecting, dragging, opening, and closing digital elements
  - With extensions to zooming in and out, stretching, and shrinking
- Based on users experience with real objects
- Early guidance for graphical user interfaces (GUI)

Manipulating: Examples

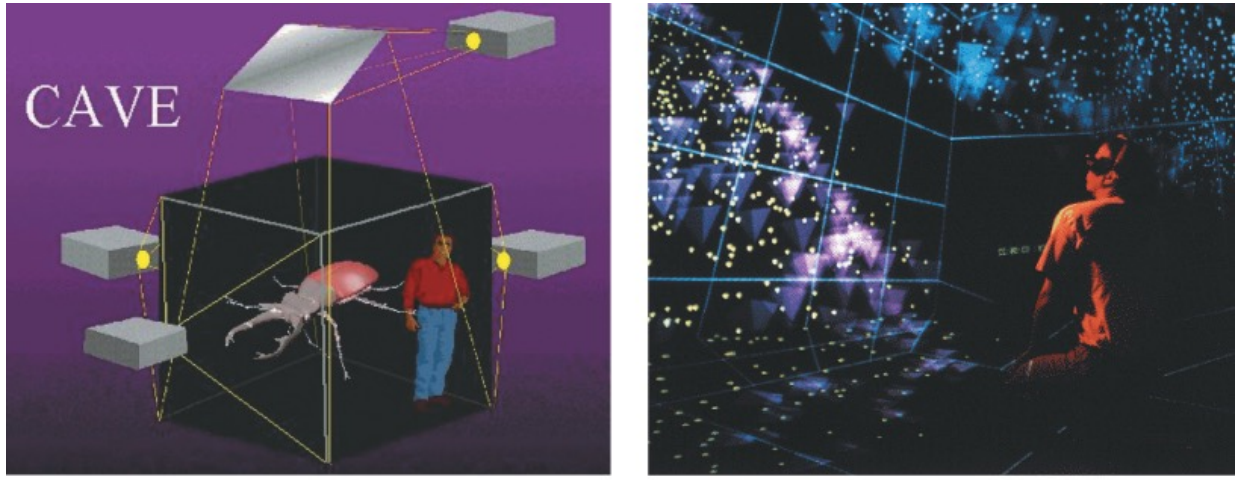
https://qwertytutorials.com/software_tutorials/windows_xp/site_graphics/desktop_icons_1b.png

Manipulating: Examples

http://4.bp.blogspot.com/_tDehER7Tf30/S-13CC-smXI/AAAAAAAAAm4/1r6hfhljuOo/s1600/press_rgb_touch-water+LR2.jpg

Exploring

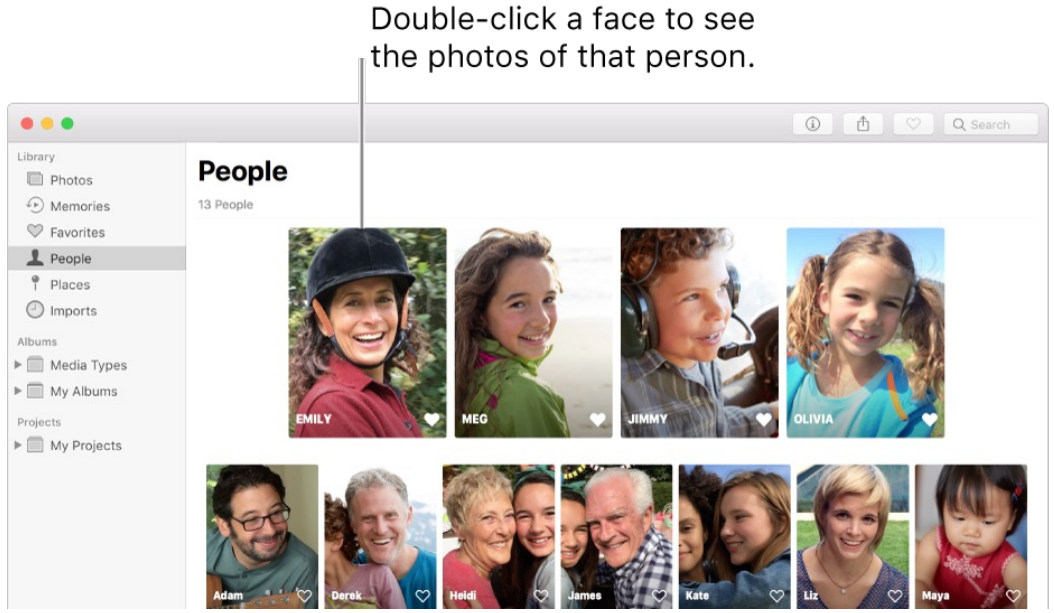
- Involves users moving through virtual or physical environments
- Similar to how we explore physical spaces
- Now even more popular with VR – Immersive and entertaining



Preece et. al., Interaction Design, 5th Edition.

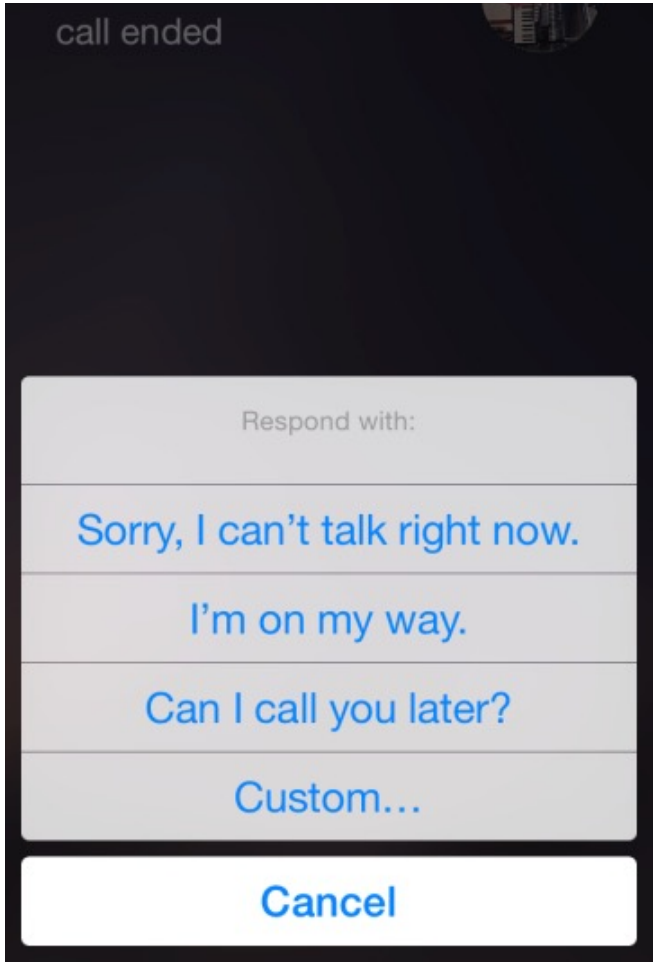
Responding

- The system takes the initiative to alert, describe, or show the user something of interest
- Relevance to the time or context



https://help.apple.com

Responding


call ended
Respond with:
Sorry, I can't talk right now.
I'm on my way.
Can I call you later?
Custom...
Cancel

Which Interaction style to use?

- Instructing
  - For repetitive tasks: Managing files, writing, programming.
- Conversing
  - Pervasive applications, users with disabilities, special use cases such as children or elderly
- Manipulating
  - Many applications, possibly most commonly used
- Exploring
  - Immersive environments, VR, AR, Tele-existence
- Responding
  - Contextual applications, suggestions, recommendations

Interface Types

- There are many different types of input and output methods available
- Given
  - different environments
  - People
  - Places
  - and activities.

We must select the appropriate interface type

https://elearningindustry.com/virtual-reality-training-vr-changes-ld-4-ways
https://qwertytutorials.com/software_tutorials/windows_xp/site_graphics/desktop_icons_1b.png
http://4.bp.blogspot.com/_tDehER7Tf30/S-13CC-smXI/AAAAAAAAAm4/1r6hfhljuOo/s1600/press_rgb_touch-water+LR2.jpg

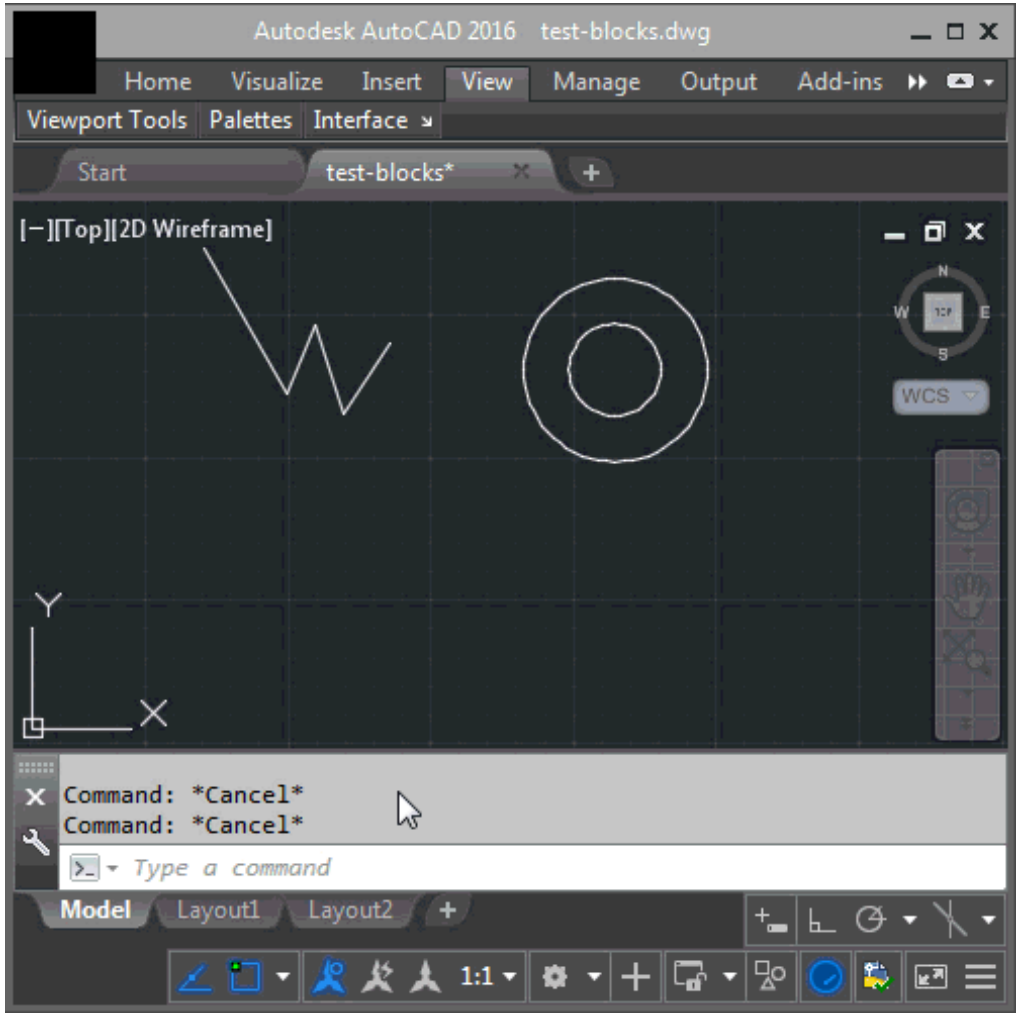
Command-Line Interfaces (CLI)

- Uses a text displays
  - Interactive
  - Input through keyboard
  - Display / print information
- Great for configurations
  - E.g. Batch processing
  - Need expertise

https://www.inexhibit.com/case-studies/computer-design-commodore-pet-2001-1977/

CLI in Modern Application

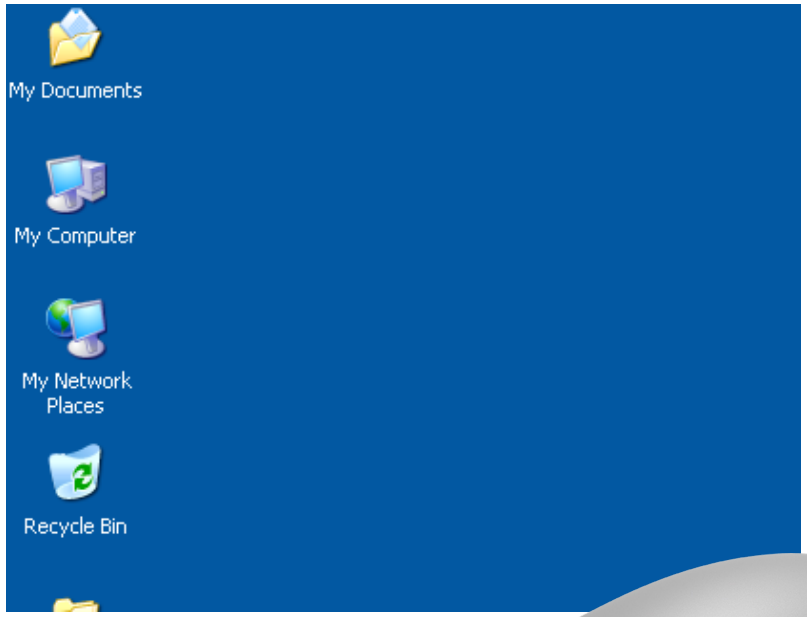
- Autodesk AutoCAD
  - Precise input



through-the-interface.typepad.com

Graphical User Interfaces (GUI)

- WIMP
  - Windows
  - Icons
  - Menus
  - Pointing device
- Great for everyday tasks
  - Intuitive
    - No need expertise
  - Not the most efficient for some tasks

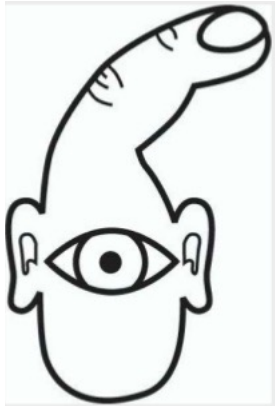


https://qwertytutorials.com/software_tutorials/windows_
cons_1b.png

through-the-interface.typepad.com

Post-WIMP User Interfaces

- Bill Buxton: WIMP GUIs … are the perfect interface only for creatures with a single eye, one or more single-jointed fingers and no other sensory organs
- WIMP reduces interaction to the visual channel



Dan O'Sullivan and Tom Igoe. 2004. Physical Computing: Sensing and Controlling the Physical World with Computers. Course Technology Press, Boston, MA, United States.

Post-WIMP User Interfaces

- Interfaces "containing at least one interaction technique, not dependent on classical 2D widgets such as menus and icons" -- Andries van Dam, 1997

https://doi.org/10.1145/253671.253708

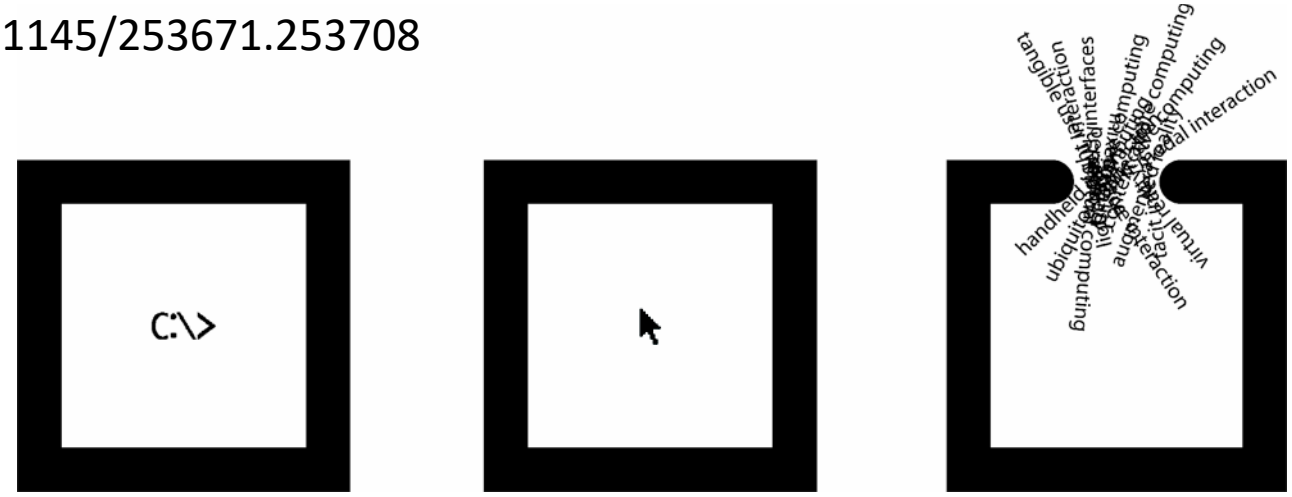
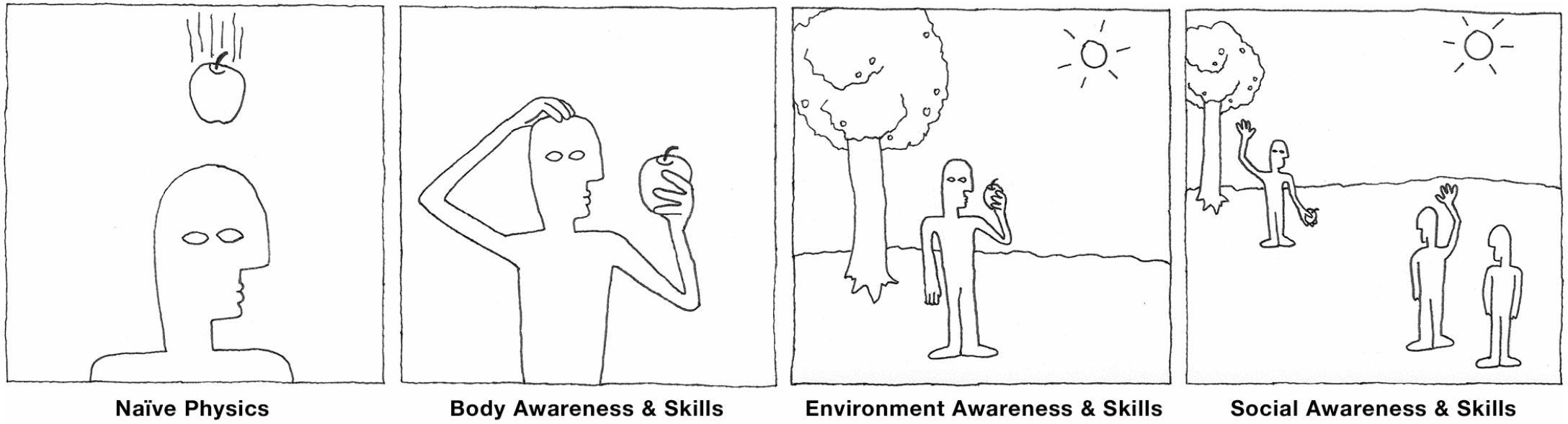


Figure 1. Generations of interaction: command line, direct manipulation, and diverse emerging interaction styles [26].

Robert J.K. Jacob, Audrey Girouard, Leanne M. Hirshfield, Michael S. Horn, Orit Shaer, Erin Treacy Solovey, and Jamie Zigelbaum. 2008. Reality-based interaction: a framework for post-WIMP interfaces. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 201-210. DOI: https://doi.org/10.1145/1357054.1357089

Aspects of Post-WIMP Interfaces



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Aspects of Post-WIMP Interfaces

- Naive physics
  - Illusion of a rubber surface when zooming into an image
- Body awareness and skills
  - Putting the iPhone next to the face, switches the display off
- Environmental awareness and skills
  - Spatial metaphor for browsing photos
- Social Awareness and Skills
  - Awareness of others and their actions, multitouch displays in shopping malls

Robert J.K. Jacob, Audrey Girouard, Leanne M. Hirshfield, Michael S. Horn, Orit Shaer, Erin Treacy Solovey, and Jamie Zigelbaum. 2008. Reality-based interaction: a framework for post-WIMP interfaces. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 201-210. DOI: https://doi.org/10.1145/1357054.1357089

Post-WIMP User Interfaces

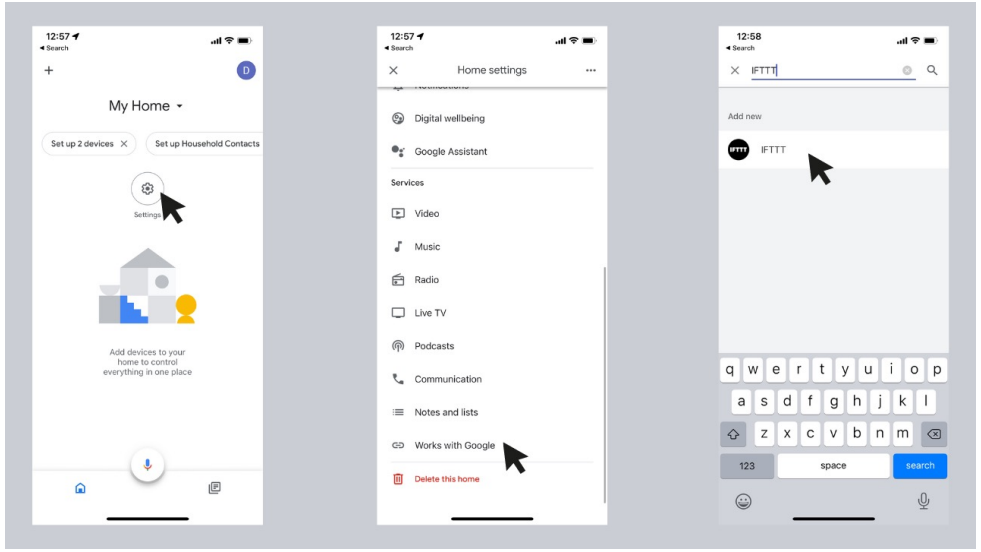
- Mobile User Interfaces
- Speech-based User Interfaces
- Interactive Surfaces
- Tangible User Interfaces
- Virtual Reality
- Wearable Computing

Speech Interfaces

- Conversation style
- Helps to create accessible interfaces (e.g., for visual impaired users)
- Hands-free interaction
- Good examples
  - Google
    - https://developers.google.com/assistant/smarthome/develop/create
  - Alexa
    - https://developer.amazon.com/en-GB/alexa/alexa-skills-kit

IFTTT - Conversational Interfaces

Google



https://ifttt.com/explore/google-assistant-changes

Amazon

https://ifttt.com/amazon_alexa/health

Interactive Surfaces

Interactive Surfaces

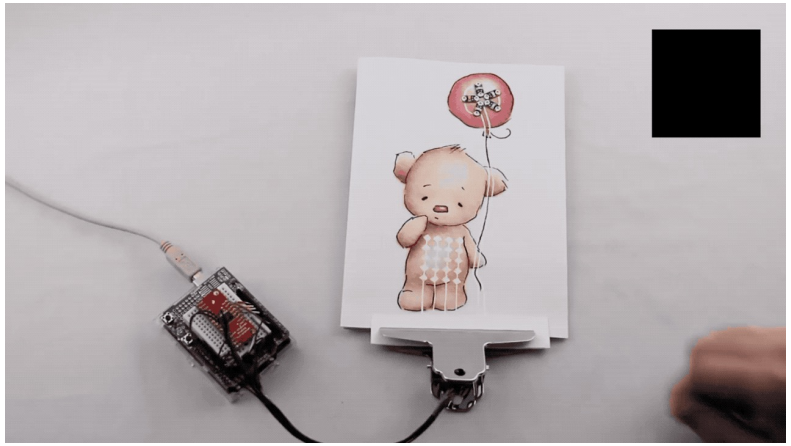
- Used in smart watches to smart walls
- Also used in artistic installations

Tangible Interfaces

- Tangible objects are used to control AND represent digital information
- Intangible representation can help to synchronize digital information with the tangible representation
  - A video projection

https://www.youtube.com/watch?v=lvtfD_rJ2hE

Think out of the box



Narjes Pourjafarian, Anusha Withana, Joseph A. Paradiso, and Jürgen Steimle. 2019. Multi-Touch Kit: A Do-It-Yourself Technique for Capacitive Multi-Touch Sensing Using a Commodity Microcontroller. In UIST '19. DOI:https://doi.org/10.1145/3332165.3347895

Virtual Reality

- Computer simulated environment
- Sensory experience is artificially created
- User can interact in this environment
- Multiple application areas
  - Telepresence, telemedicine, gaming, simulation

Wearable Interfaces

- Operational while user is on the move
- Always-on
  - direct access & hands-free use Context awareness
- Various form factors
  - e.g., textile, glass, wrist-worn, interactive skin, ...
- Various interaction modalities
  - e.g., visual output, haptic output, touch input, gaze input, ...

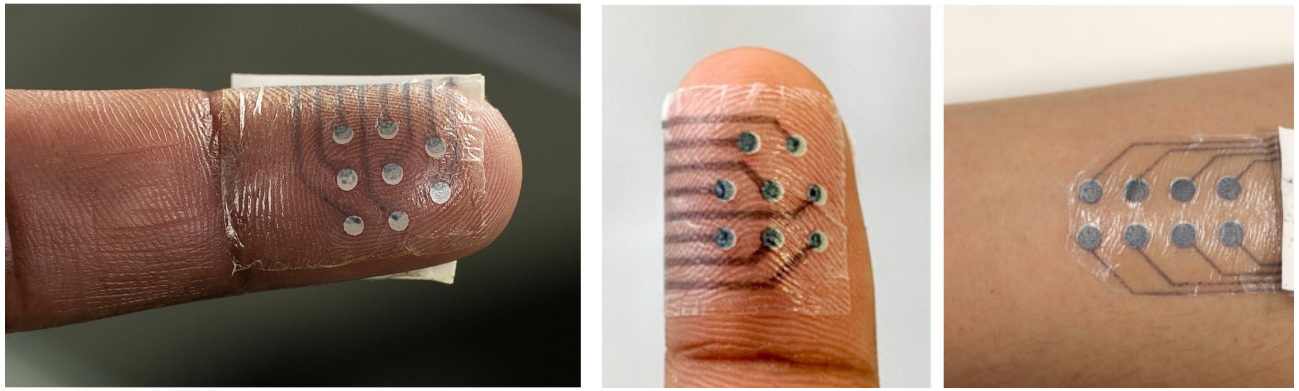
www.toptal.com/designers/ui/the-psychology-of-wearables

How electronic skin could help people with disabilities

9 July 2019

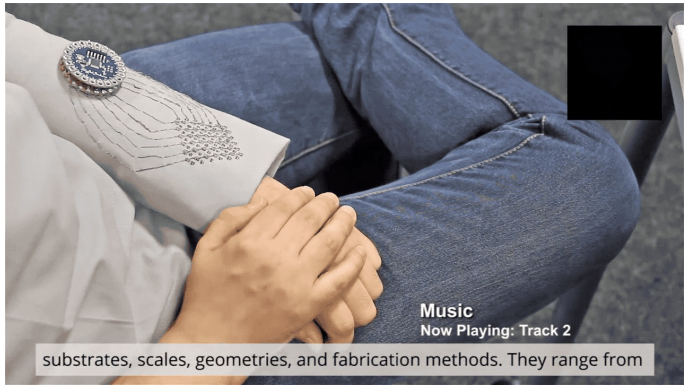
Technology delivers information at a touch

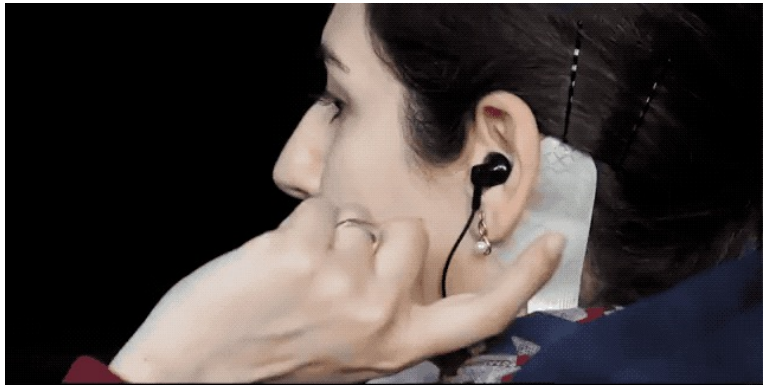
A University researcher is developing wearable technology that could be used to control devices, receive information and even register sensation.



Withana is developing a hyper-flexible sticky tape, printed with electronic circuits.

Anusha Withana, Daniel Groeger, and Jürgen Steimle. 2018. Tacttoo: A Thin and Feel-Through Tattoo for On-Skin Tactile Output. In UIST '18. https://doi.org/10.1145/3242587.3242645





Aditya Shekhar Nittala, Anusha Withana, Narjes Pourjafarian, and Jürgen Steimle. 2018. Multi-Touch Skin: A Thin and Flexible Multi-Touch Sensor for On-Skin Input. In CHI'18, https://doi.org/10.1145/3173574.3173607

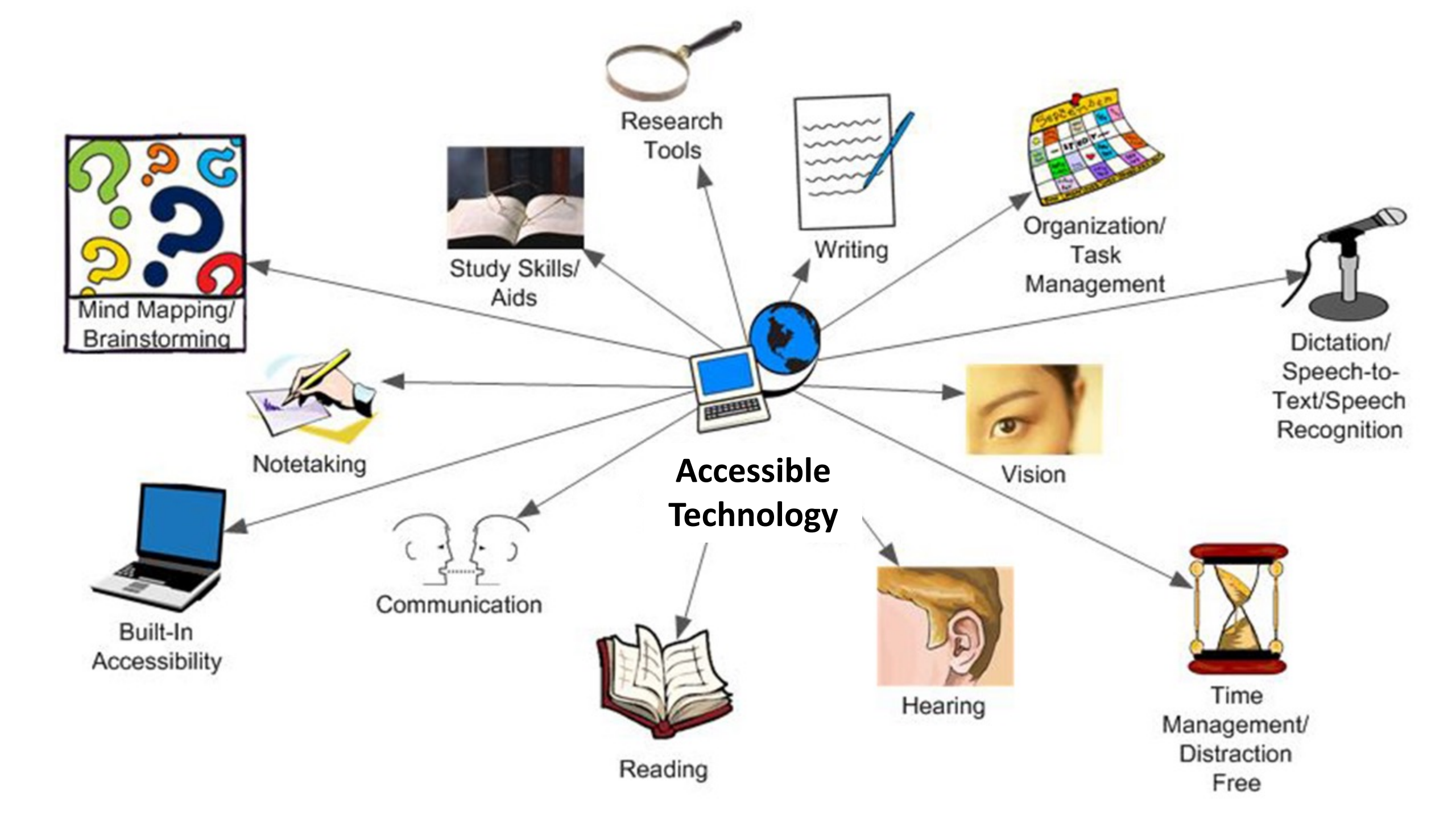
Summary

- Selecting interaction style and interface types is important
- Different interface types suit different applications
- Post WIMP user interfaces are more suited for user interfaces in pervasive computing

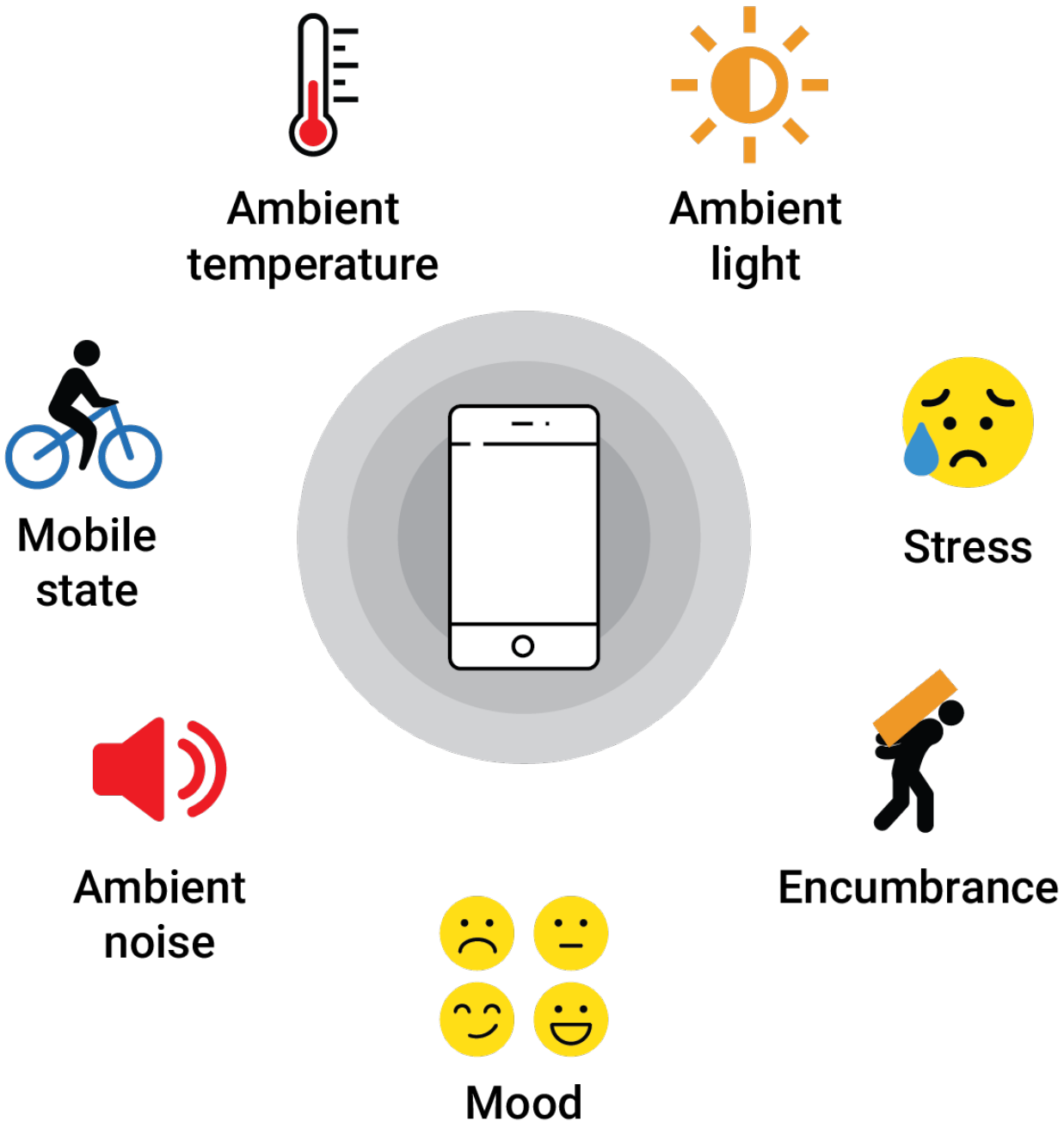
Accessibility Research in HCI

Zhanna Sarsenbayeva
Lecturer
The University of Sydney


Create accessible technologies to empower people of all abilities


Research Tools
Writing
Organization/ Task Management
Study Skills/ Aids
Mind Mapping/ Brainstorming
Dictation/ Speech-to-Text/Speech Recognition
Notetaking
Vision
Accessible Technology
Built-In Accessibility
Communication
Hearing
Reading
Time Management/ Distraction Free

Adaptive Environment or Adaptive Interface?



Situationally-Induced Impairments and Disabilities (SIIDs)

- Andrew Sears and Mark Young (2003)

Why Study SIIDs?

- Situational impairments affect users of all abilities

- Accessibility benefits everyone
  - Gregg C. Vanderheim (1997)

Why Study SIIDs?

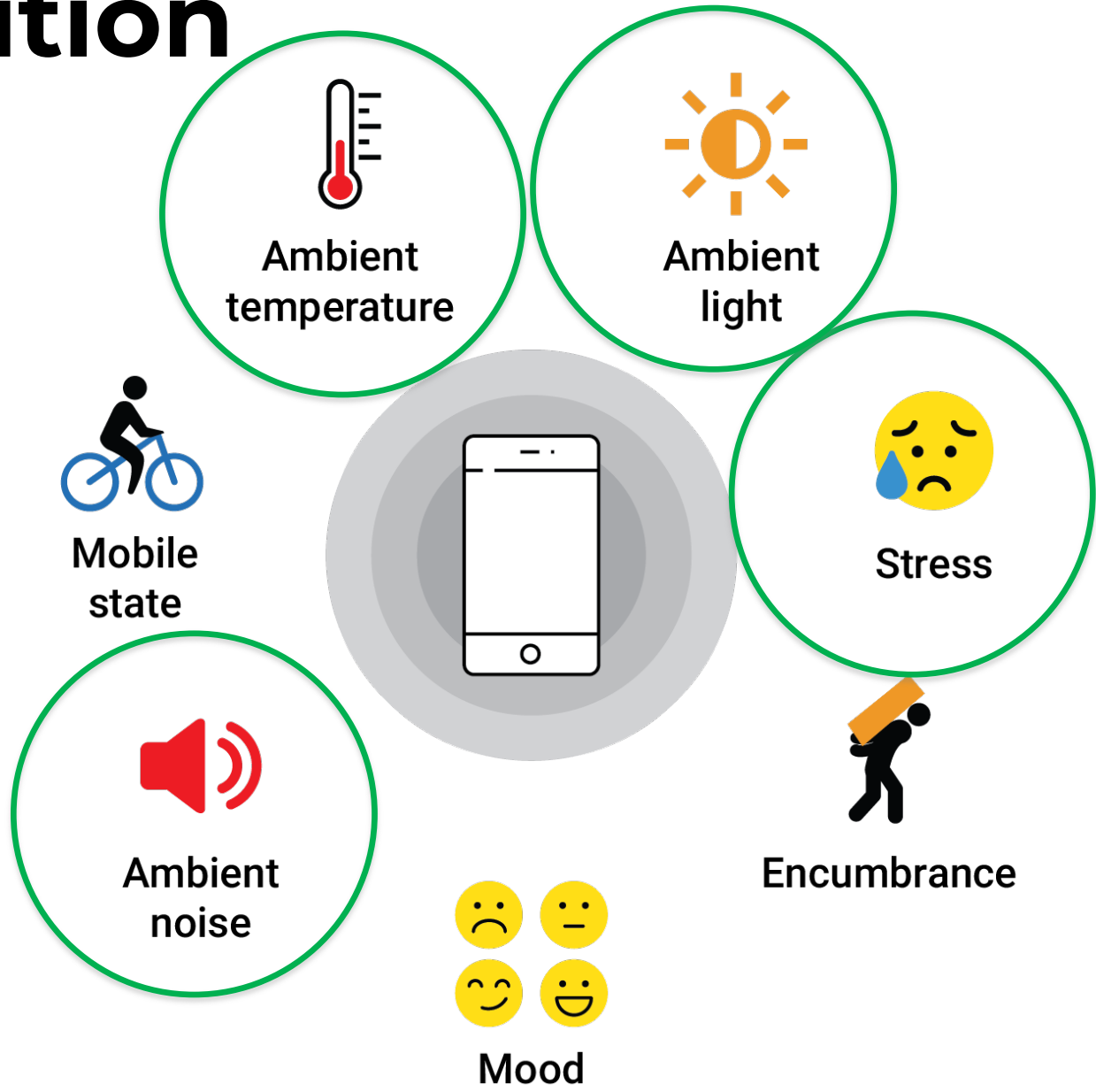
- Similarity of the effects of situational and permanent impairments
  - Yesilada *et al.*, 2010
  - Wobbrock, 2006

Why Study SIIDs?

- Similarity of the effects of situational and permanent impairments
  - Yesilada *et al.*, 2010
  - Wobbrock, 2006
- Situational impairments worsen the experience of permanently impaired users
  - Visually impaired: Walking & encumbrance (Abdolrahmani *et al.*, 2016)
  - Visually/ motor impaired: Ambient light, on-the-go (Kane *et al.*, 2009)
  - Device accessibility issues (Naftali & Findlater, 2014)

Research Contribution

- The effects of:
  - Ambient noise
    - Effect of Distinct Ambient Noise Types on Mobile Interaction, PACM IMWUT/UbiComp'18
  - Ambient light
    - Effect of Ambient Light on Mobile Interaction, INTERACT'19
  - Stress
    - Measuring the Effects of Stress on Mobile Interaction, PACM IMWUT/UbiComp'19
- Sensing mechanism
  - Ambient temperature
    - Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature, PACM IMWUT/UbiComp'17



Research Contribution

- Investigate and quantify the effects of SIIDs in a **systematic** way
  - Same smartphone tasks
    - Target acquisition
    - Visual search
    - Text entry

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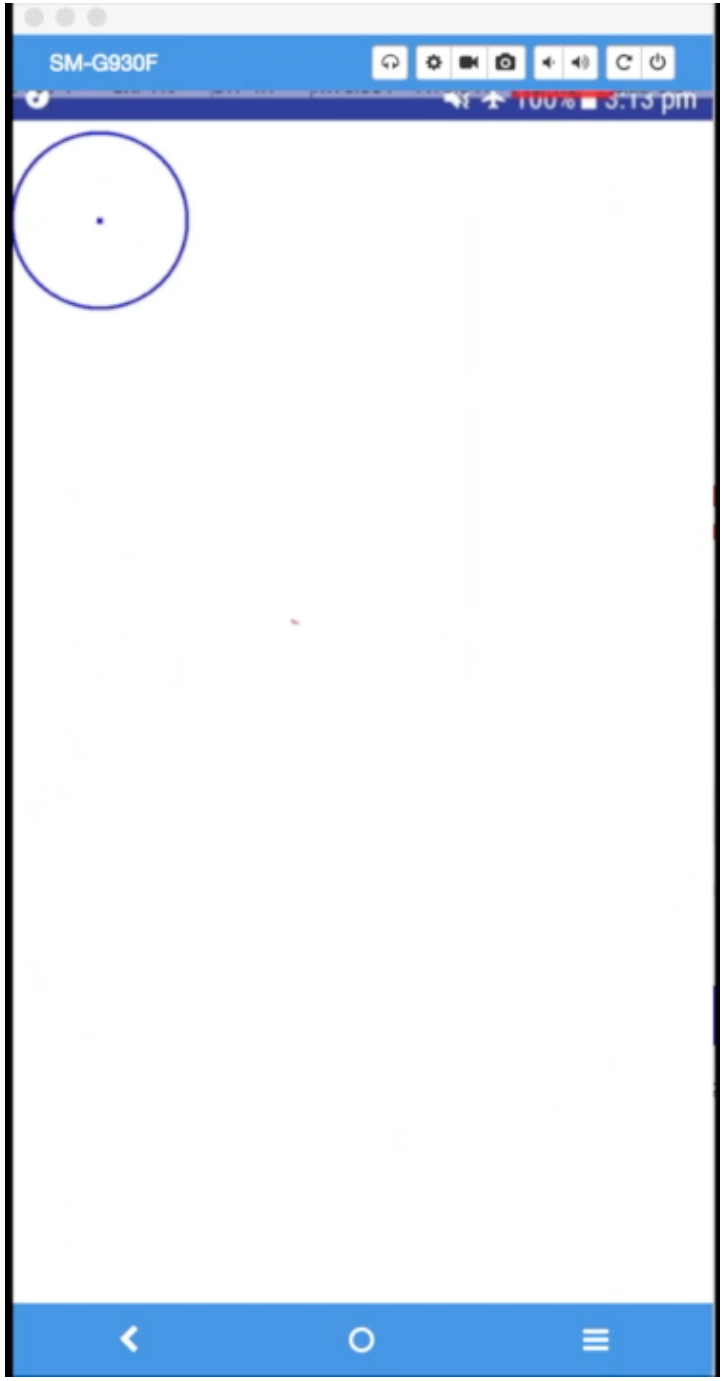
    - Text entry
  - Same variables
    - Reaction, accuracy, memorisation and search time, text entry rate, error rate

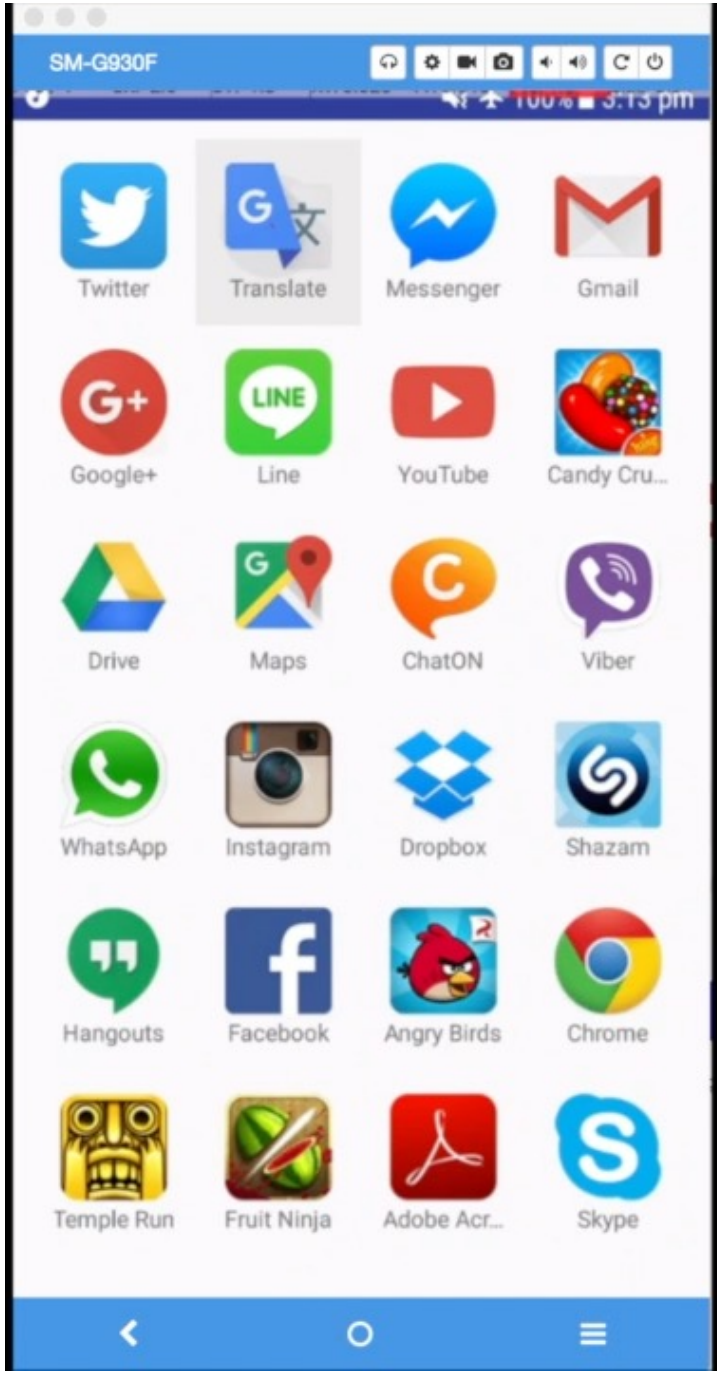
Research Contribution

- Investigate and quantify the effects of SIIDs in a **systematic** way
  - Same smartphone tasks
    - Target acquisition
    - Visual search
    - Text entry
  - Same variables
    - Reaction, accuracy, memorisation and search time, text entry rate, error rate
  - Consistent protocol
    - Baseline condition in each of the studies

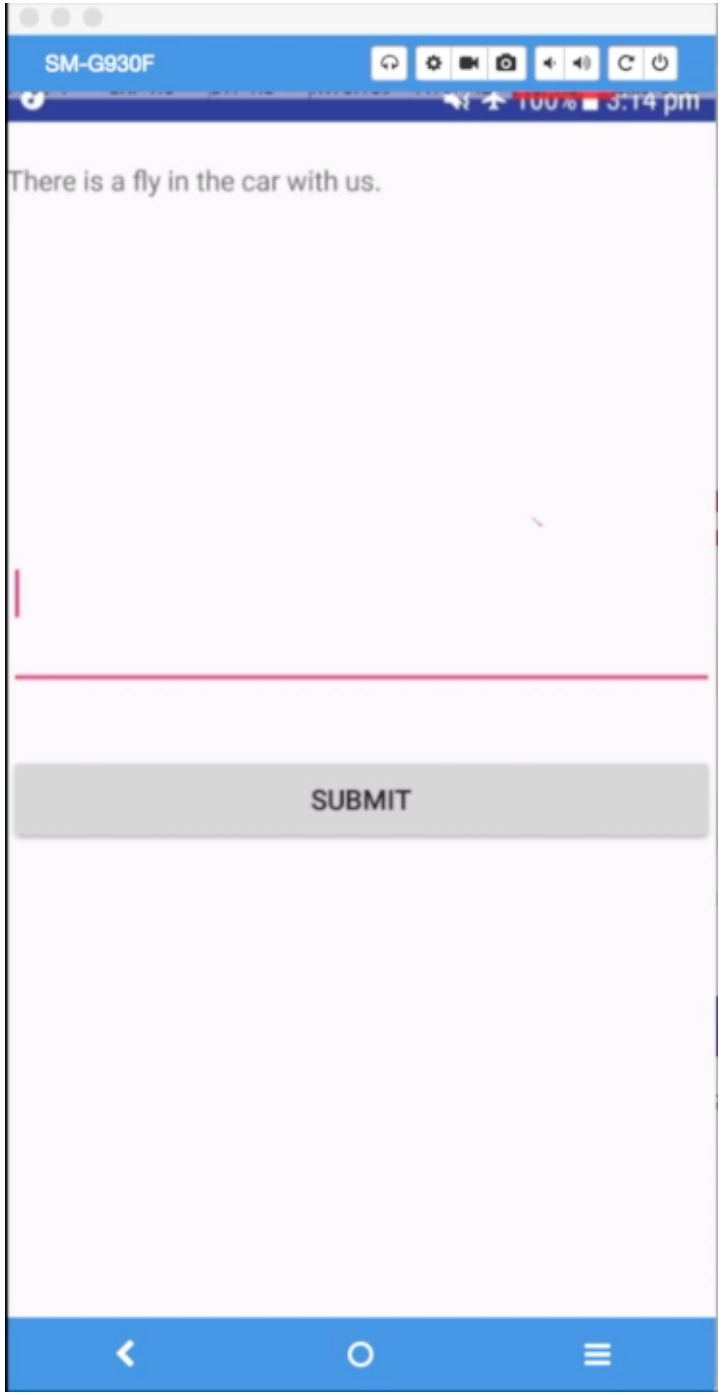
Mobile Interaction Tasks – *Target Acquisition*

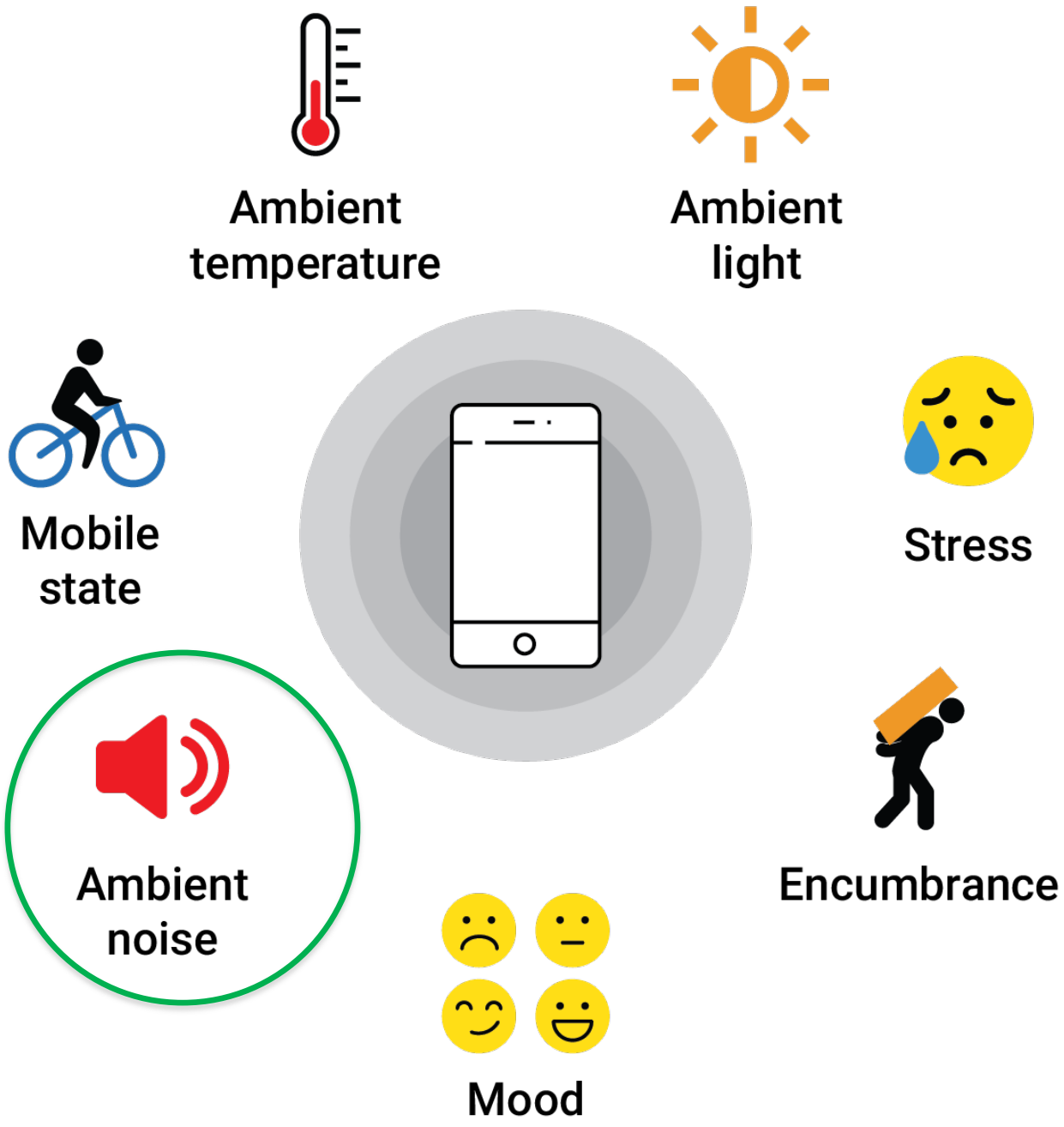


Mobile Interaction Tasks – *Visual Search*



Mobile Interaction Tasks – *Text Entry*





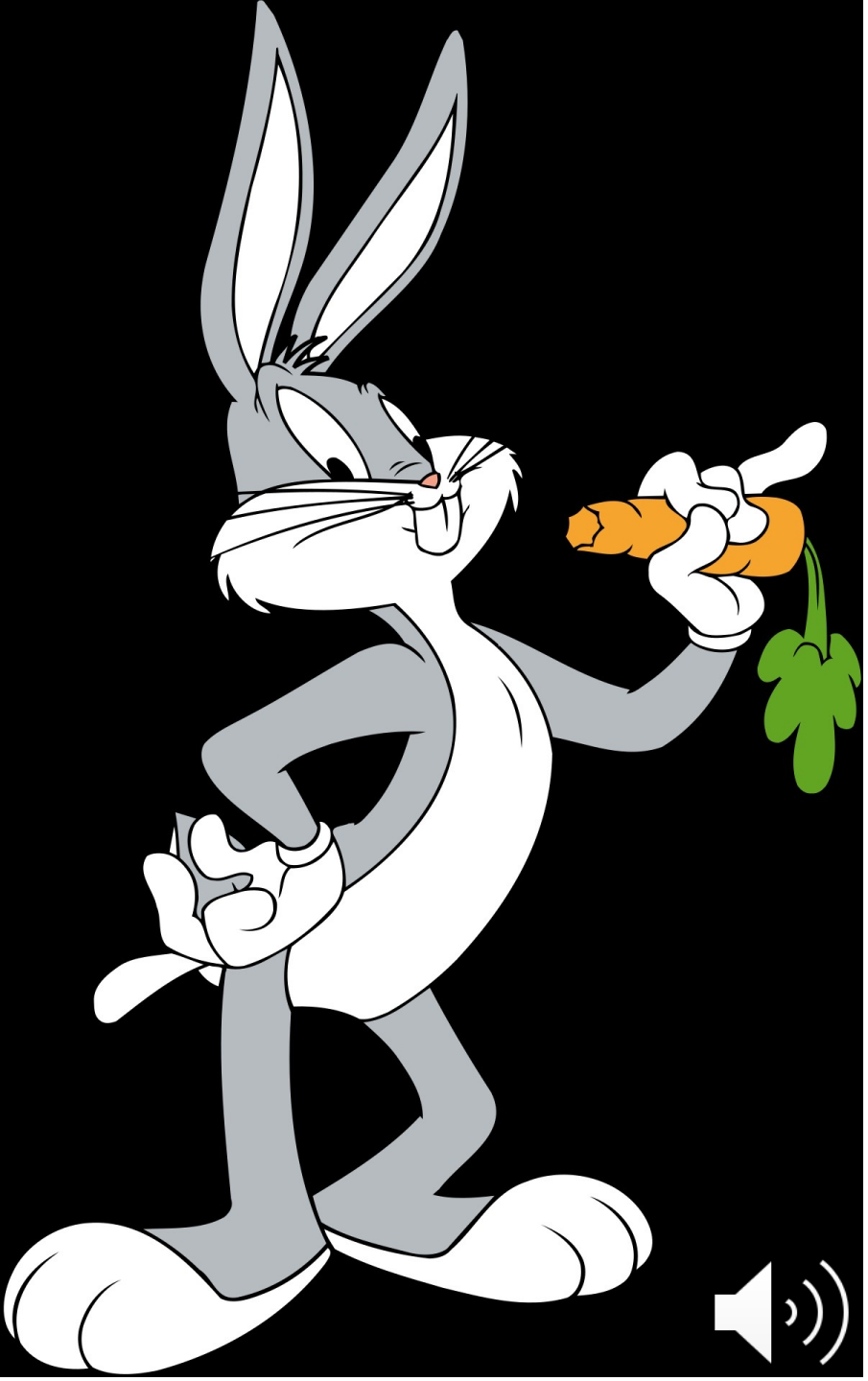
Research Contribution

- Effect of Distinct Ambient Noise Types on Mobile Interaction.
  - PACM IMWUT/Ubicomp'18
  - Sarsenbayeva et al. (2018)

Effects of Ambient Noise on Mobile Interaction

- Background music
  - Faster tempo → faster task completion (Milliman *et al*., 1986)
  - Faster music is more cognitively demanding (Holbrook *et al*., 1981)
- Urban noise
  - Outdoor urban noise negatively affects recall (Cassidy & MacDonald, 2007)
  - Indoor urban noise worsens performance in Maths tasks (Banbury & Berry, 1997)
- Speech
  - Adversely affects reading performance (Martin *et al*., 1982)
  - Distracts memory recall (Tremblay *et al*., 2000)

MUSIC



MUSIC

MUSIC

URBAN NOISE

URBAN NOISE

URBAN NOISE

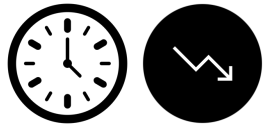
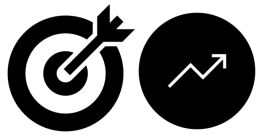
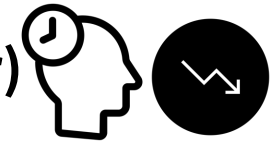
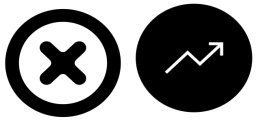
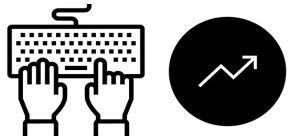
SPEECH

SPEECH

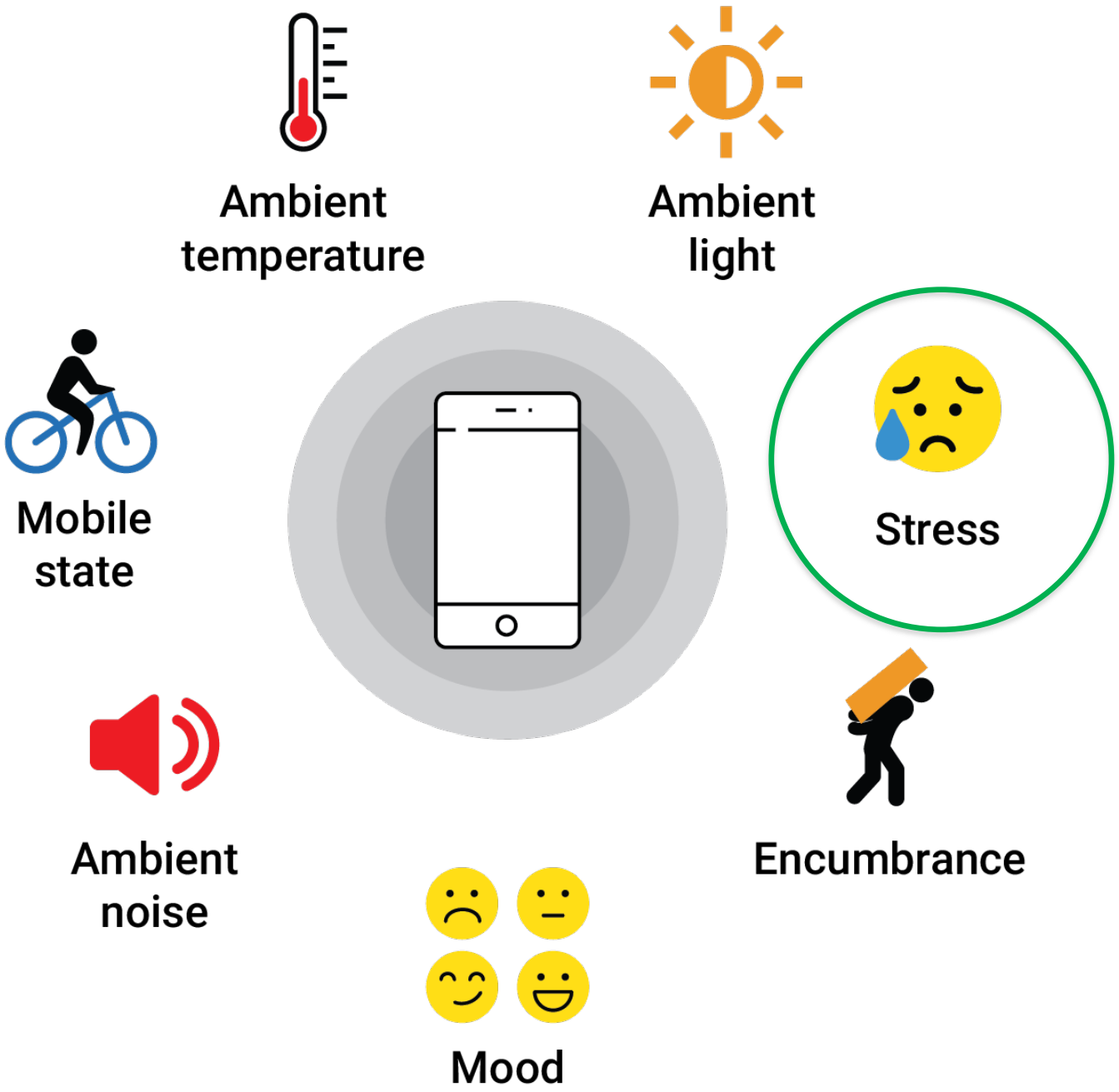
SPEECH

SILENCE

Results

- **Target Acquisition Time (Music: Fast and Slow)** 
- **Offset size (Music: Fast and Slow)** 
- **Time to Memorise Icons (Urban Indoor)** 
- **Errors in Visual Search (Urban Outdoor)** 
- **Time per Char Entry (Urban Outdoor, Meaningful Speech)** 

Moving From External To Internal Situational Impairments



Research Contribution

- Measuring the Effects of Stress on Mobile Interaction
  - PACM on IMWUT/UbiComp'19
  - Sarsenbayeva et al. (2019)

Measuring the Effects of Stress on Mobile Interaction

- Impairs working and declarative memory
  - Reduces memory retrieval (Kuhlmann *et al.*, 2005; Lupien *et al*., 1998; Newcomer *et al.*, 1999)

Measuring the Effects of Stress on Mobile Interaction

- Impairs working and declarative memory
  - Reduces memory retrieval (Kuhlmann *et al.*, 2005; Lupien *et al*., 1998; Newcomer *et al.*, 1999)
- Affects interaction with stationary technology
  - Stronger keyboard taps (Karunaratne *et al.*, 2011)
  - More mouse movements (Rodrigues *et al.*, 2013)

Study Protocol

- Trier Social Stress Test
  - Public Speaking
  - Arithmetic Subtraction

Study Protocol

SELF-EVALUATION QUESTIONNAIRE STAI Form Y-1

Please provide the following information:

Name_____Date_____S_____

Age_____ Gender (*Circle*) **M** **F** T_____

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

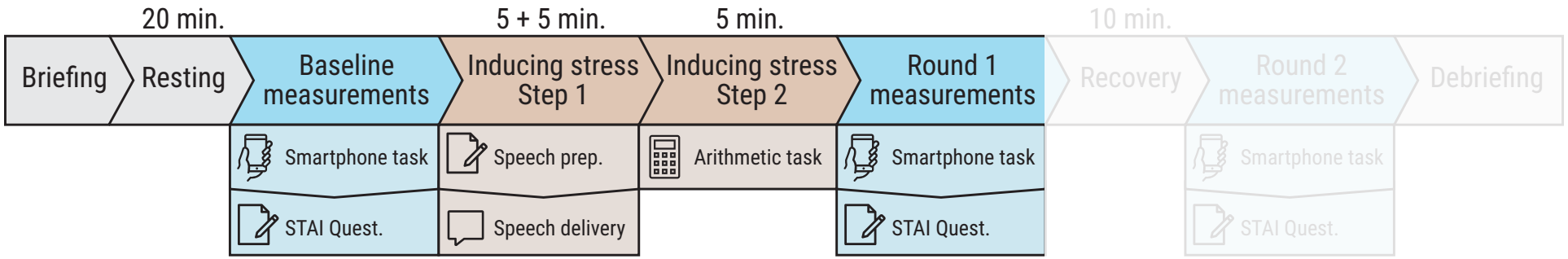
	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4

State-Trait Anxiety Inventory (STAI)

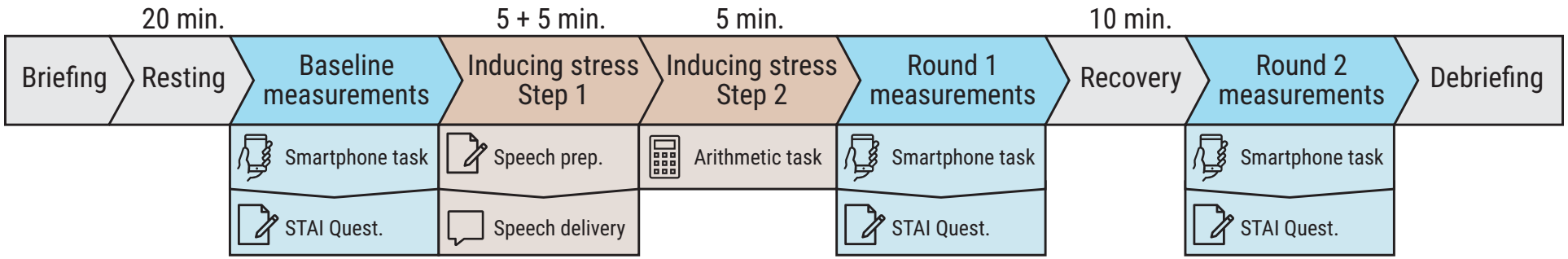
Empatica E4 sensor

Study Protocol

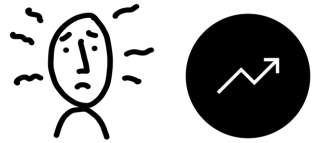
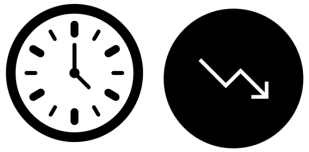
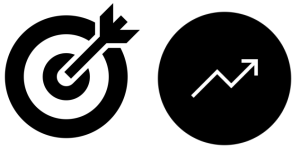
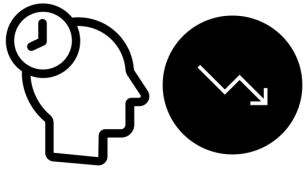
Study Protocol

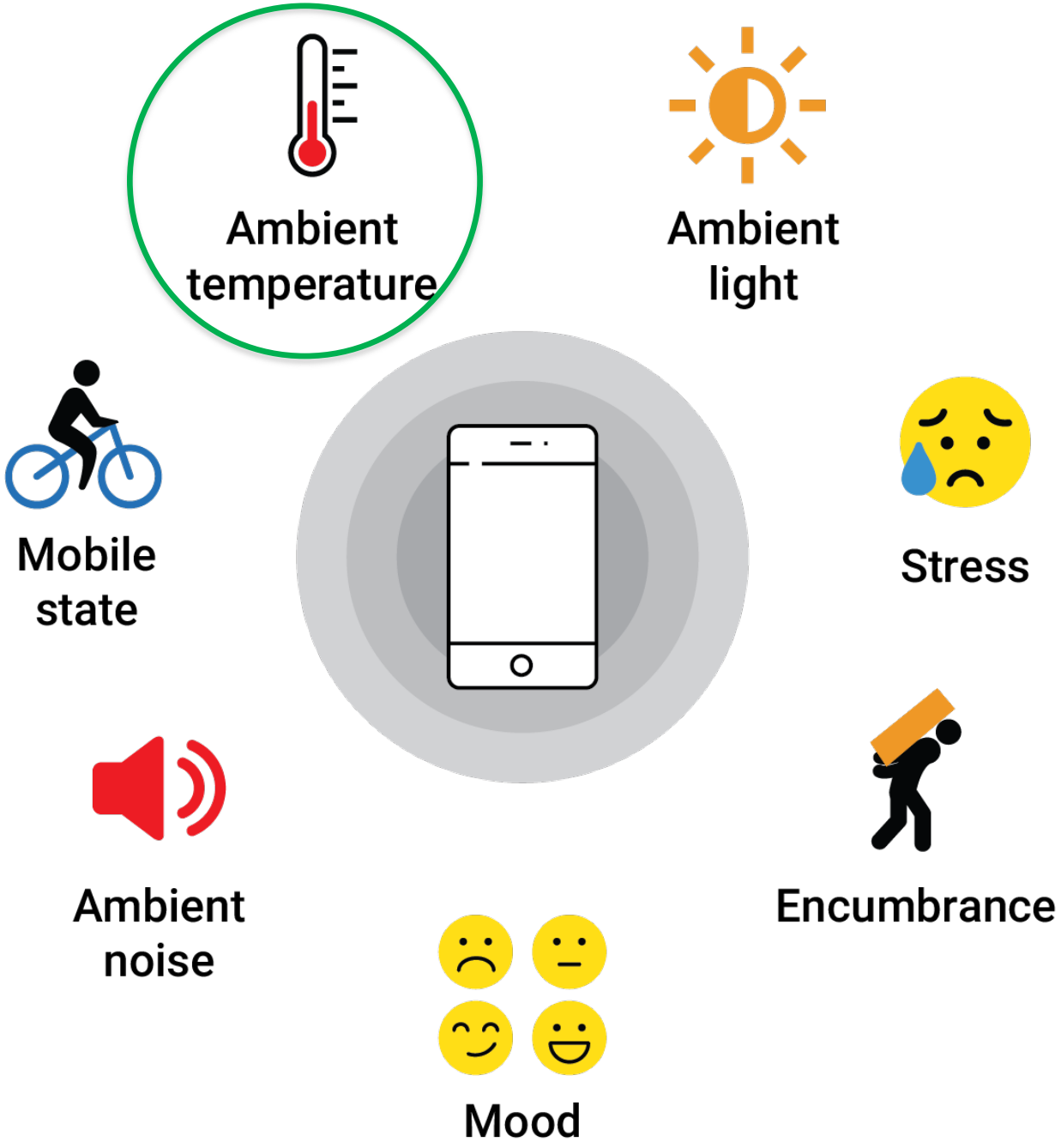


Study Protocol



Results

- **HF HRV (Stress, Post-Stress)** 
- **STAI Scores (Stress)** 
- **Target Acquisition Time (Stress, Post-Stress)** 
- **Offset Size (Stress, Post-Stress)** 
- **Time to Memorise Icon (Stress, Post-Stress)** 



Research Contribution

- Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature.
  - PACM IMWUT/Ubicomp'17
  - Sarsenbayeva et al. (2017)

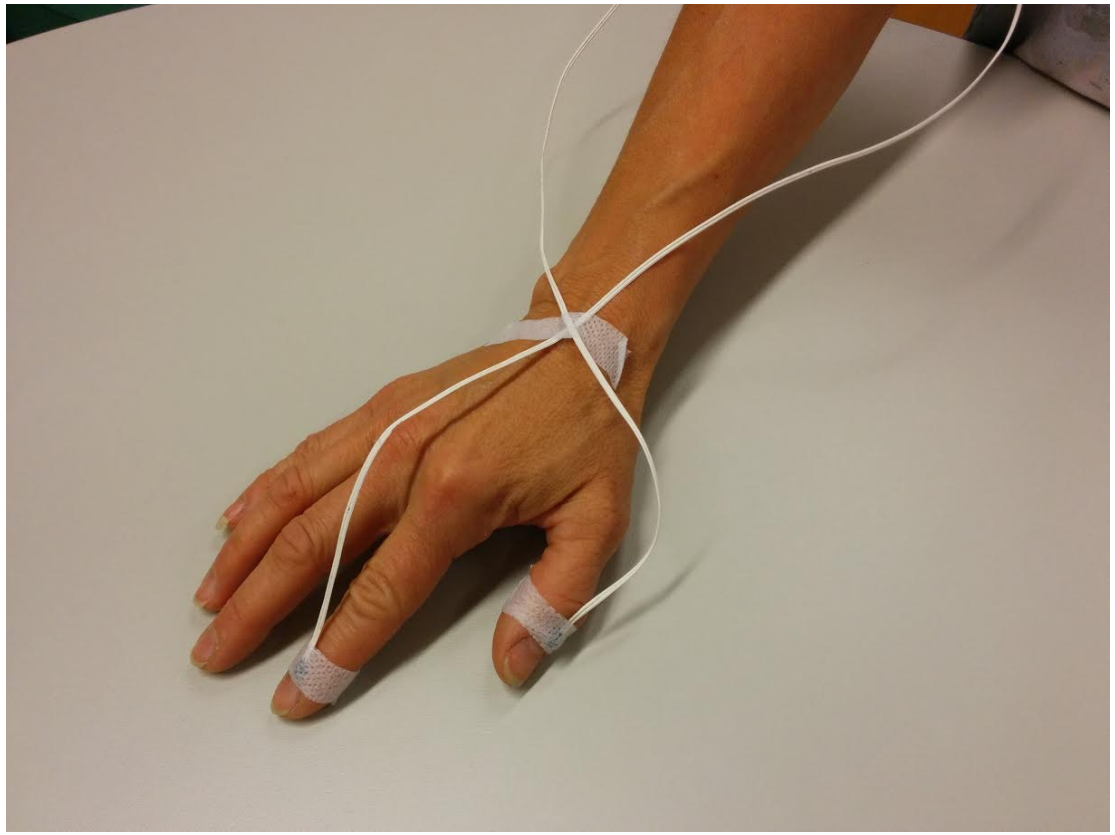
Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature

- Ambient temperature affects finger temperature
  - Montgomery et al., 1976

- Finger temperature affects input performance
  - Goncalves et al., 2017

- Finger temperature affects precision and reaction time
  - Sarsenbayeva et al., 2016

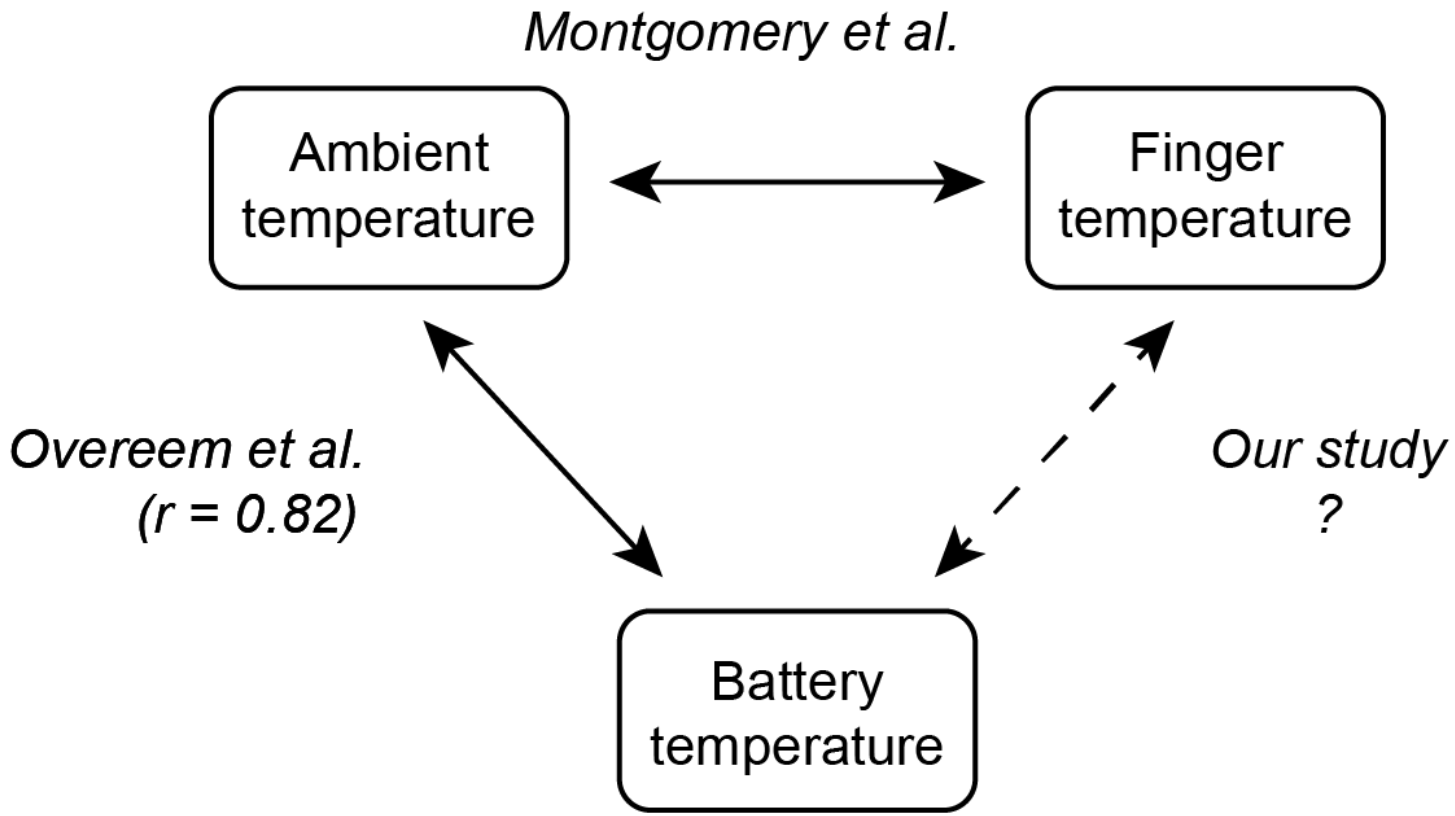
Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature



Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature

- Smartphone pressure sensors to measure environmental pressure
  - Mass and Madaus, 2014
- Smartphone battery sensors to measure air temperature
  - Overeem *et al.,* 2013

Sensing Cold-Induced Situational Impairments in Mobile Interaction Using Battery Temperature



Methodology – Study 1

Motorola Moto G3

Samsung Galaxy S4 Mini

LG Nexus 5X

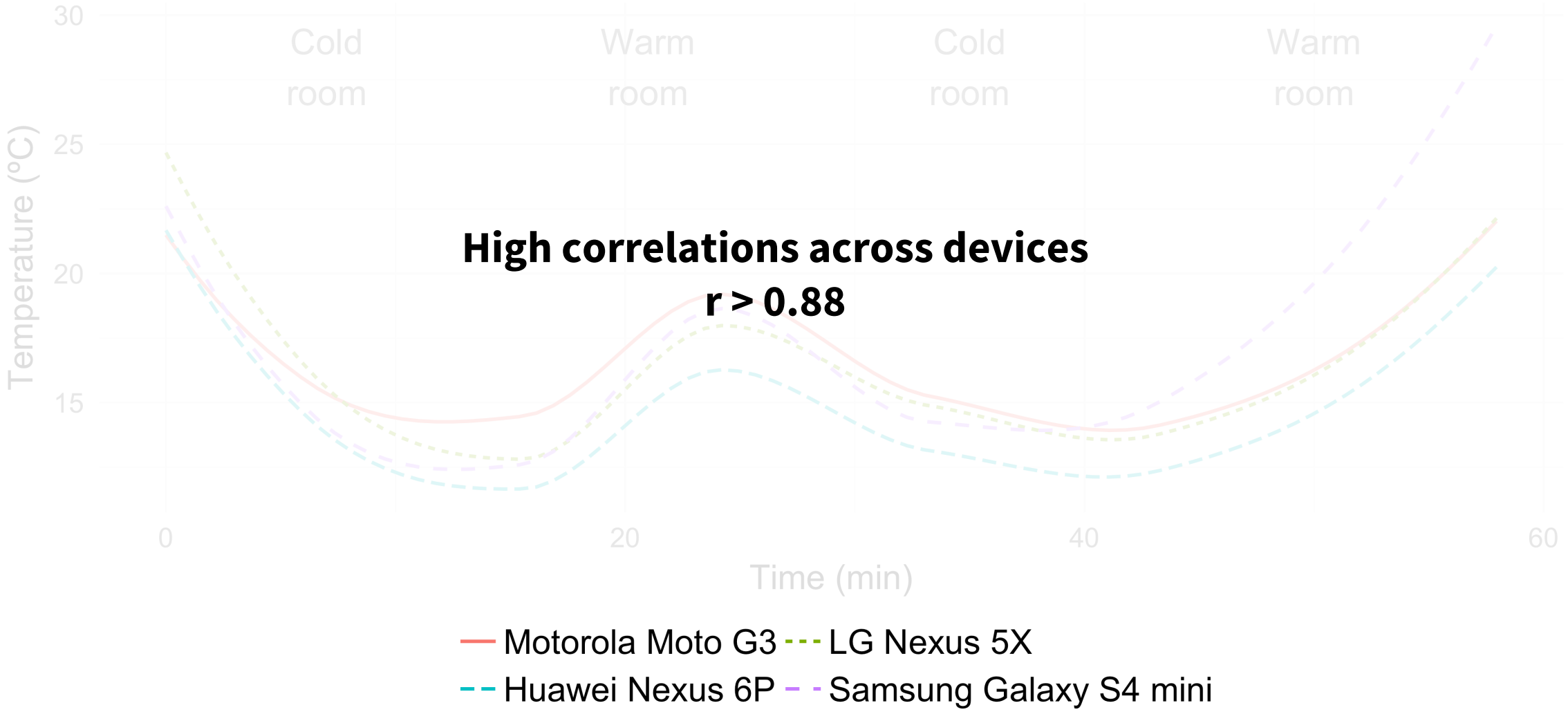
Huawei Nexus 6P

Methodology – Study 1

Cold Chamber	Warm Room	Cold Chamber	Warm Room
-10 °C ~ 14 mins	+20 °C ~ 14 mins	-10 °C ~ 14 mins	+20 °C ~ 14 mins

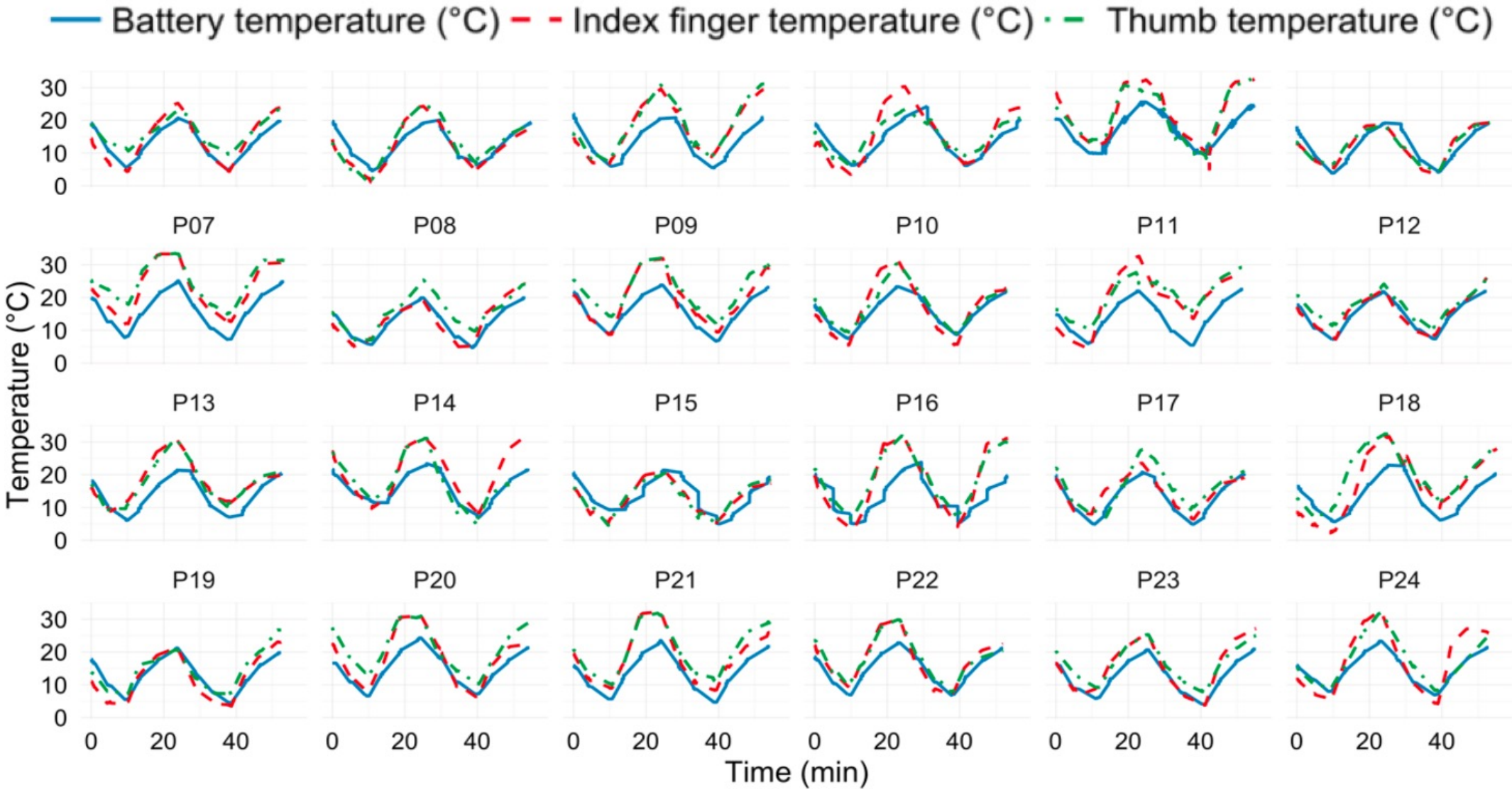
Sarsenbayeva et al., 2016
Goncalves et al., 2017

Results – Study 1

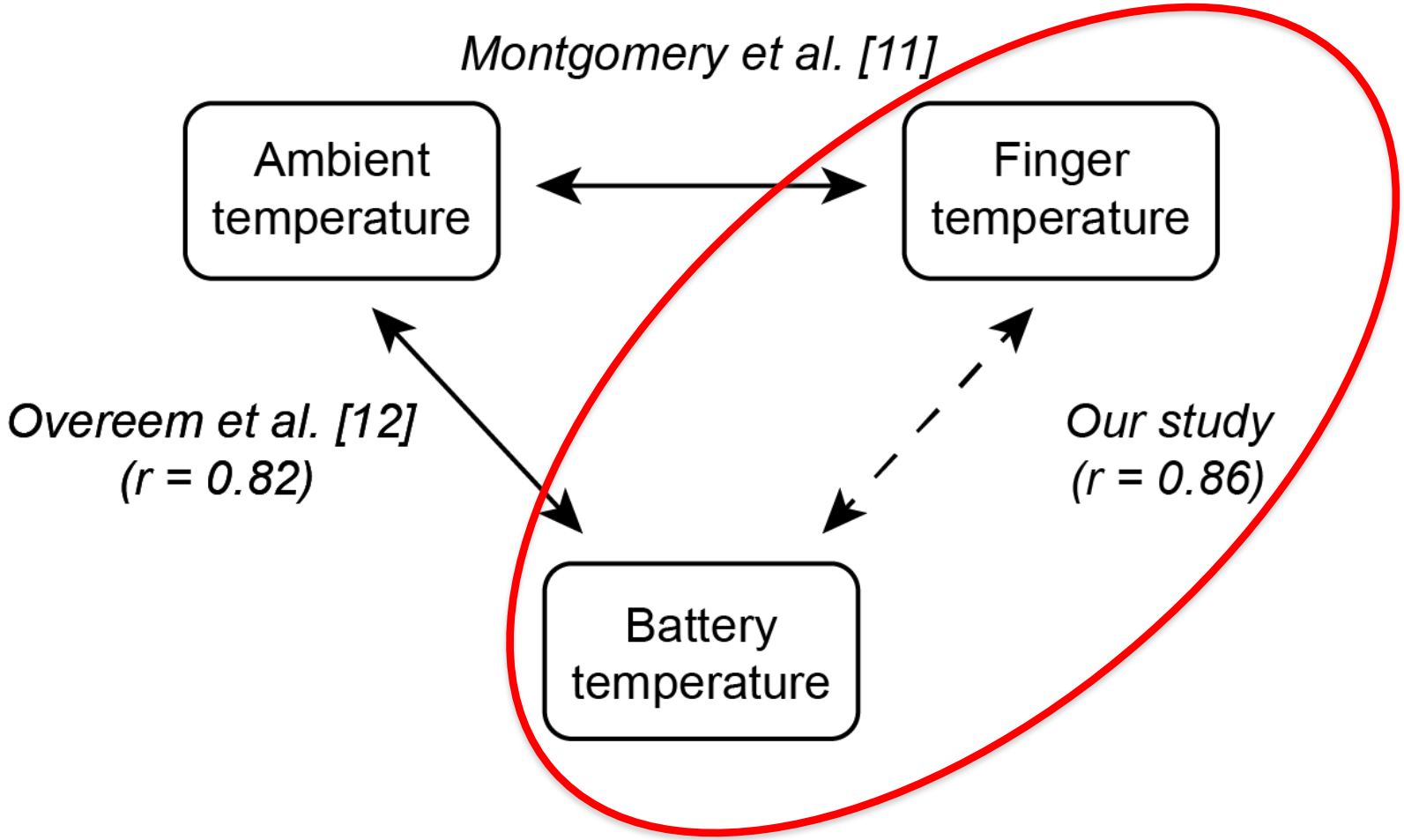


Methodology – Study 2

Results – Study 2



Results – Study 2



Applications

User initiates interaction

Device registers battery temperature

Device registers certain threshold of temperature decrease

Interface adapts accordingly/ warns the user

Thank you!

Zhanna Sarsenbayeva

zhanna.sarsenbayeva@sydney.edu.au