Digital synesthesia

Using Mobile Technology to Interact with Our World

PhD Thesis By:
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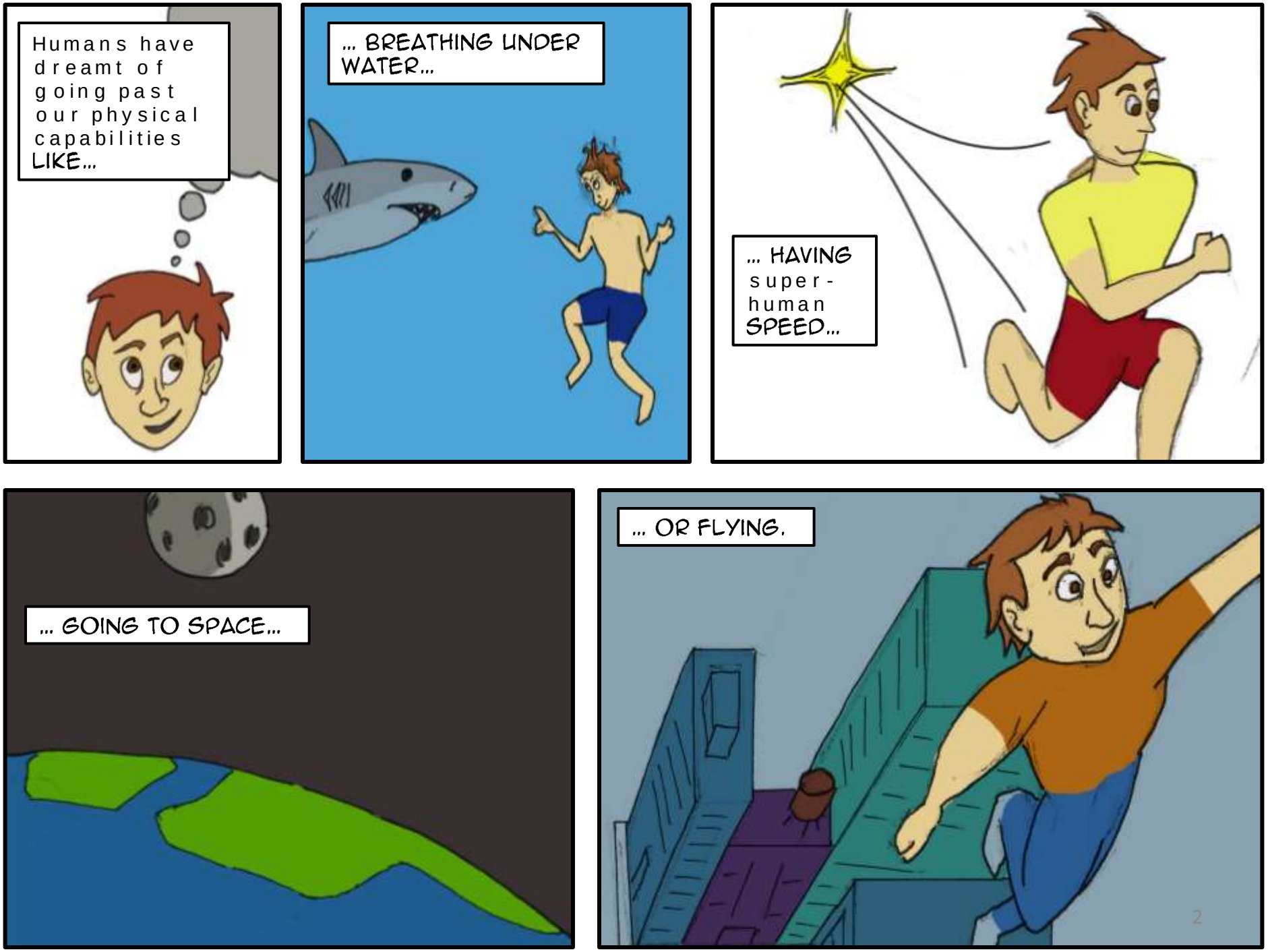
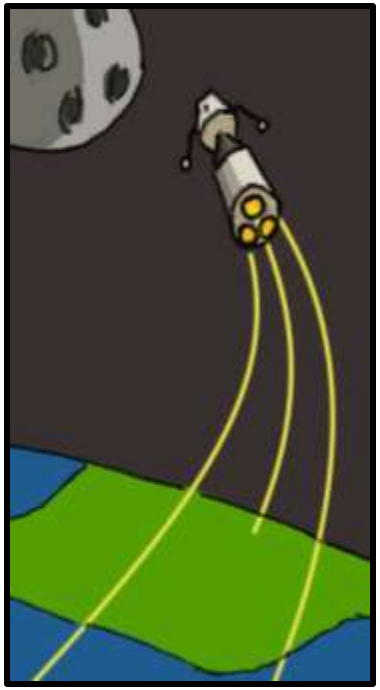
Joseph Paradiso
Kevin Slavin

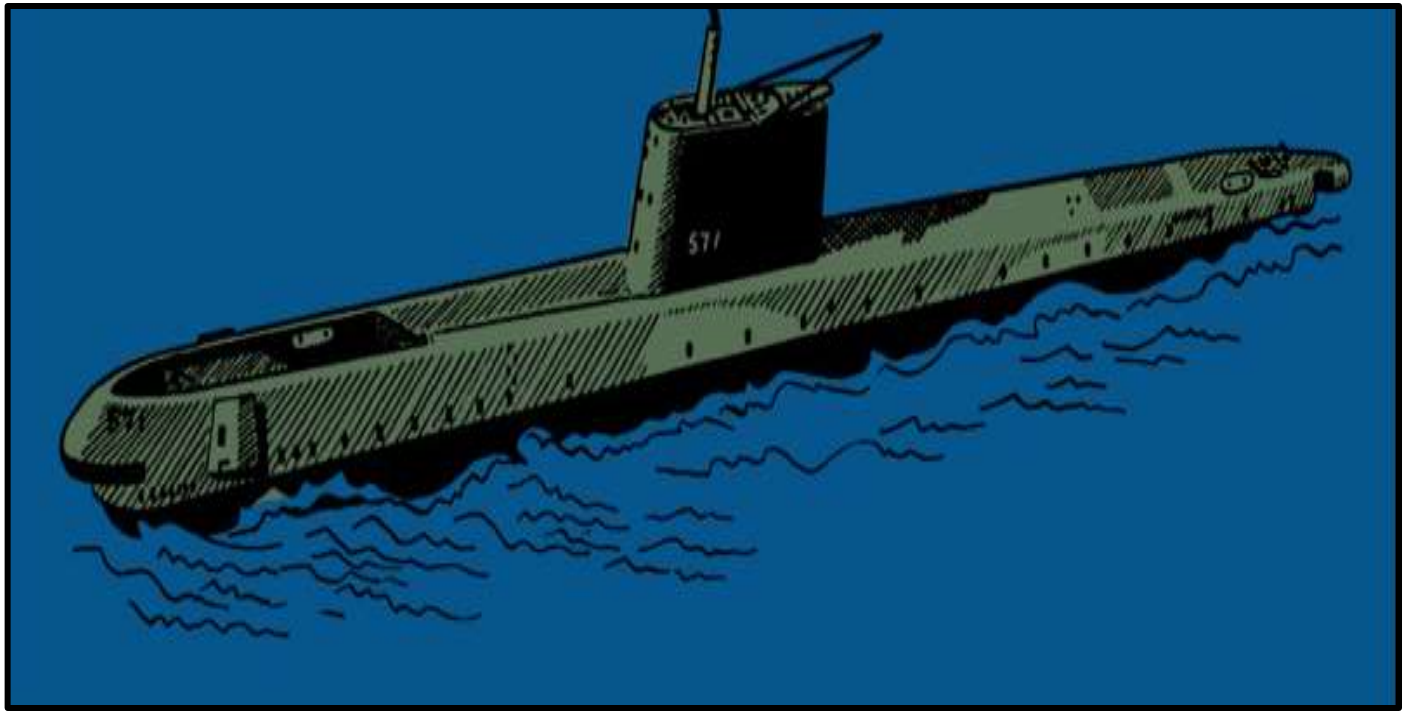

Humans have dreamt of going past our physical capabilities LIKE...
... BREATHING UNDER WATER...
... HAVING super-human SPEED...
... GOING TO SPACE...
... OR FLYING.

WE have reached some dreams

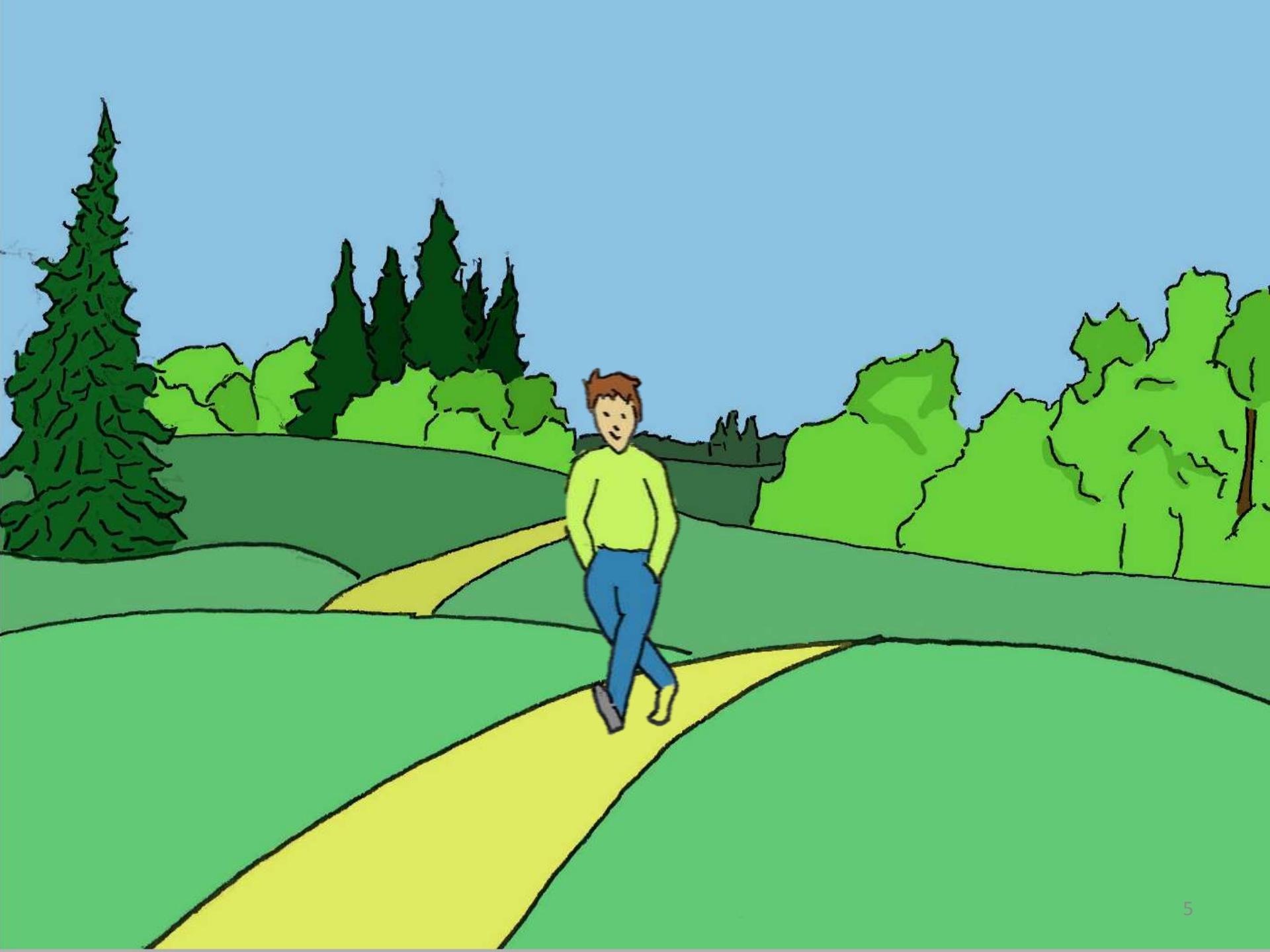
With technology

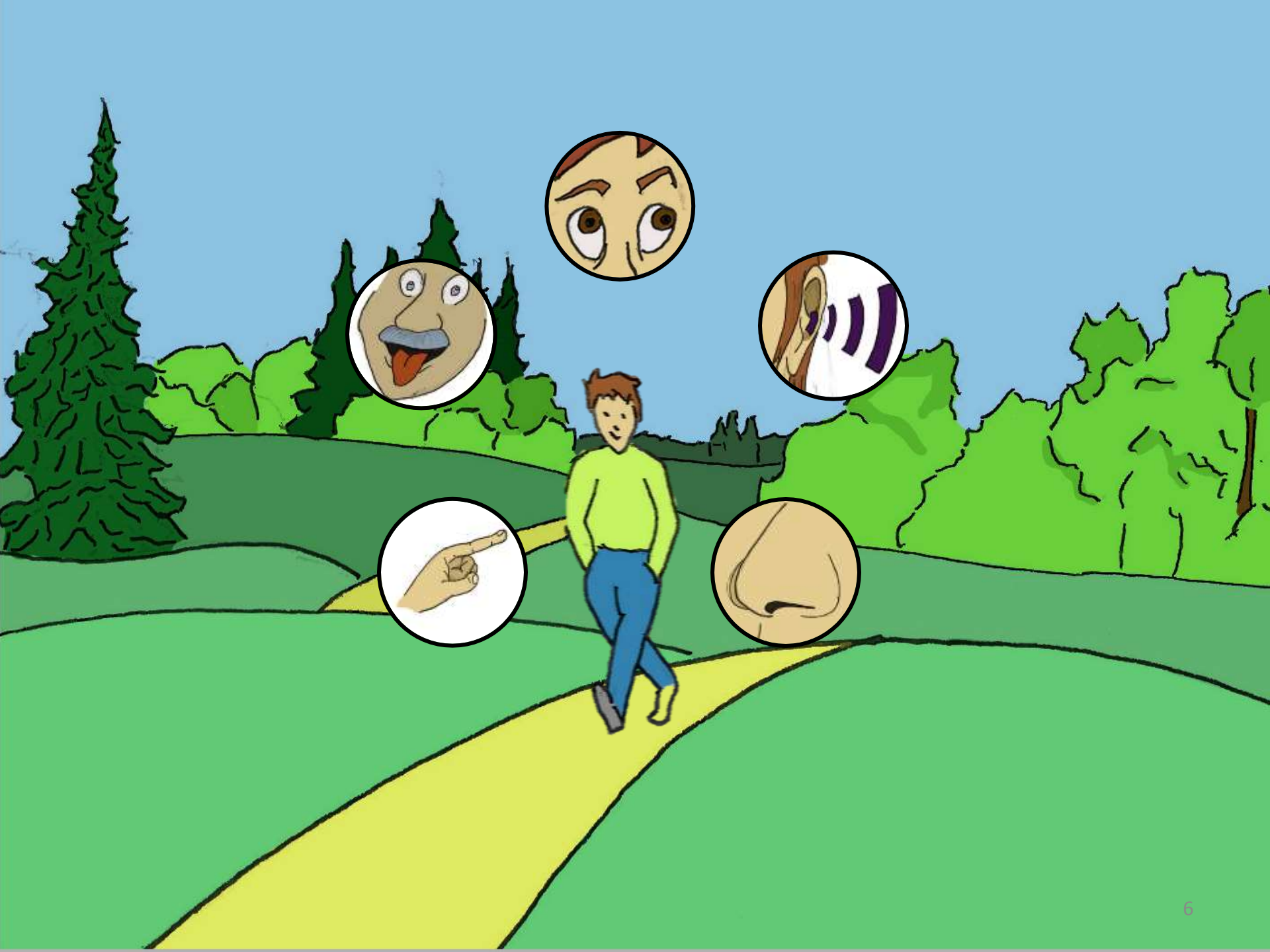


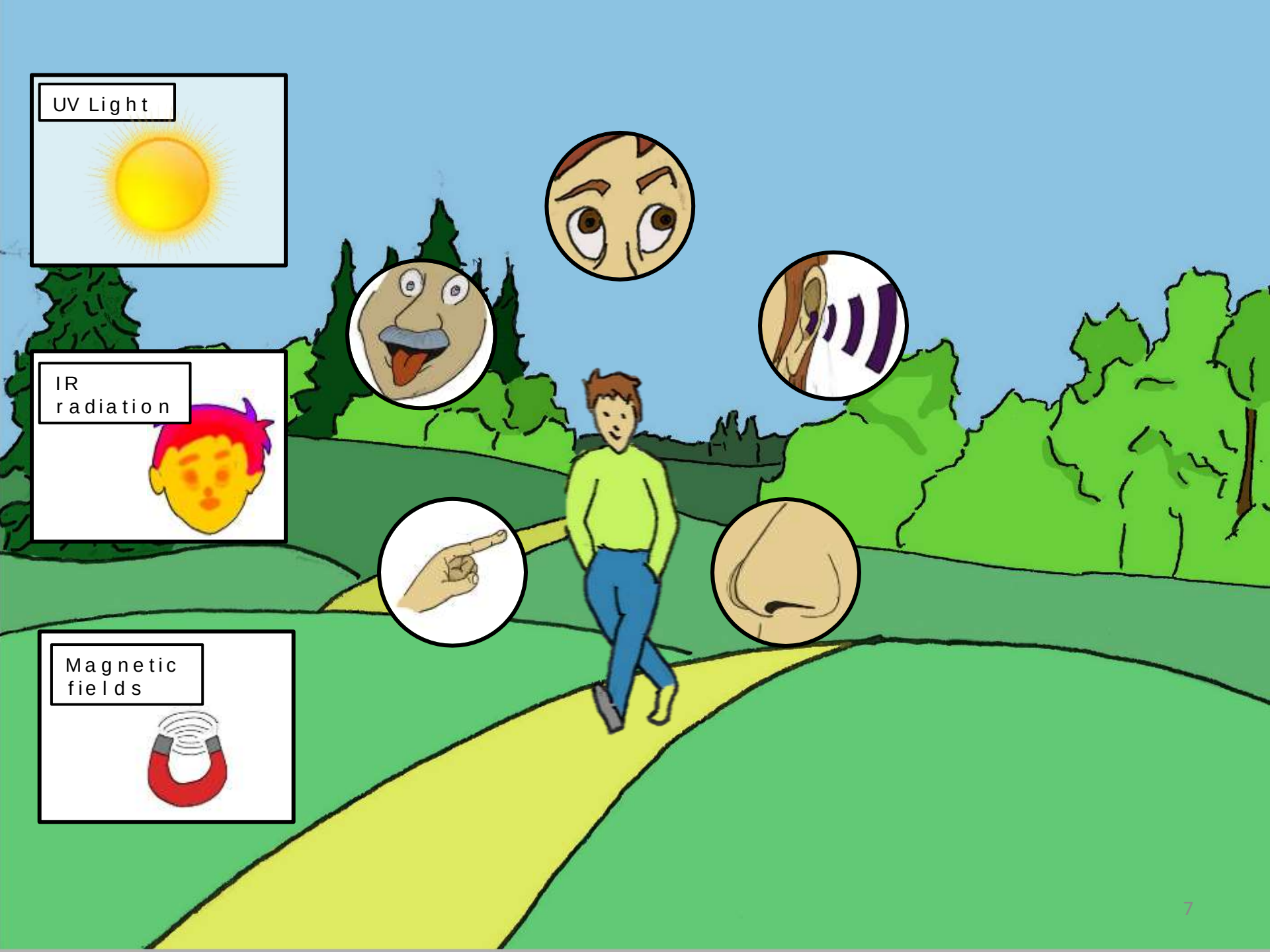
AND By UNDERSTANDING OUR WORLD

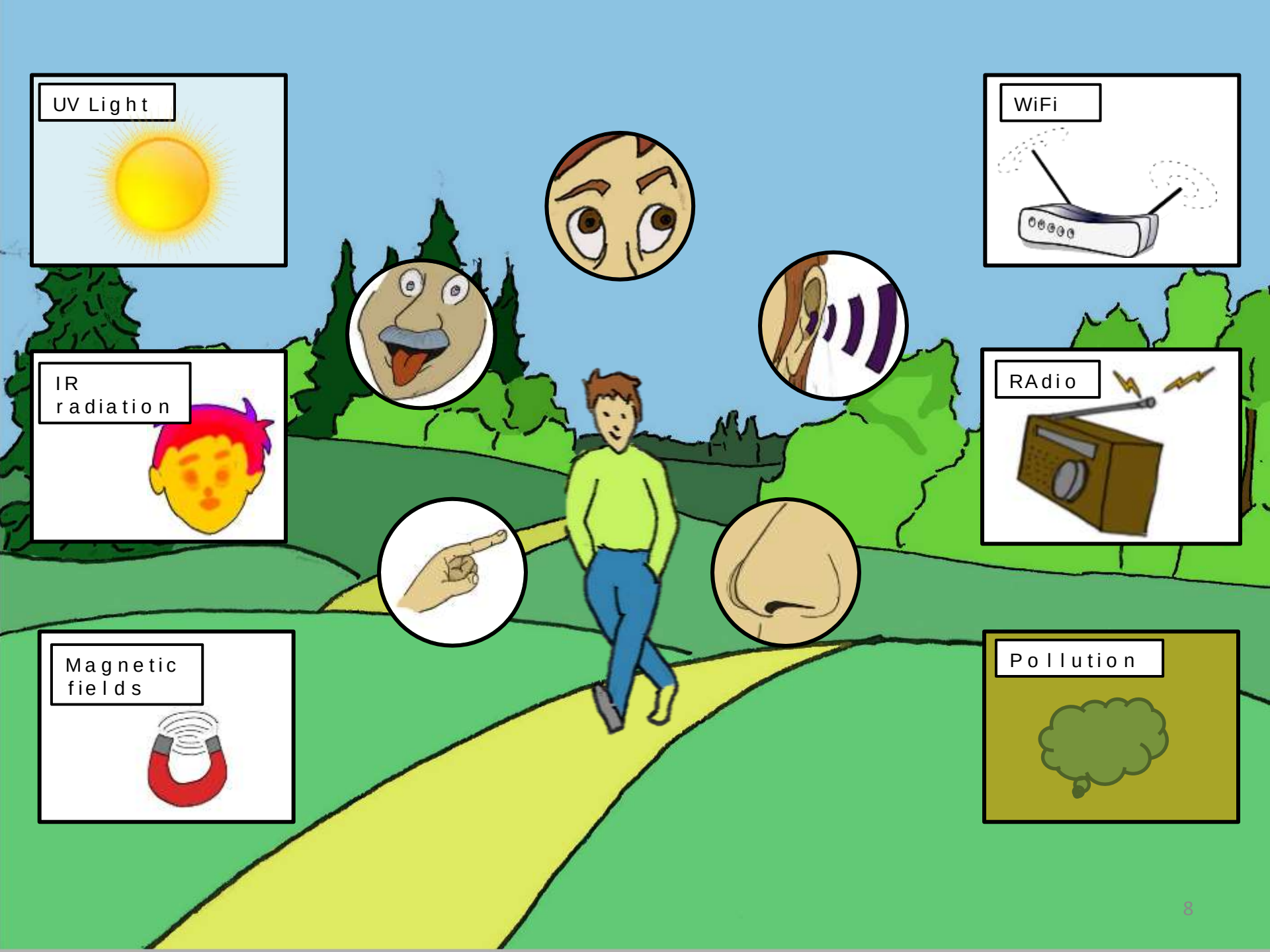


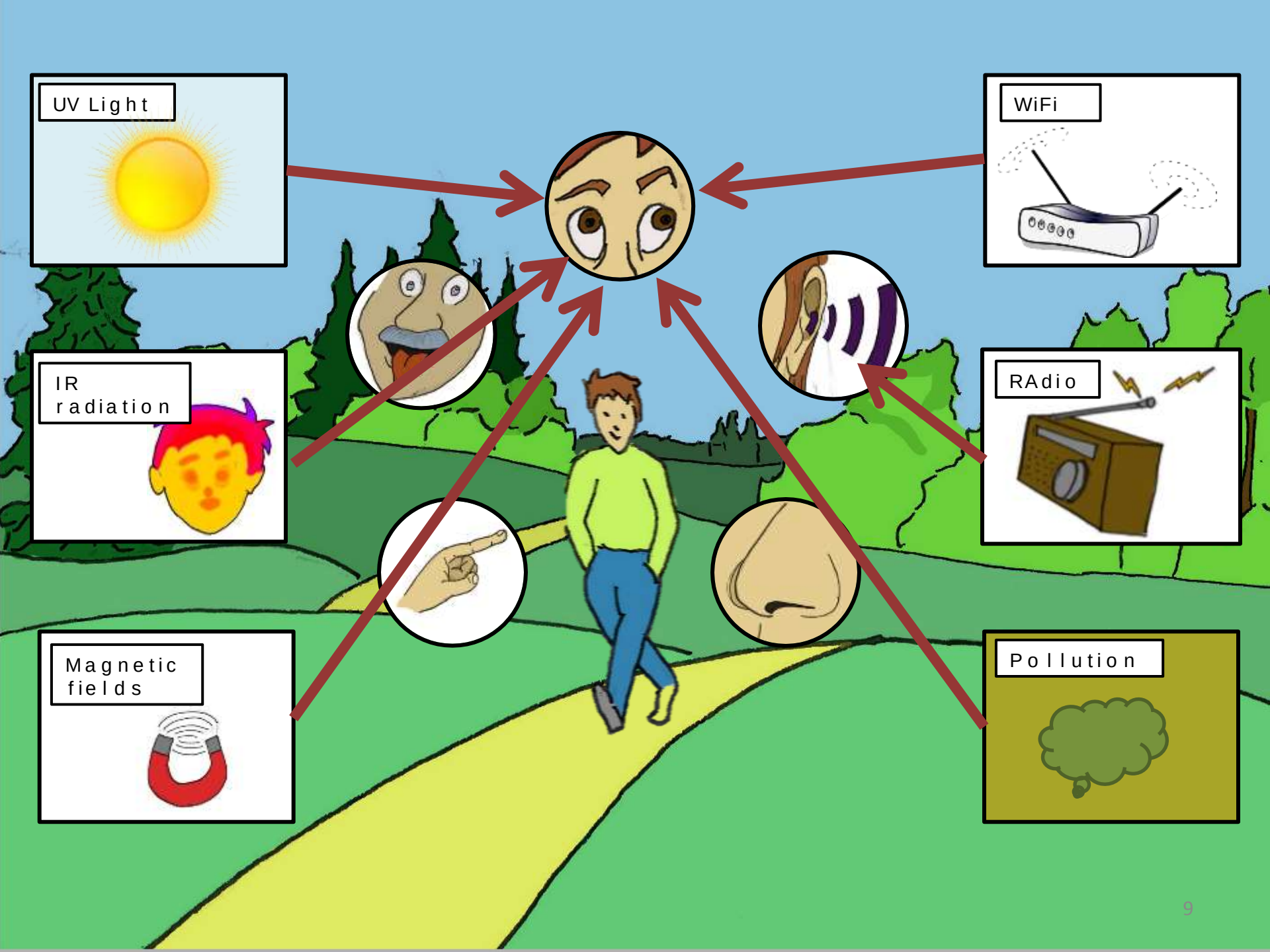
Other dreams are about OUR SENSES…






UV Light
IR radiation
Magnetic fields


UV Light
WiFi
IR radiation
RAdio
Magnetic fields
Pollution


UV Light
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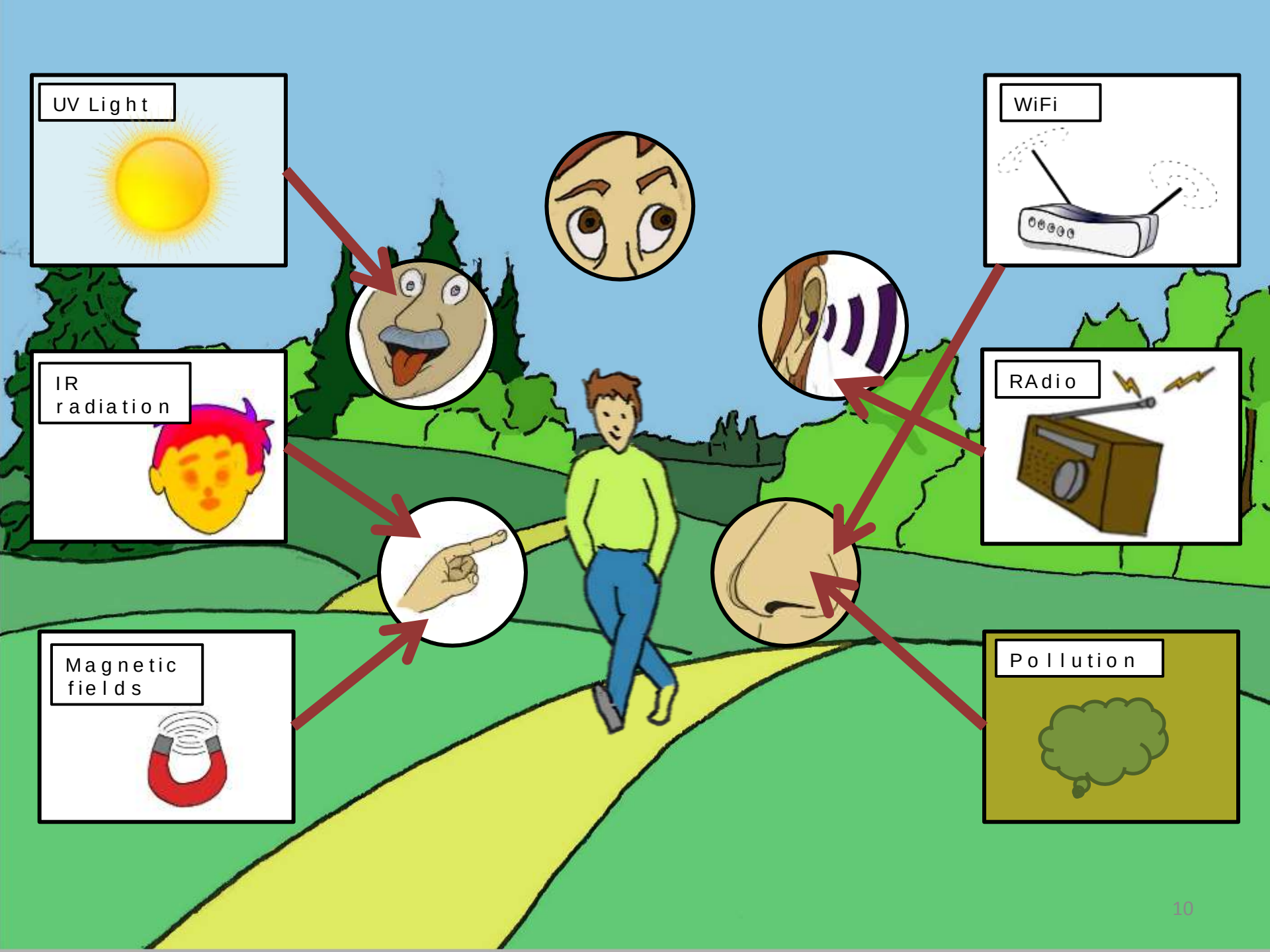
UV Light
WiFi
IR radiation
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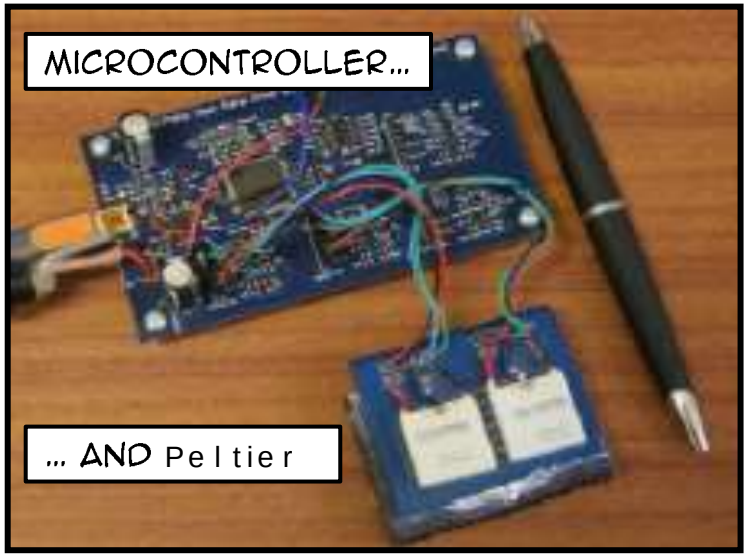
Background:

- Thermal interfaces
- Vibration interfaces
- Mobile device interfaces
- Sensory substitution
- New sensory experiences

Background:

Thermal interfaces



users detect hot and cold stimuli presented to the fingertips, the palm and the arm

Two studies. One static indoor and one mobile

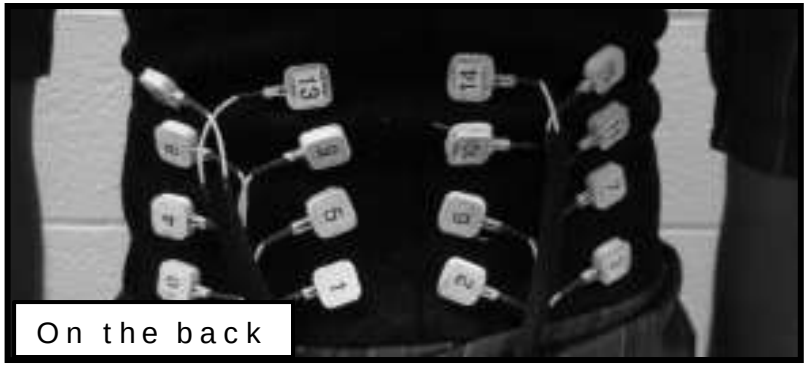
The experiment was repeated with the subjects walking around

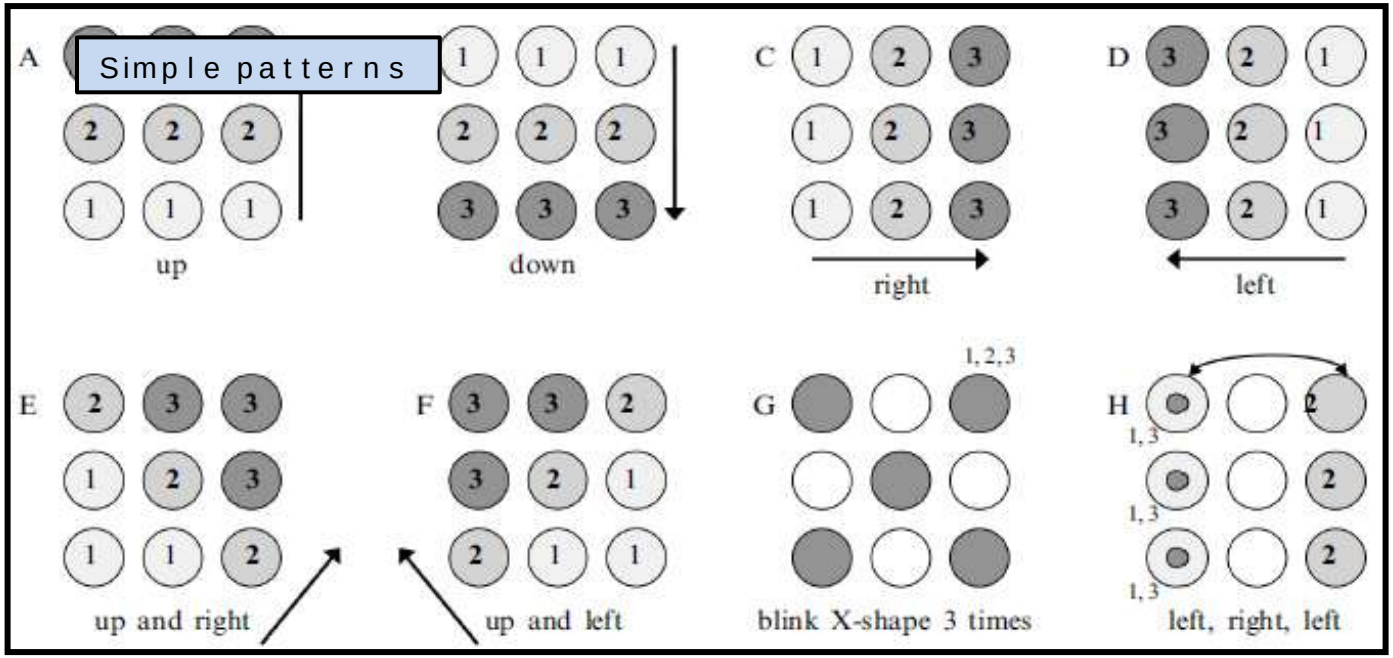
Wilson, G., Halvey, M., Brewster, S. A., & Hughes, S. A. (2011). Some Like it Hot? Thermal Feedback for Mobile Devices. Human Factors, 2555–2564. doi:10.1145/1978942.1979316

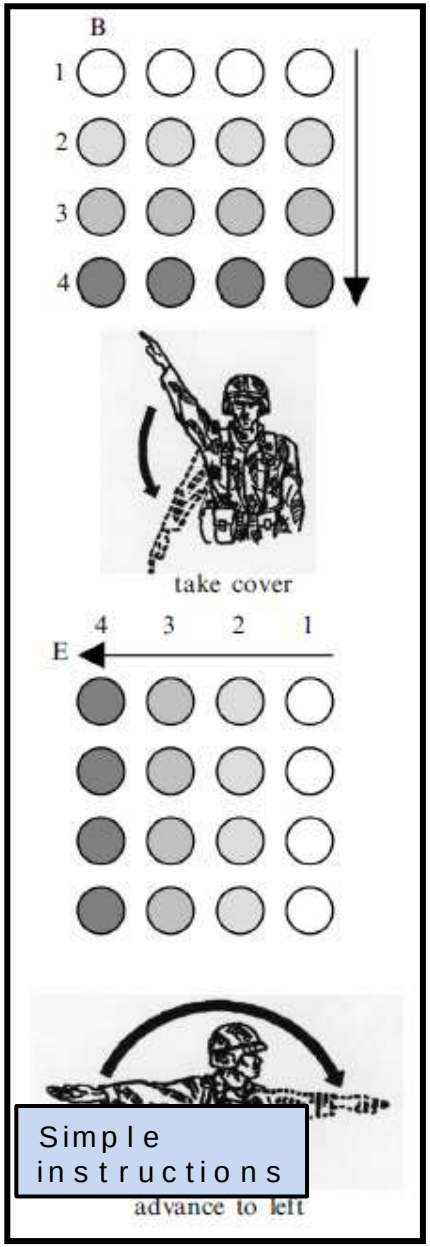
Background:

Vibration interfaces

How a tactile display can communicate simple instructions and commands







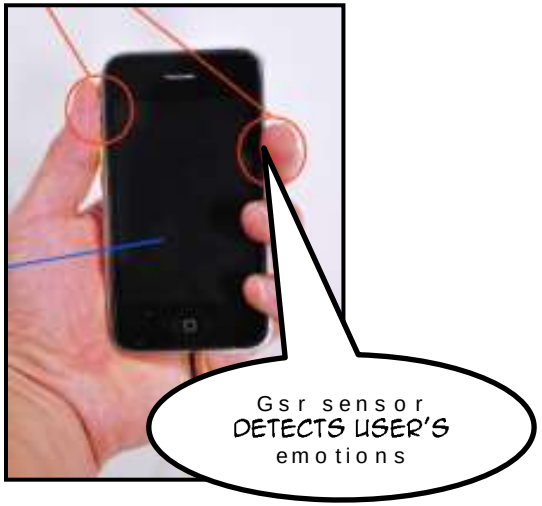
Jones, L. A., Kunkel, J., & Piateski, E. (2009). Vibrotactile pattern recognition on the arm and back. Perception, 38(1), 52–68. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19323136

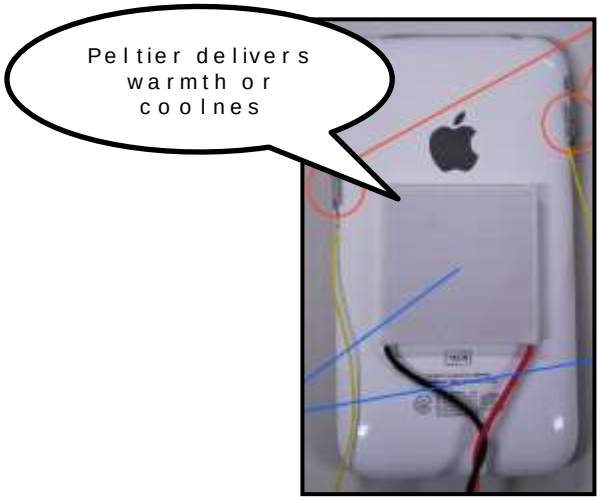
Background:

Mobile device interfaces

AffectPhone

detects A USER'S emotional state using GSR, and conveys this state via changes in the temperature of the back panel of the other handset

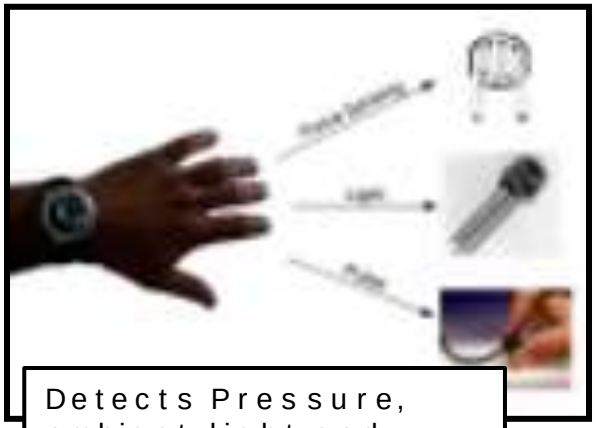




Iwasaki, K., Miyaki, T., & Rekimoto, J. (2010). AffectPhone: A Handset Device to PRESENT USER'S EMOTIONAL STATE WITH WARMTH/COOLNESS. B-Interface

connexus

Aims to detect various conditions at a time and transmit them in different ways



Detects Pressure, ambient light and heartbeat

Gives heat, light and vibration

Paulos, E. (2003). Connexus: A COMMUNAL INTERFACE. PROCEEDING DUX '03 Proceedings of the 2003 Conference on Designing for User Experiences, 1–4.

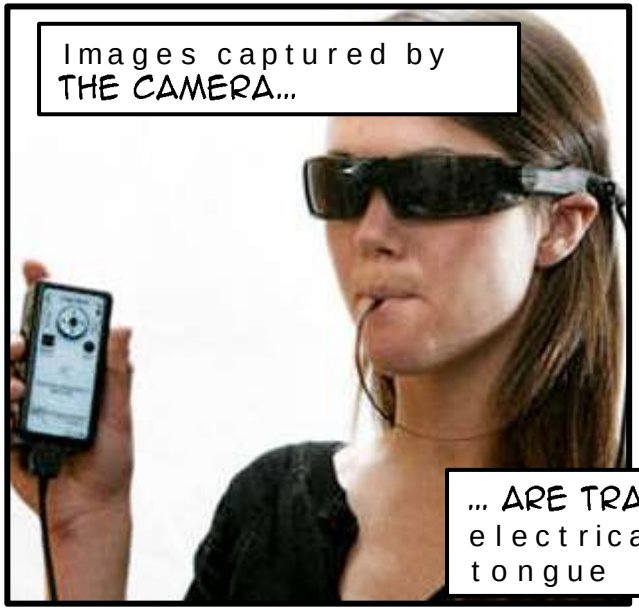
Background:

Sensory Substitution

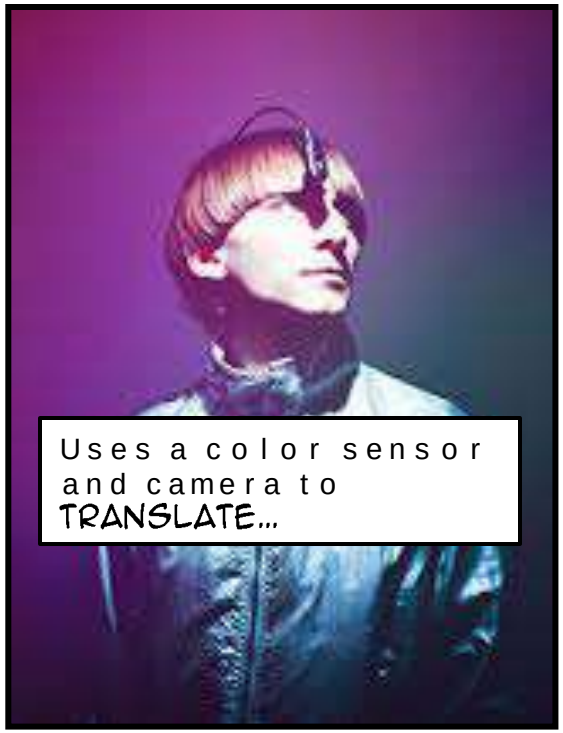
Brainport and eyeborg

DANILOV, Y., & Tyler, M. (2005). Brainport: an alternative input to the brain. Journal of Integrative Neuroscience, 4(4), 537–50. doi:10.1142/S0219635205000914

Images captured by THE CAMERA…



… ARE TRANSLATED TO electrical signals in the tongue



Uses a color sensor and camera to TRANSLATE…

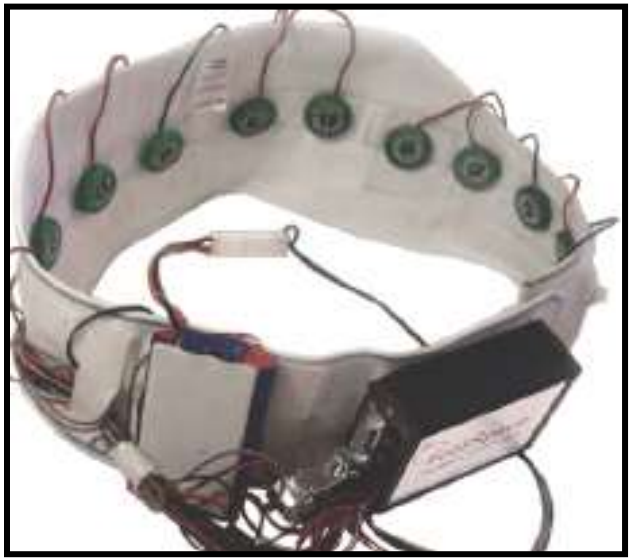
… COLOR INFORMATION to sound

Seymour, S. (1965). Cyborg--EVOLUTION OF THE SUPERMAN, (1960), 1–24.

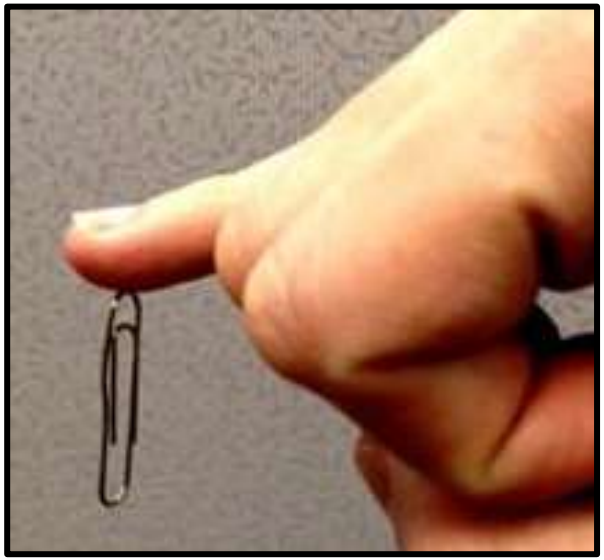
Background:

Artificial sensory experiences

Feelspace belt, body hacking and momo



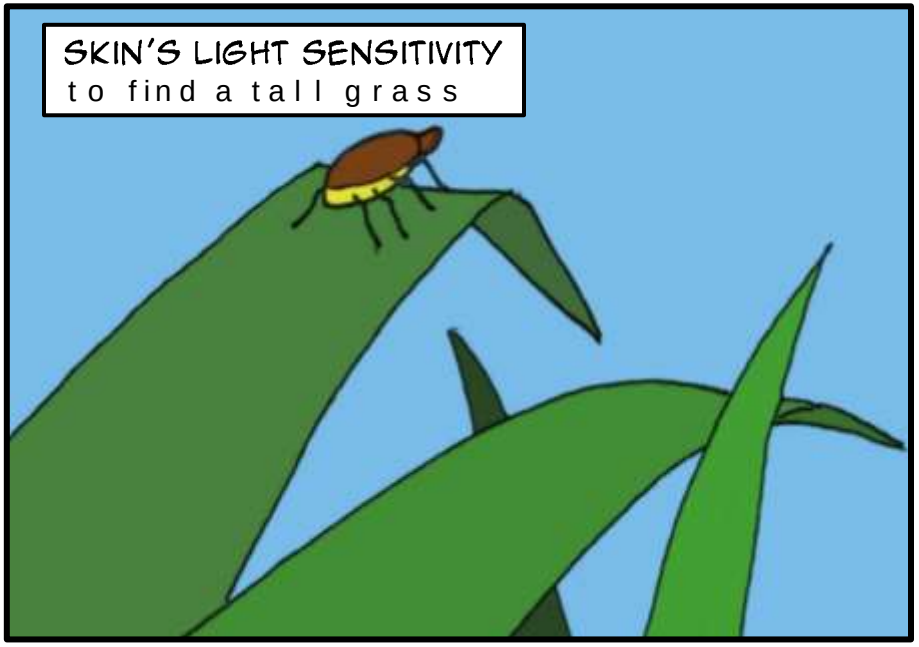
"feelSpace BELT"
Nagel, S. K., Carl, C., Kringe, T., Märtin, R., & König, P.

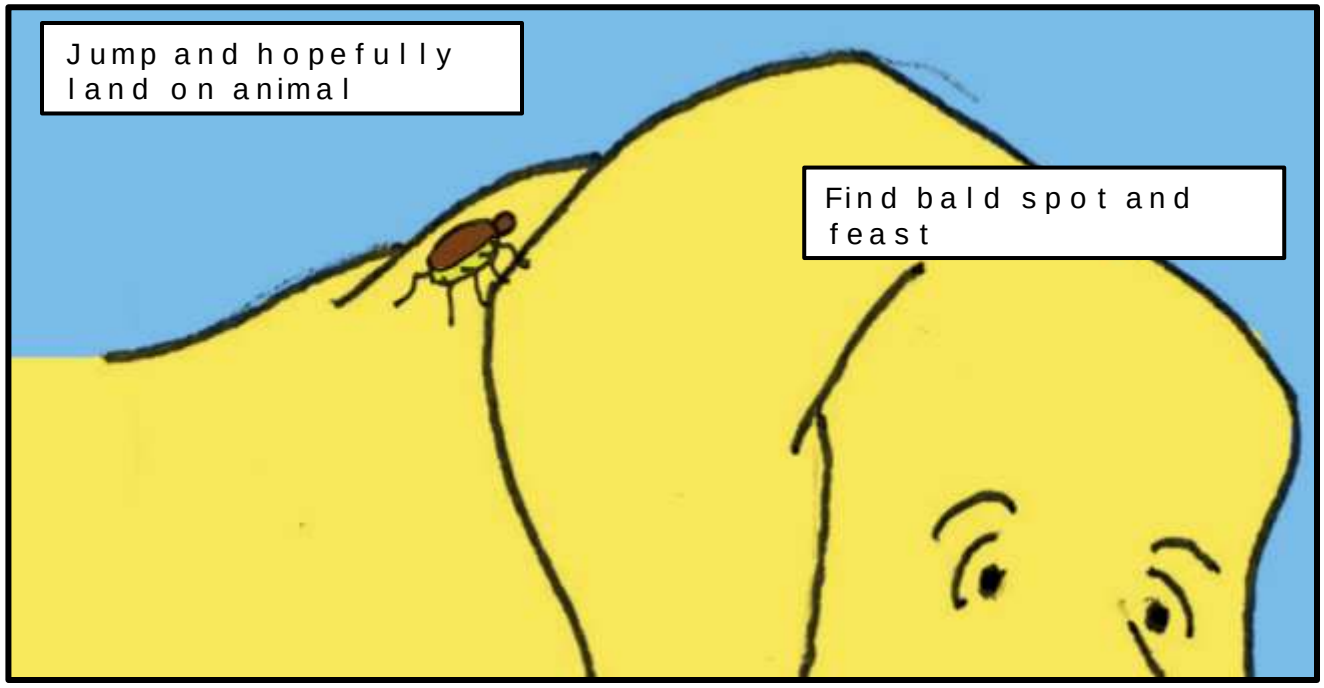


"Body Hacking: My Magnetic Implant"
D. Berg

"MOMO: a haptic navigation device"
C. WANG AND K. O'FRIEL

Digital Synesthesia





The tick understands
only three signs

Smell

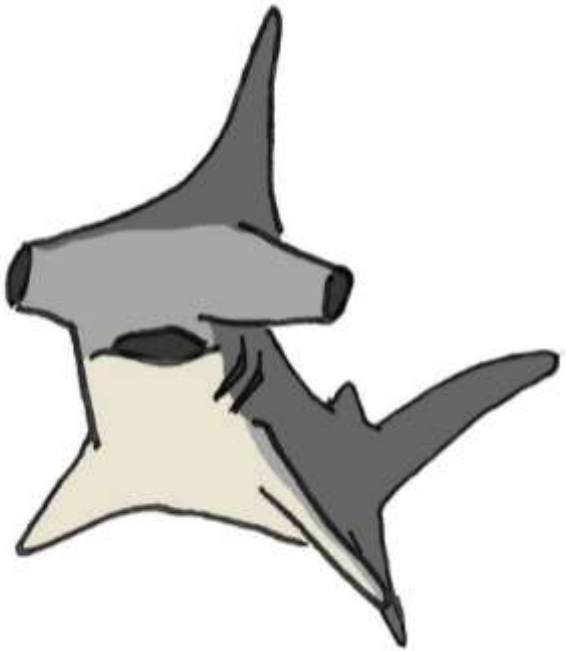
Temperature

hairiness

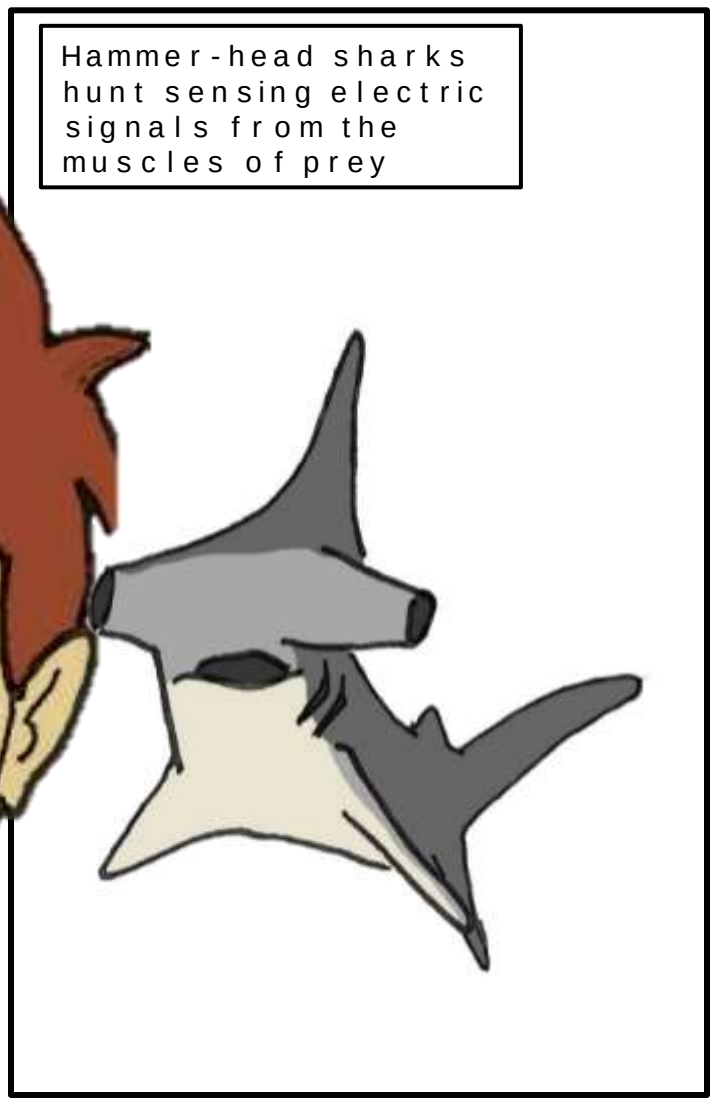
"A FORAY INTO THE WORLDS OF
ANIMALS AND HUMANS"
Jakob von Uexküll

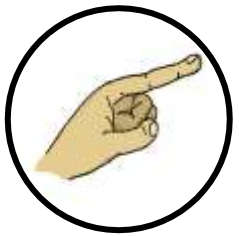
Bees can use uv light to pick flowers

Hammer-head sharks hunt sensing electric signals from the muscles of prey



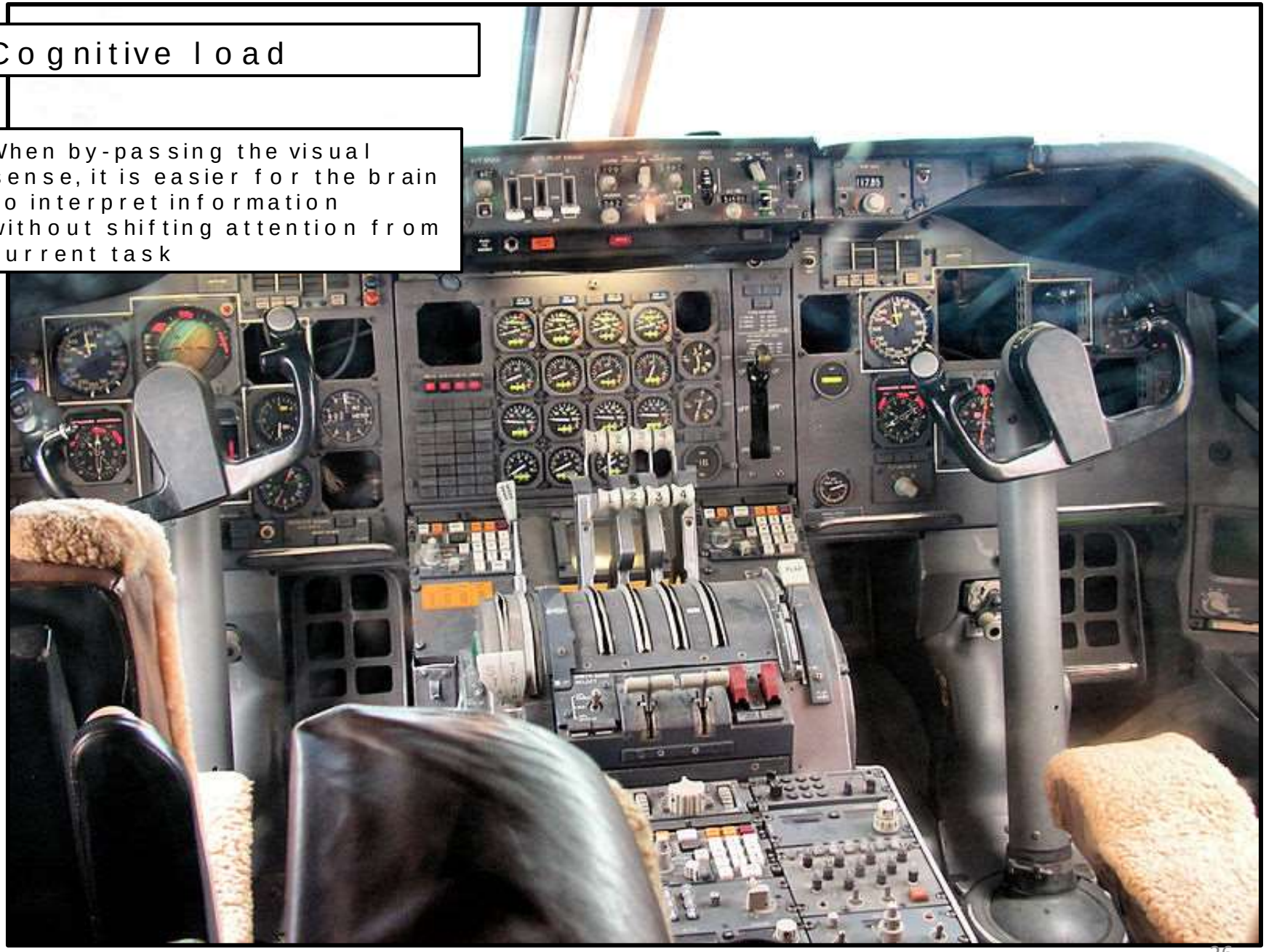

Bees can use uv light to pick flowers


Hammer-head sharks hunt sensing electric signals from the muscles of prey



Cognitive load

When by-passing the visual sense, it is easier for the brain to interpret information without shifting attention from current task



We all feel the same conditions in a different way

Research questions, stage iv

Discrete and Continuous Data

1. Will a discreet signal (high-low) be more effective than a continuous signal representing changing data?

Sensory Substitution

2. will Digital Synesthesia prove to be a valid alternative to a natural sense when accomplishing the same task?

Sensory Augmentation

3. Will users be able to understand the ability to fine tune the sensitivity of an artificial sense?

Research questions, stage iv

New Senses

4. Is the user able to correctly interpret a new artificial sense that the body previously did not have?

The User and the New Stimuli

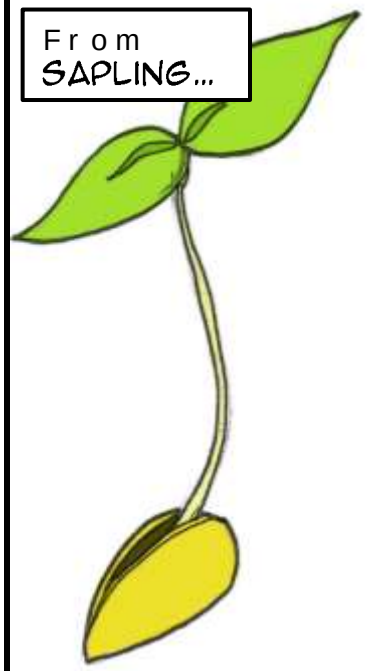
5. How accurate is the interpretation of data when experienced through new artificial senses?

6. Will there be feelings of "phantom sense"?

This is only the beginning

Design thinking

From SAPLING…



… TO TREE

What are the design principles and rules that we need to establish to create a new FIELD OF…

… ARTIFICIAL SENSORY INTERFACES

User Studies

i Proximity sensing:

Artificial experience with High redundancy

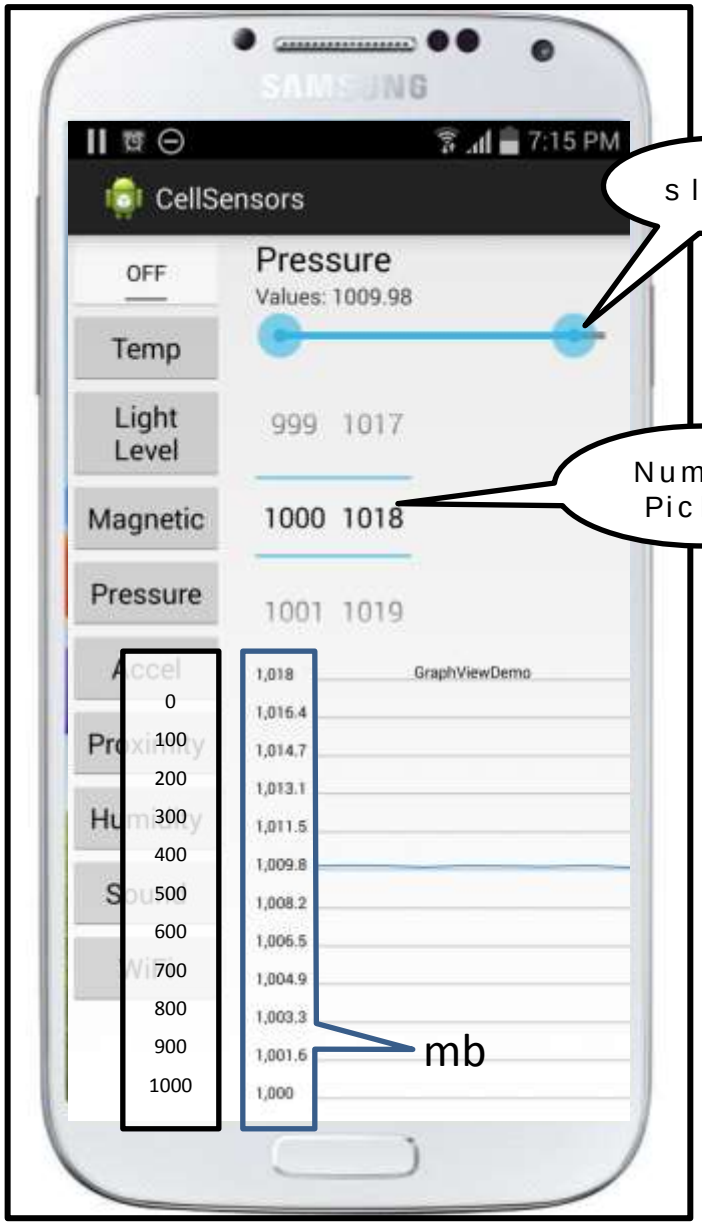
ii Temperature sensing:

Artificial sensory experience with no redundancy

iii Mobile sensors:

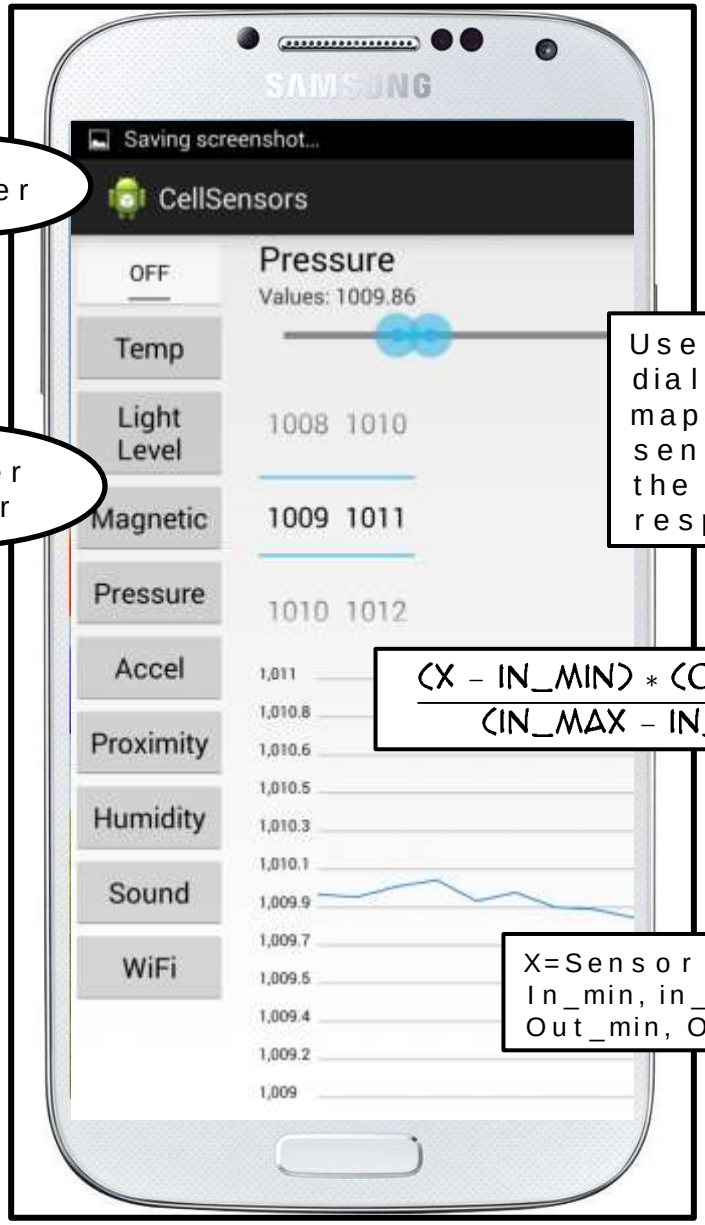
Artificial sensory experience with unknown context

Sensitivity Control



slider

Number Picker

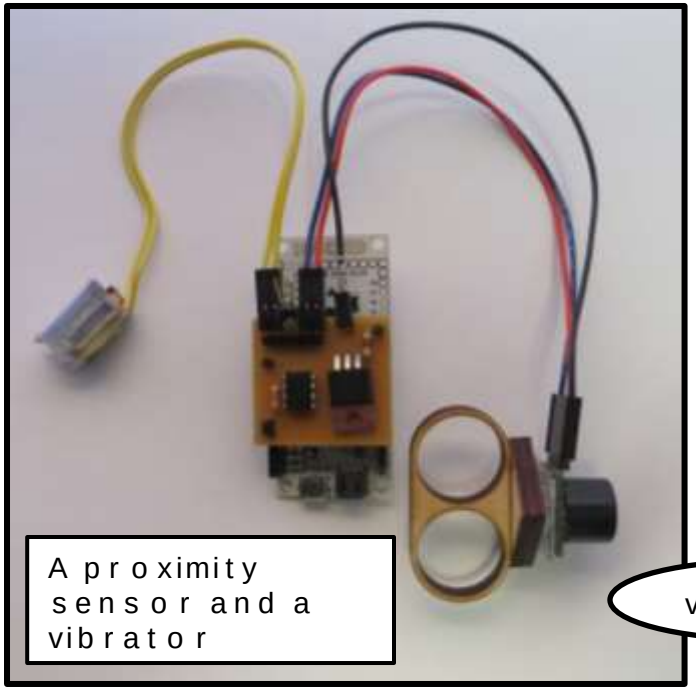


Use the sensitivity dial to change the mapping between the sensed signal and the frequency response

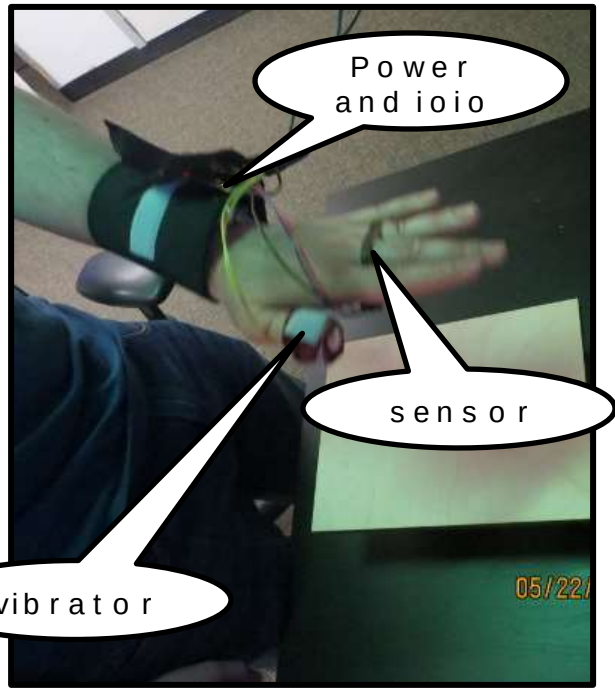
$$\frac{(X - IN\_MIN) * (OUT\_MAX - OUT\_MIN)}{(IN\_MAX - IN\_MIN) + OUT\_MIN}$$

X=Sensor Value
In_min, in_max = sensor range
Out_min, Out_max = 0, 1000

User study i: proximity

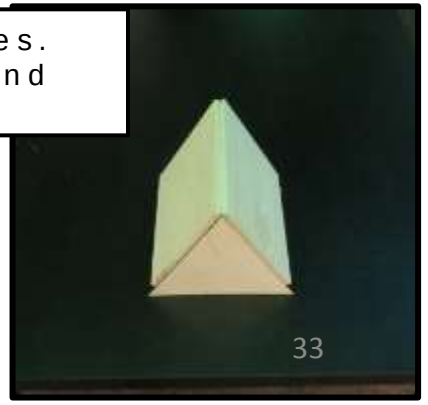


A proximity sensor and a vibrator

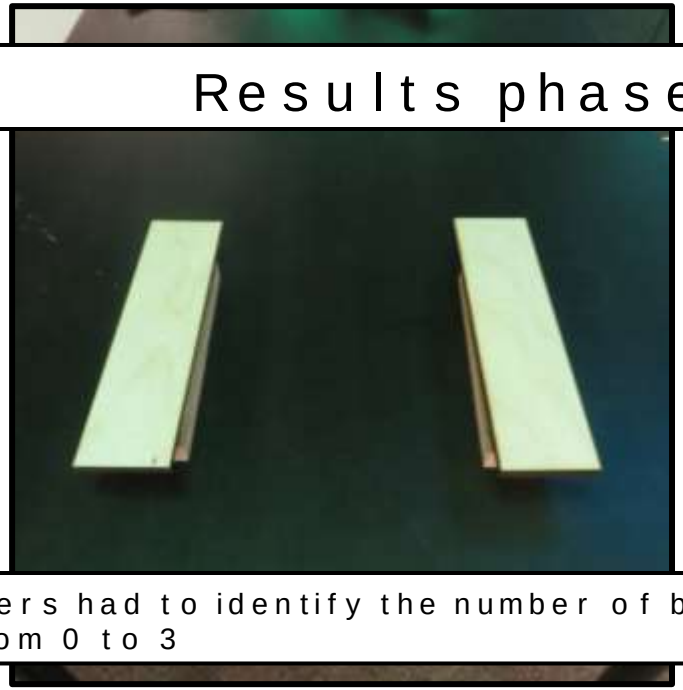


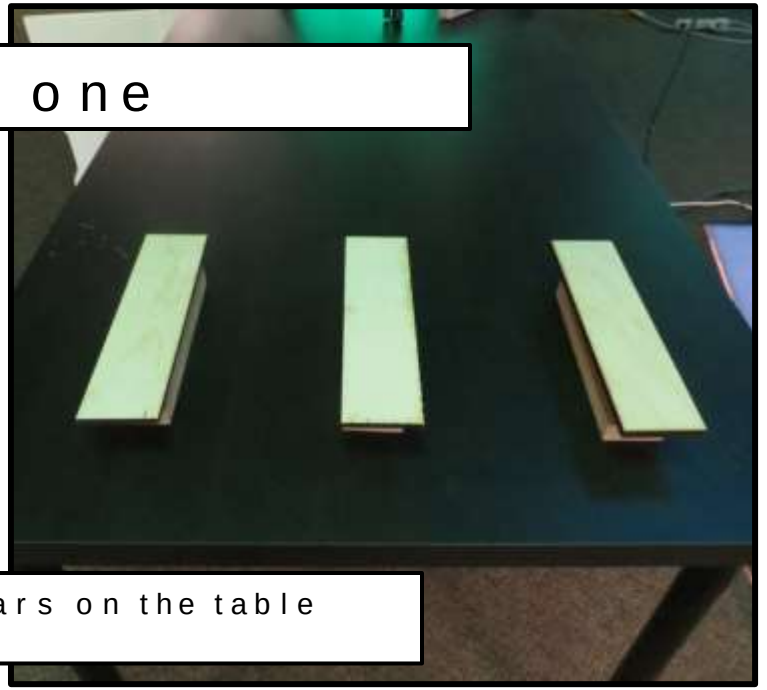
The user is asked to identify the number and shapes of the objects on the table

The task was done 3 times. With Bars, flat shapes and volumes.

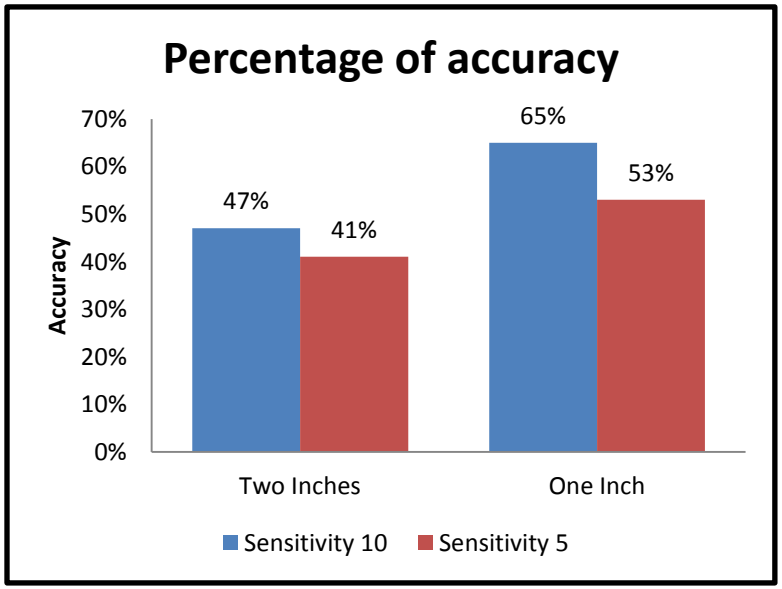


Results phase one



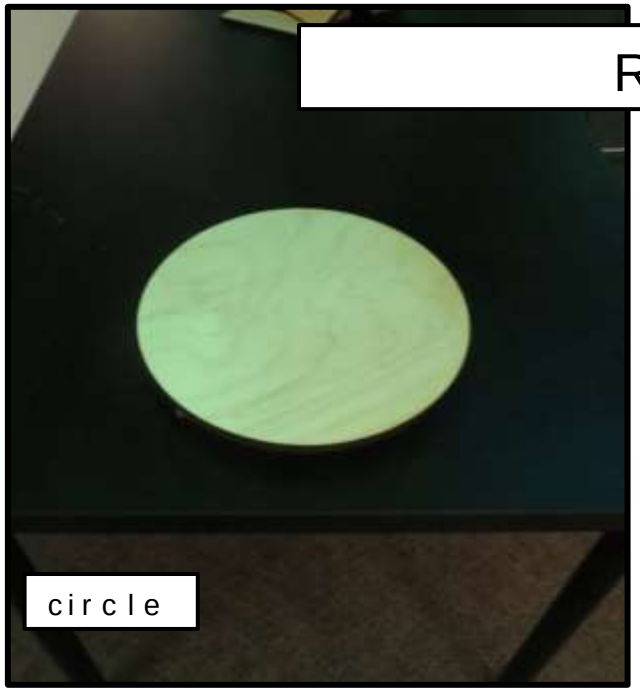


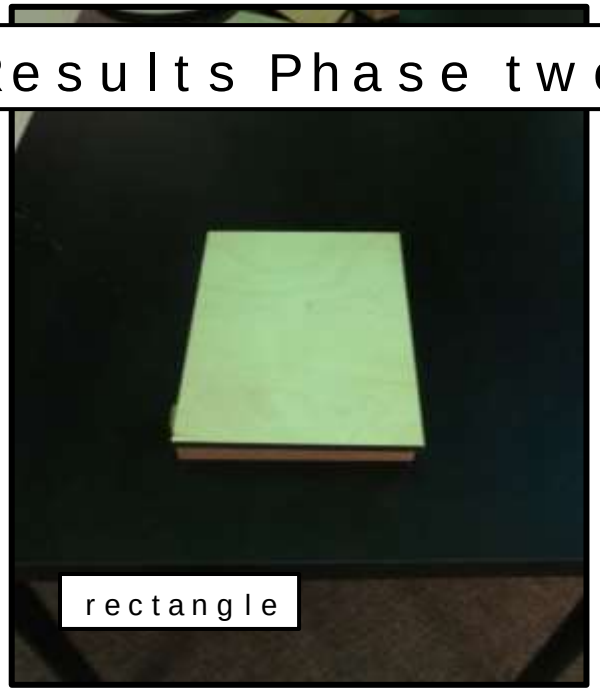
Users had to identify the number of bars on the table from 0 to 3

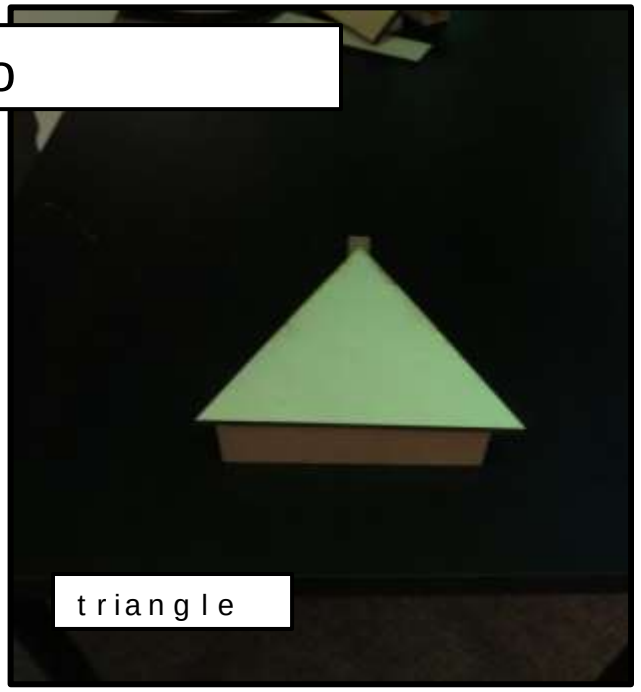


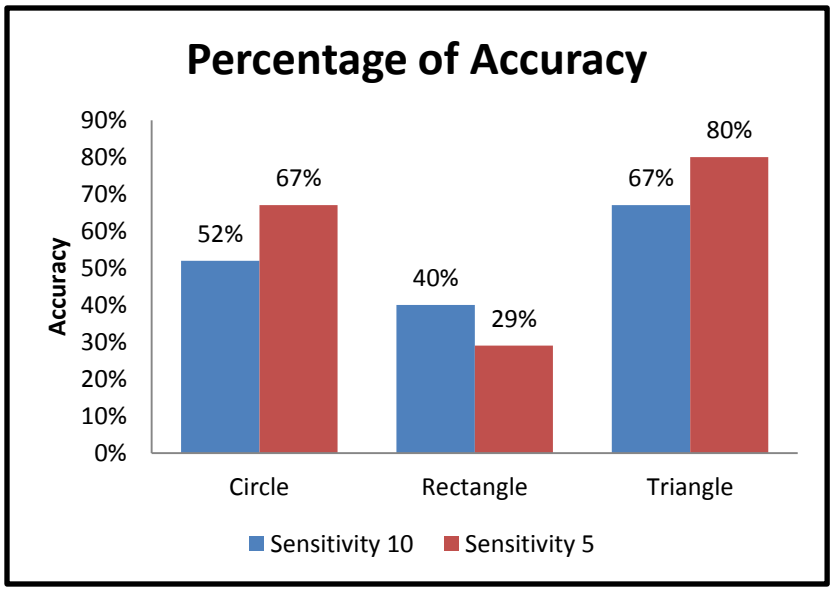
N= 17

Results Phase two



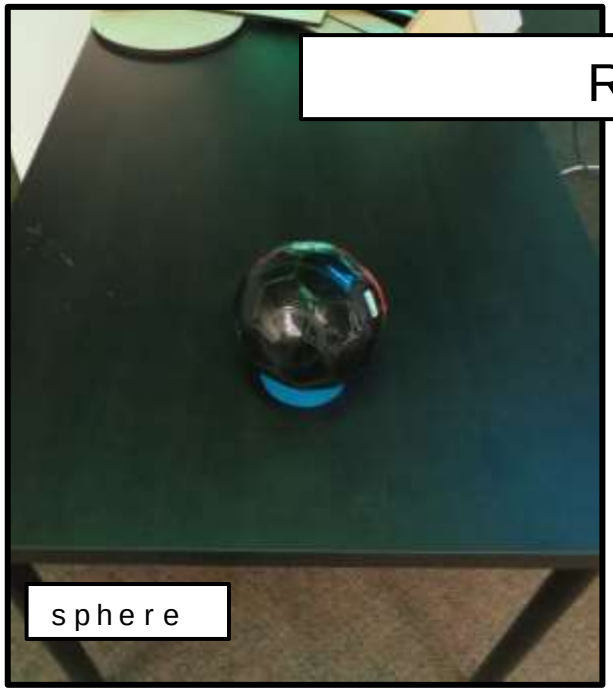


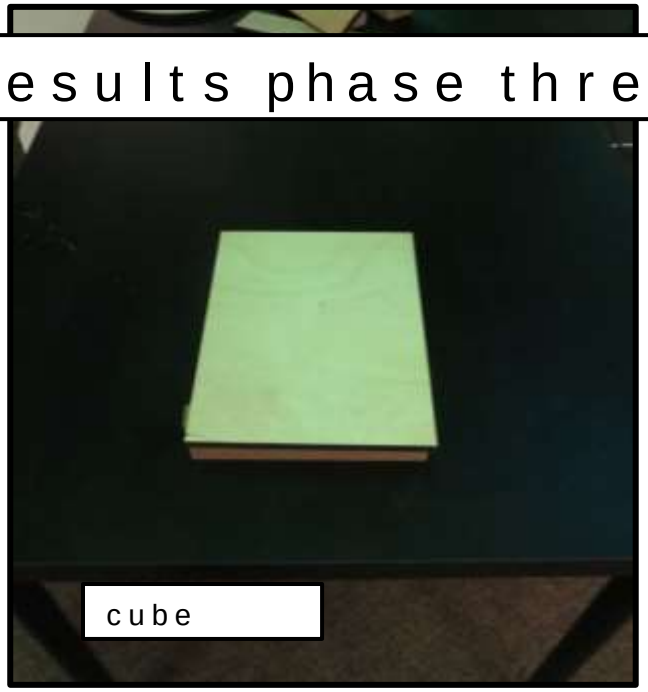


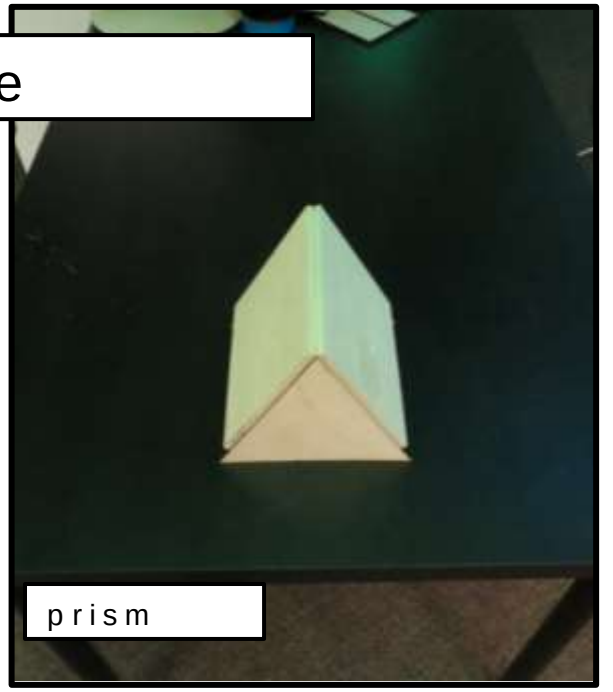


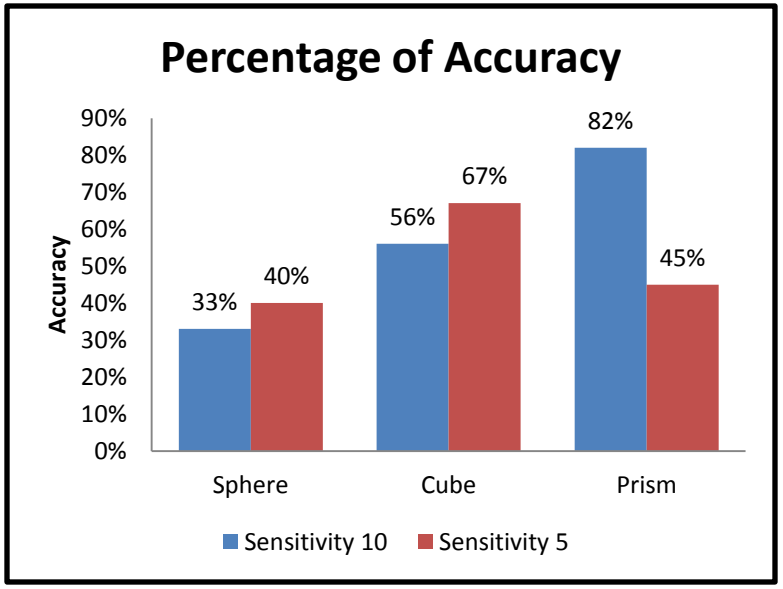
N = 17

Results phase three



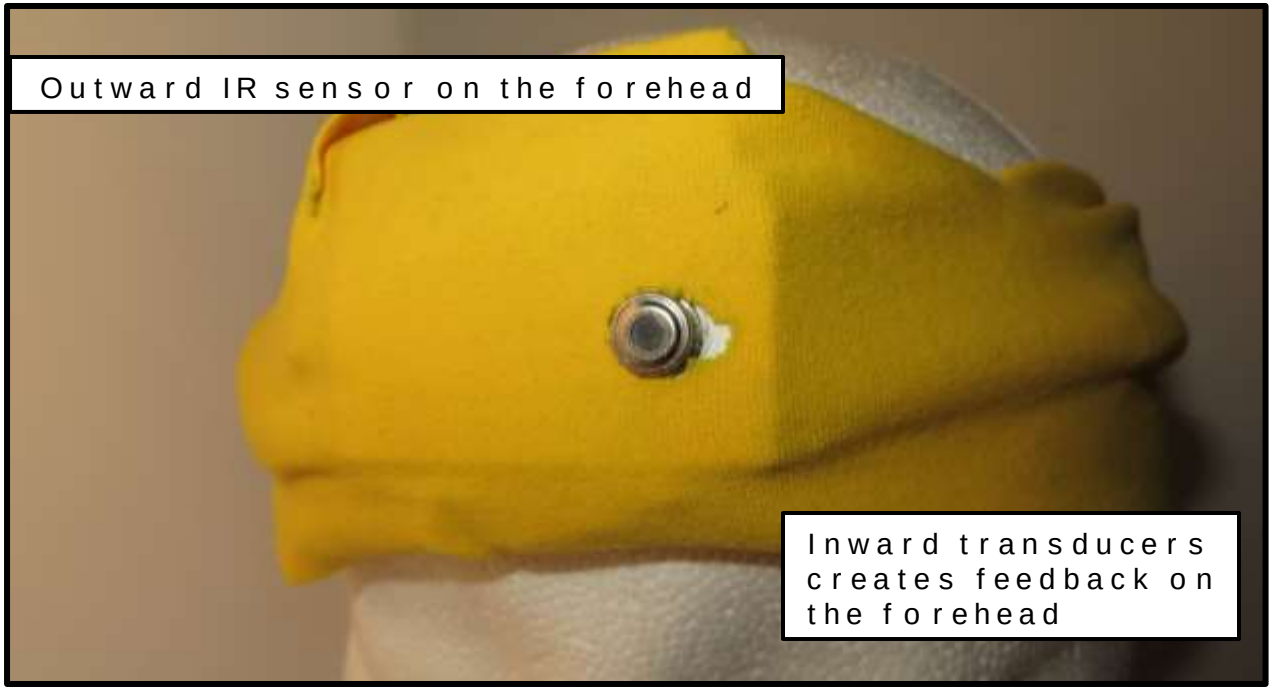


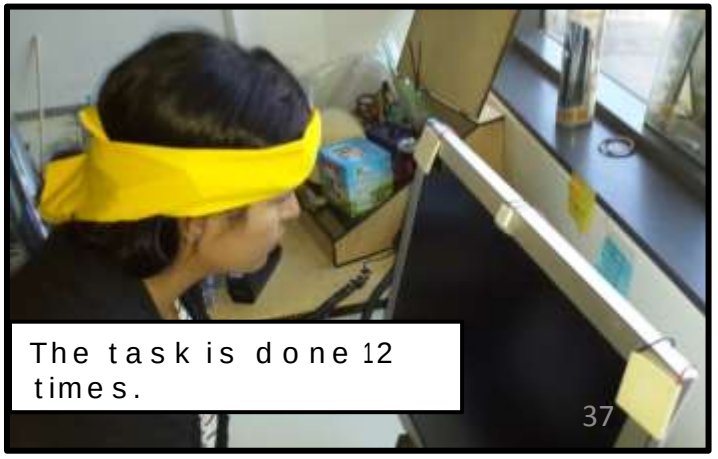




N= 17

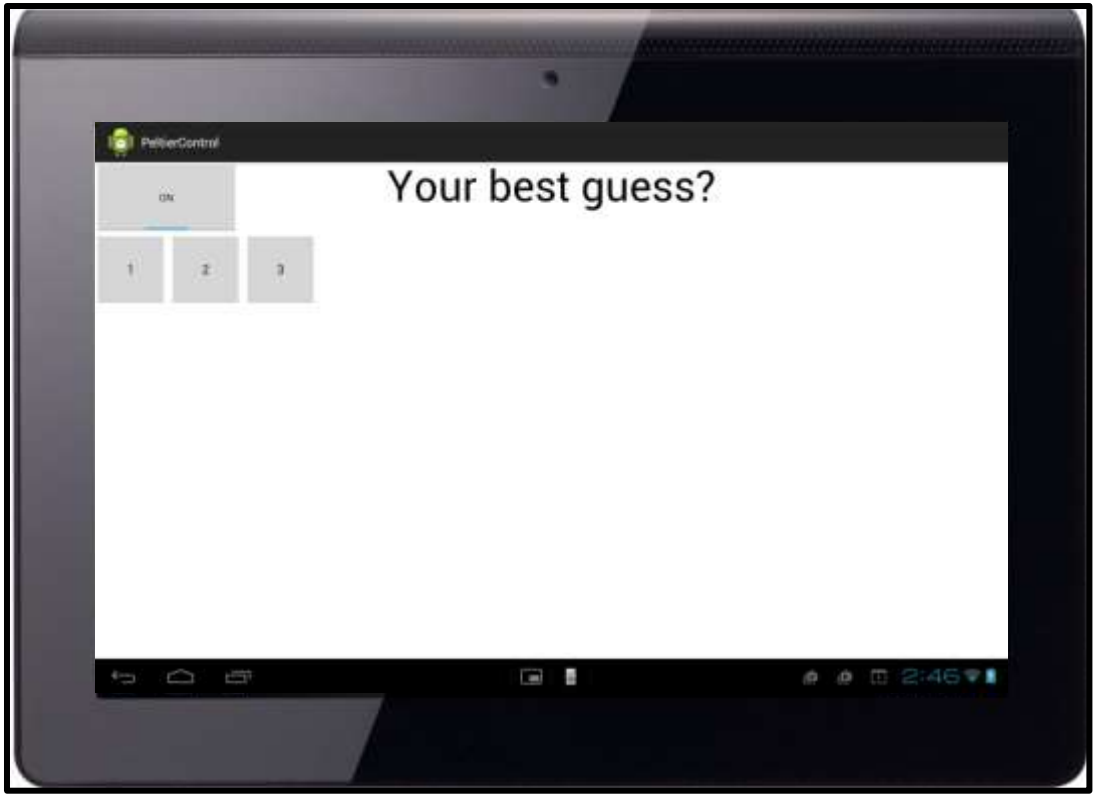
User study ii: Heat sensing



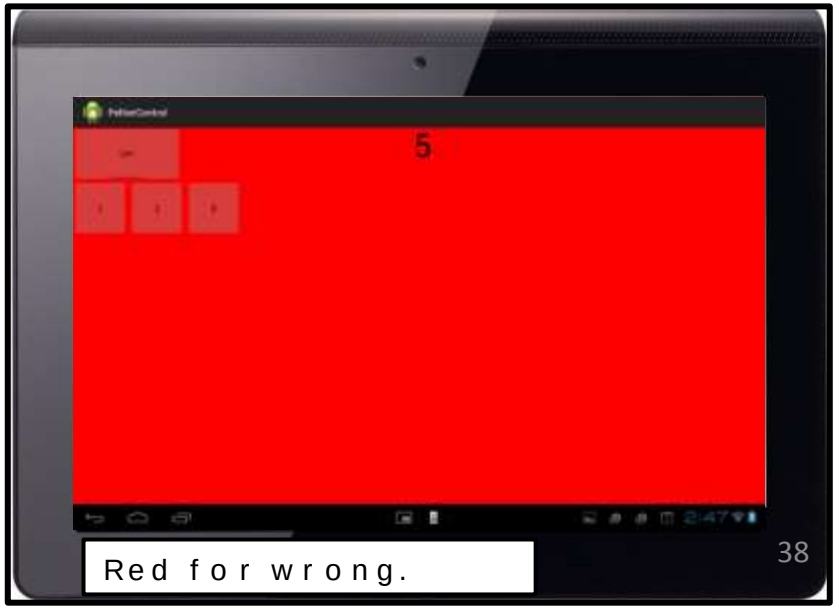


User study ii: Heat sensing

Main User Interface



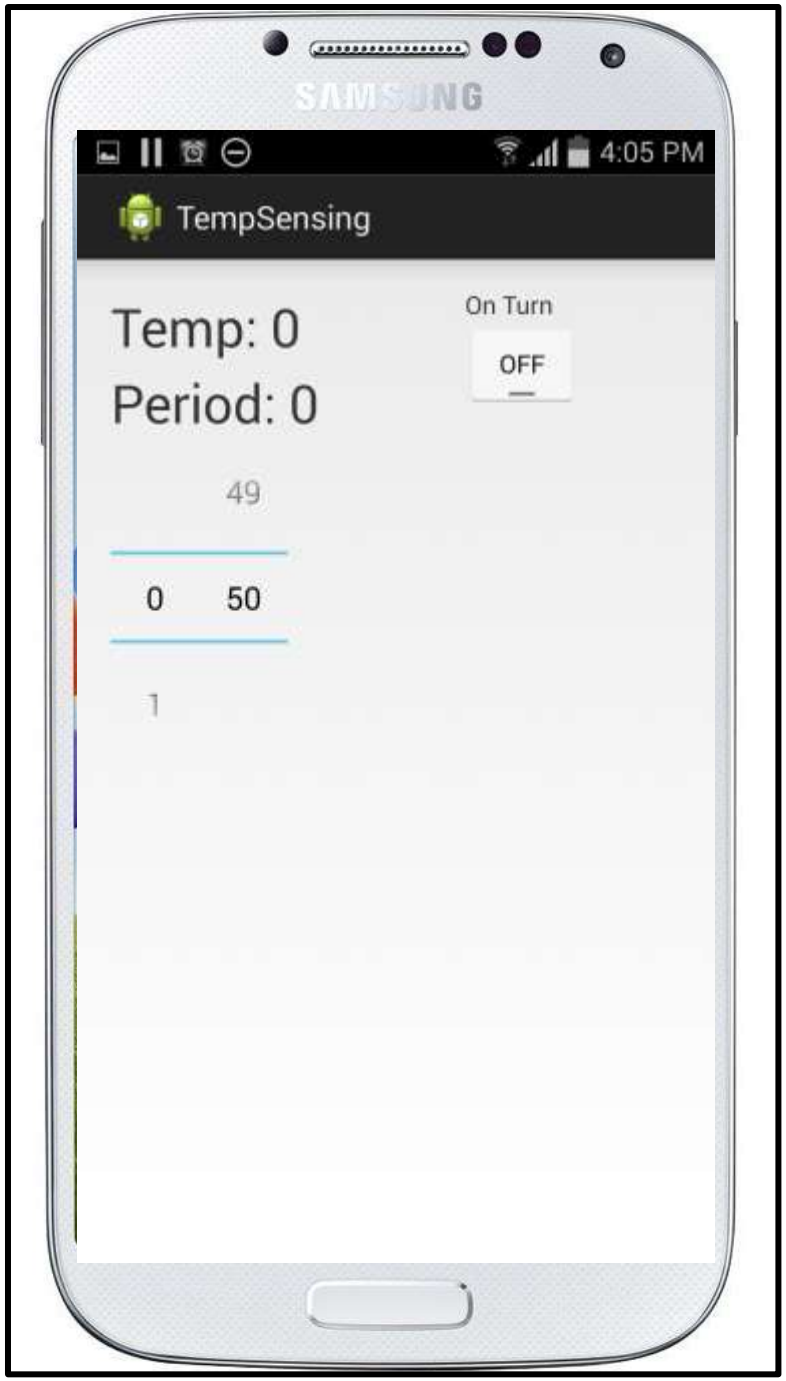
Visual feedback, green for CORRECT…



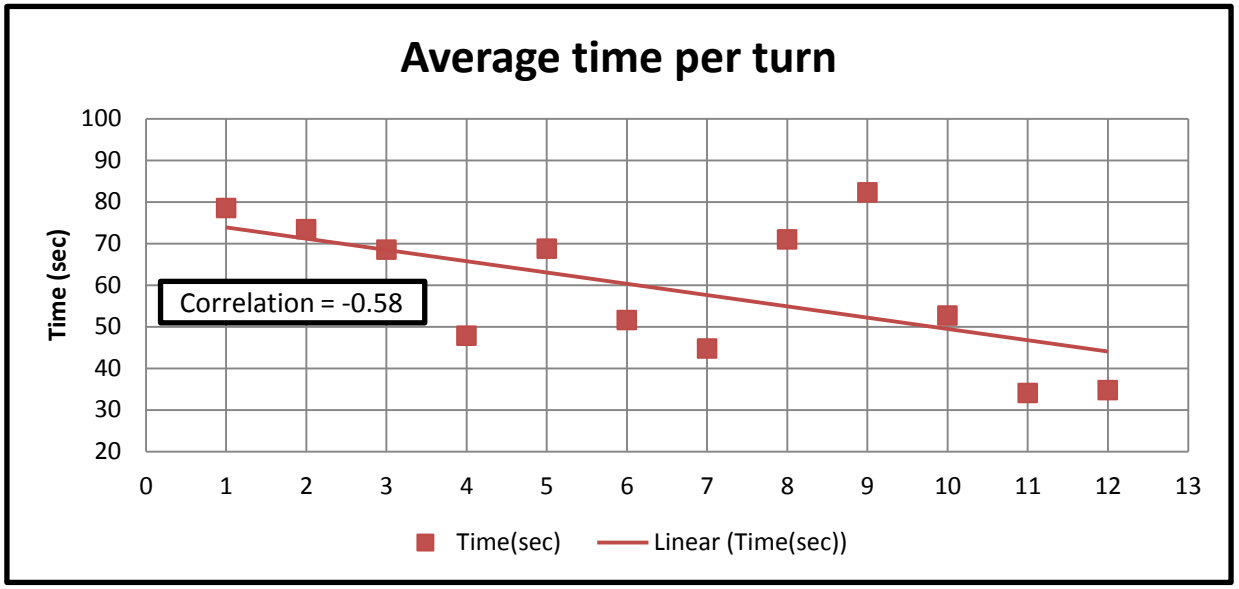
Red for wrong.

User study ii: Heat sensing

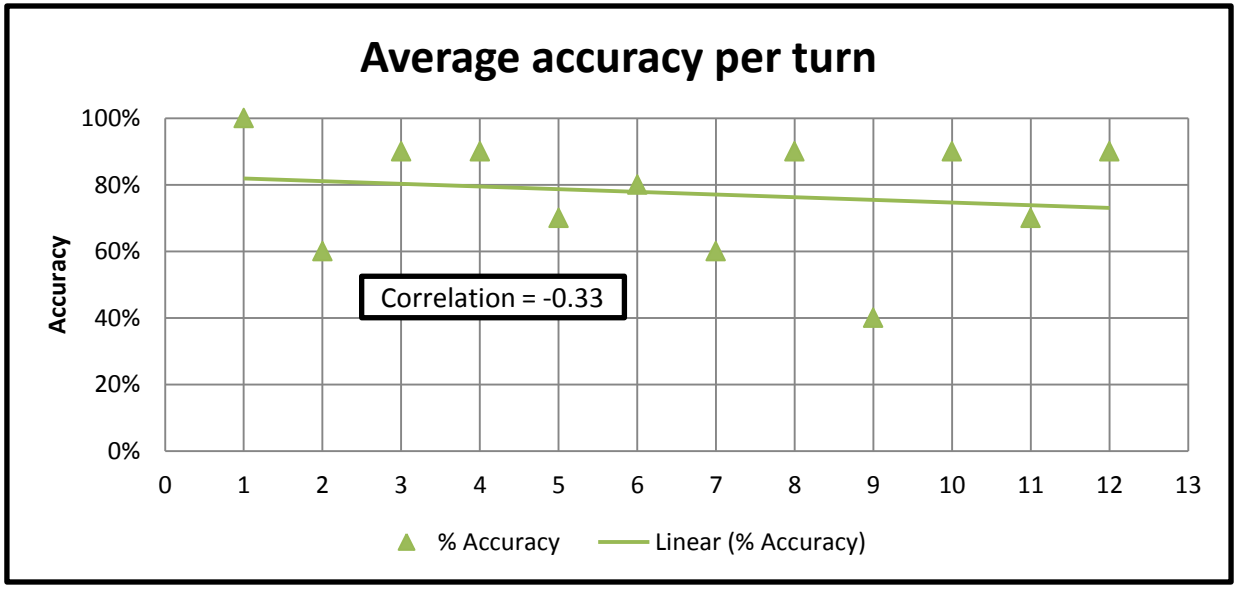
Second User Interface



Results of second user study



N= 15



Results of second user study

Average time of feedback Vs no feedback		
Feedback	Time(sec)	Accuracy
Feedback	57.99	80
No Feedback	59.93	75

Time with or without feedback through the study averages out to roughly the same.

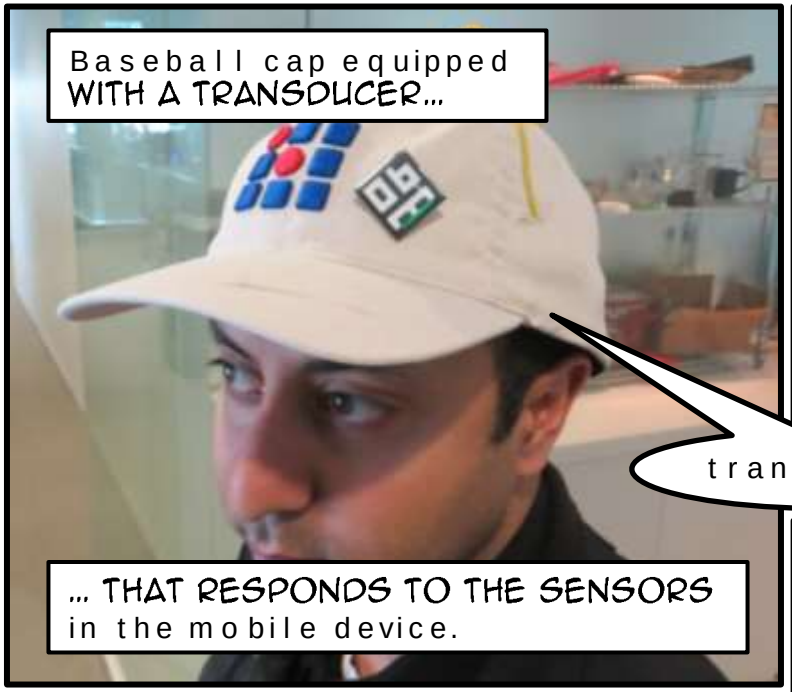
Accuracy is slightly higher with feedback

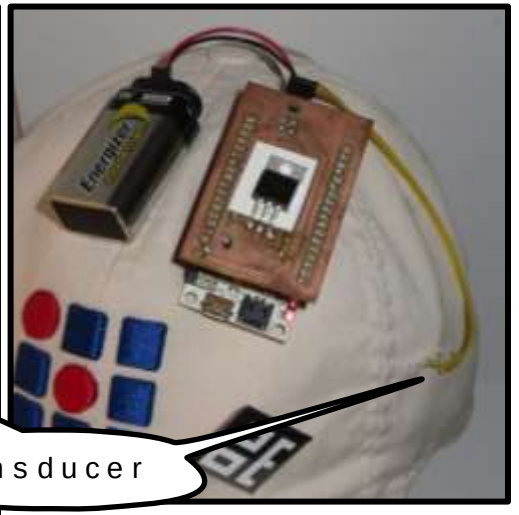
Time and Accuracy of the last 6 turns, with and without feedback		
Feedback	Time(sec)	Accuracy
No feedback	58.01	66.67
Feedback	45.95	83.33

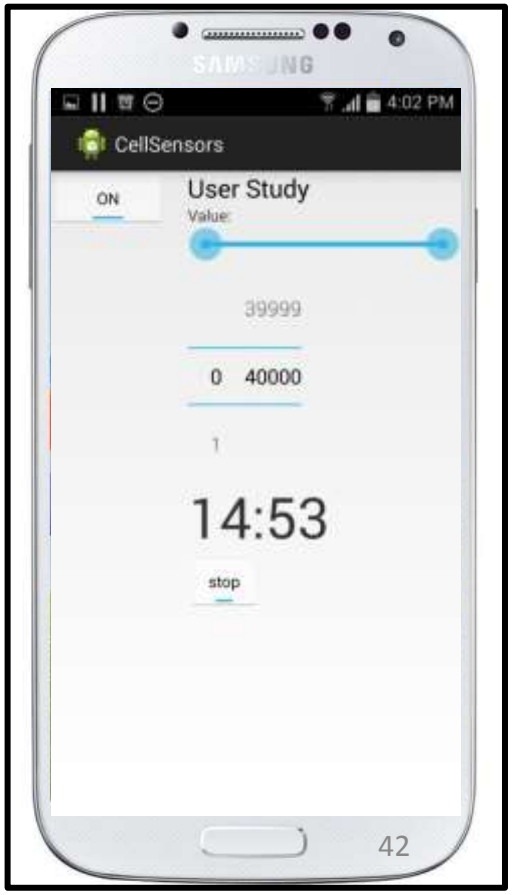
Time with feedback was significantly shorter

Accuracy is significantly higher with feedback

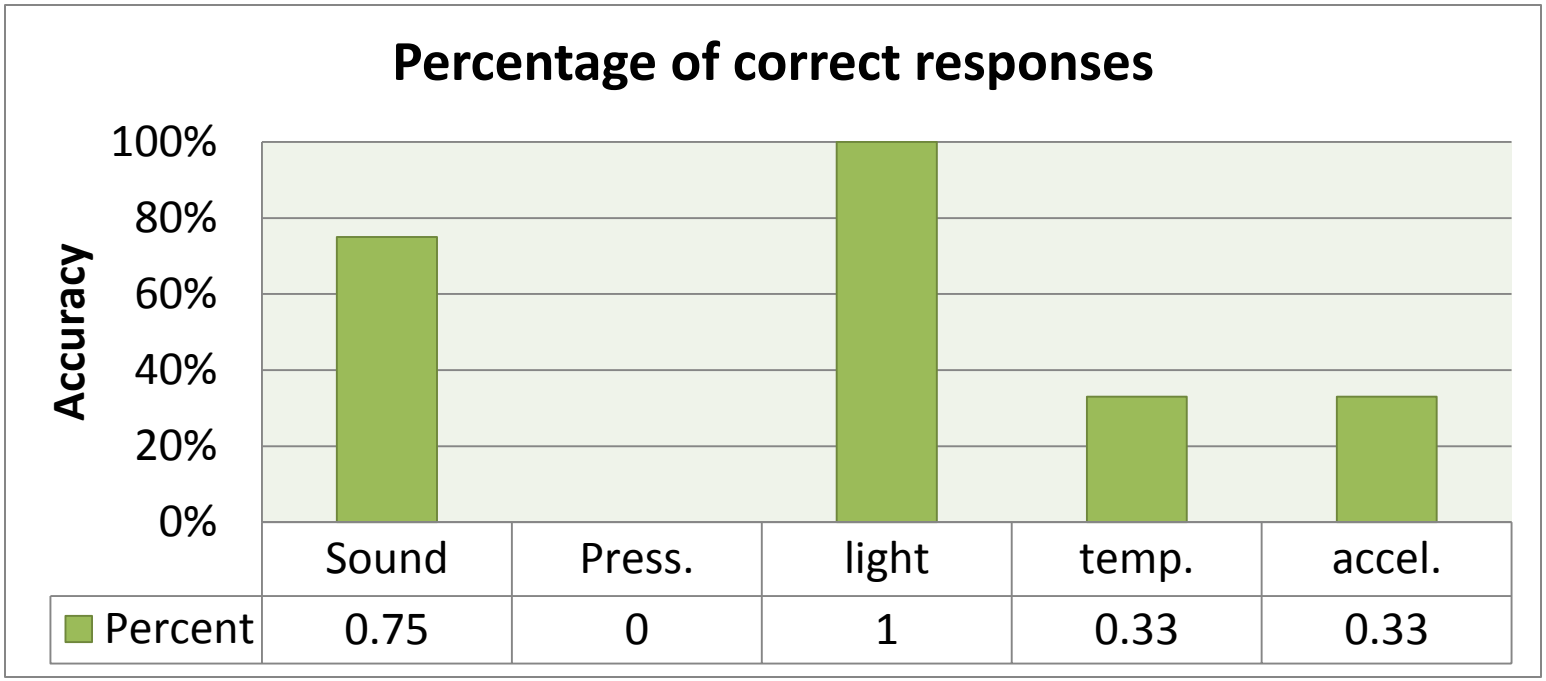
User study iii: Cell sensors







Results of third user study



N= 17

The wrong responses		
Sensor	**Response**	**N=**
Sound	Wind or weather related	4
Pressure	Has to do with the stairs. Shape, Distance or Materials	4
Temperature	No Idea	3
Accelerometer	Screens or Bluish light	3

Other Studies

Smell Explorations

A gaming Scenario

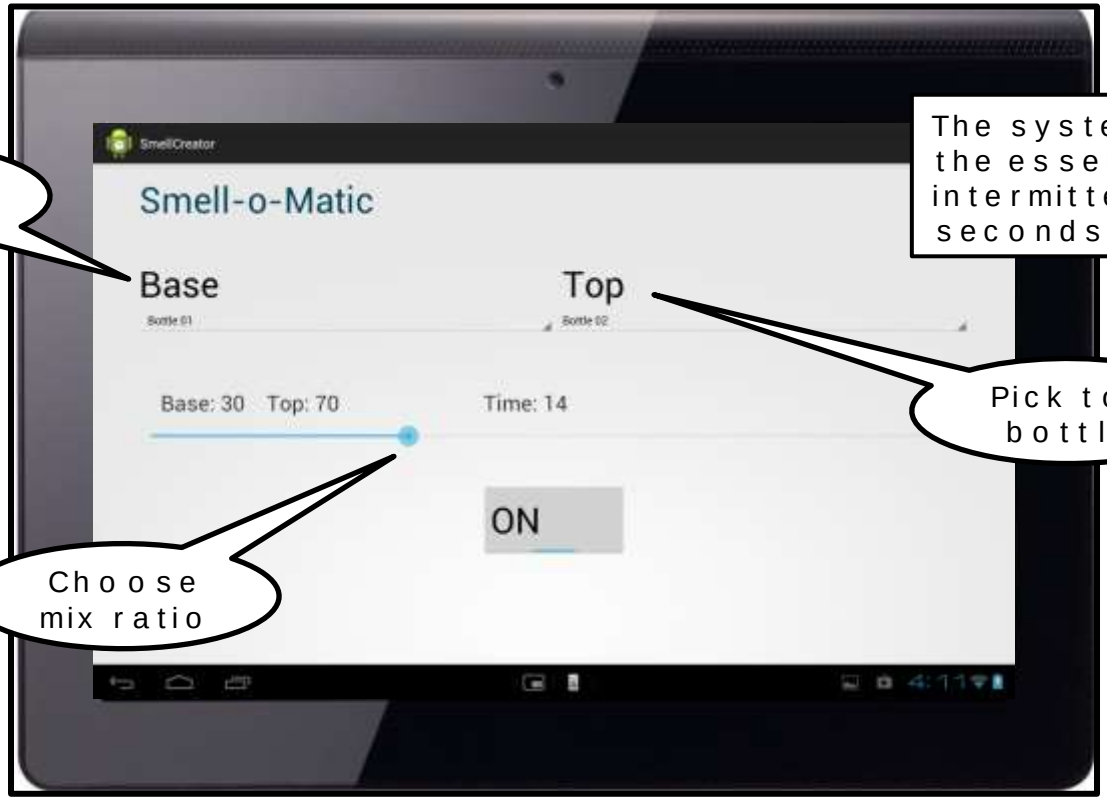
Temperature as output

Smell experiences i: foodcam

An off-the-shelf automatic air freshener Is modified to respond to the foodcam feed

Smell experiences ii: Smell mixer

Following principles of perfumery we created a smell mixing device.



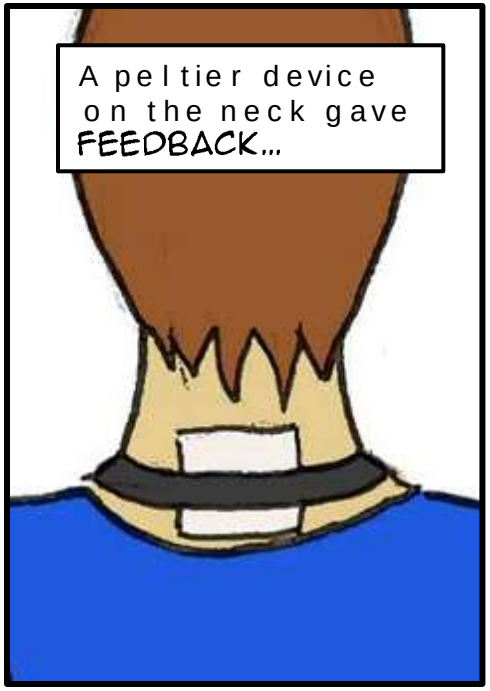
Pick Base bottle

Pick top bottle

Choose mix ratio

The system will activate the essential oils intermittently during 20 seconds.

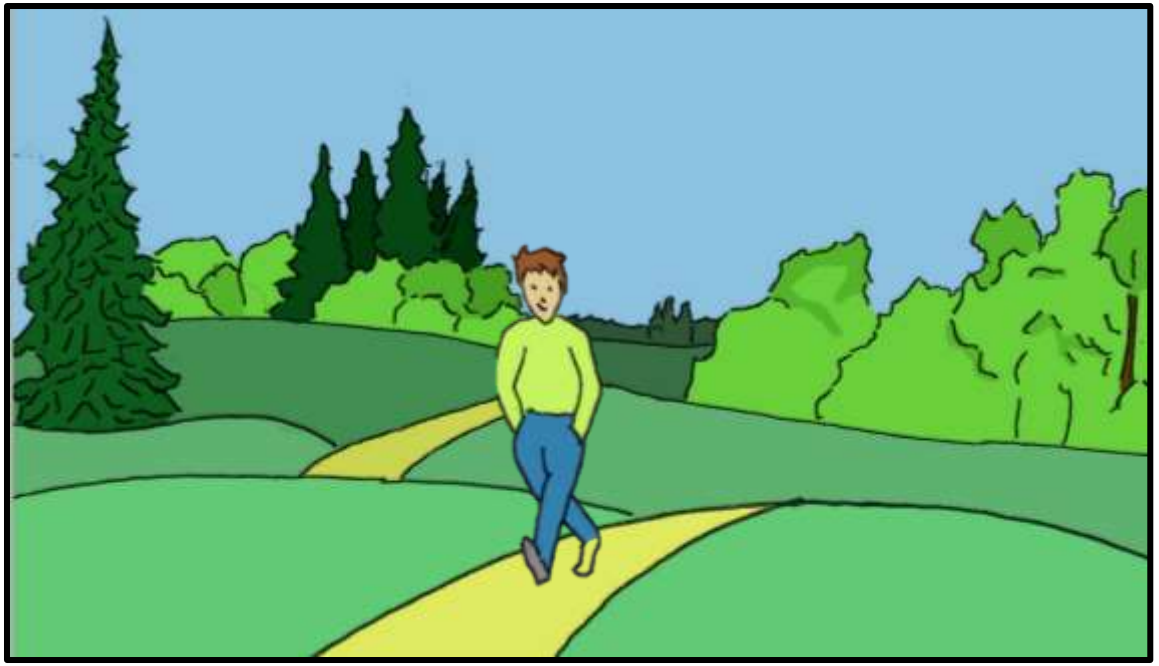
Temperature as feedback



Design thinking

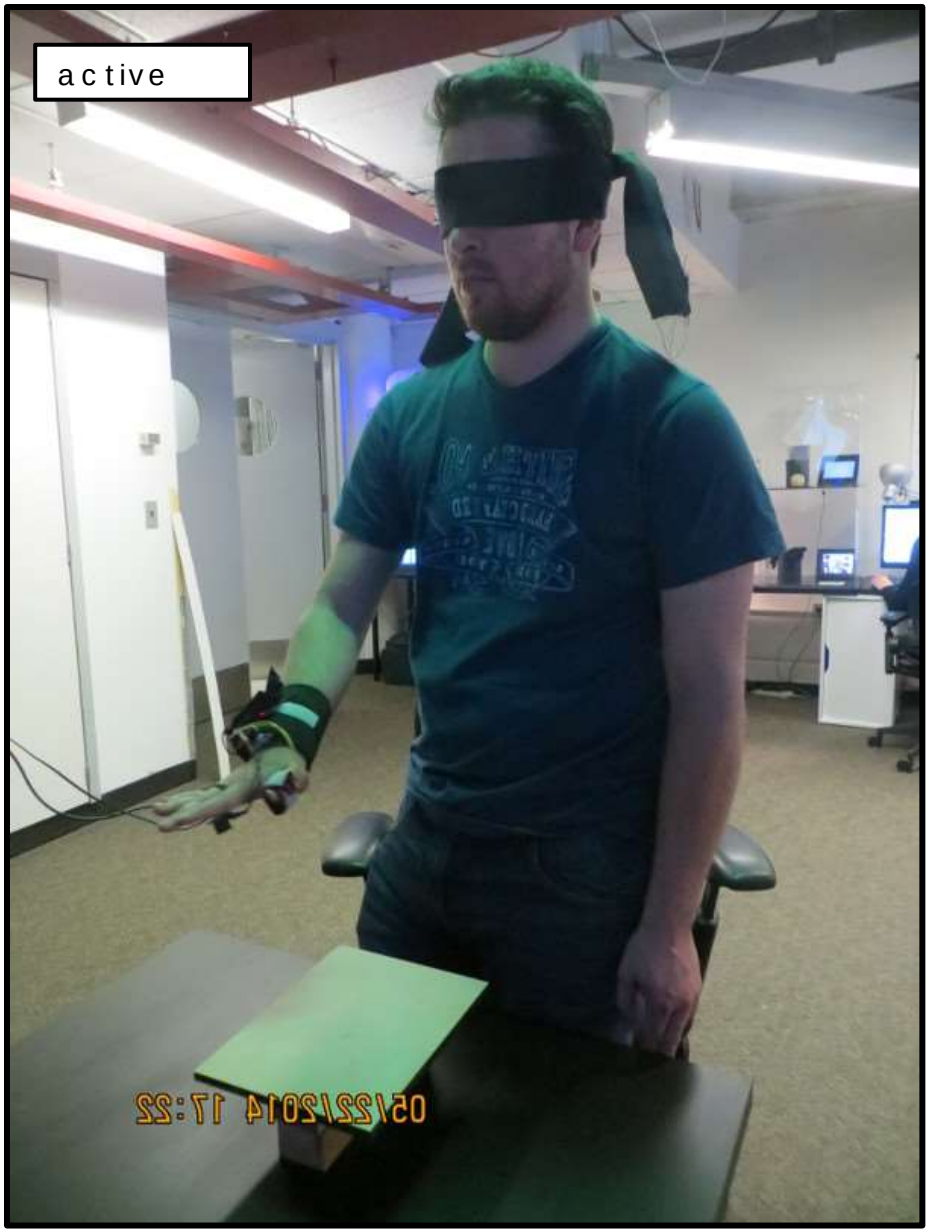
Design Thinking

1. What is the Main Activity?



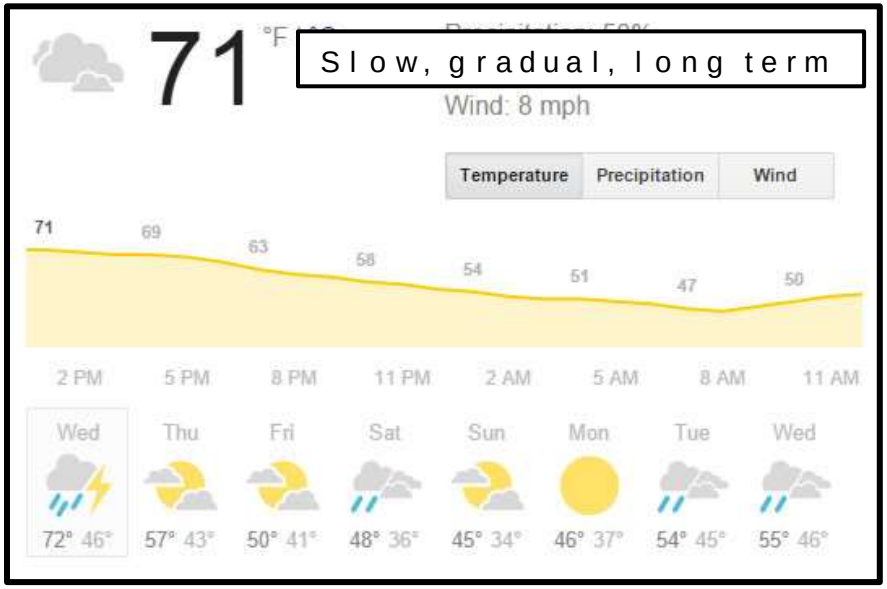
Design Thinking

2. what type of sensing experience will be created?



Design Thinking

3. What kind of signal are we tracking?



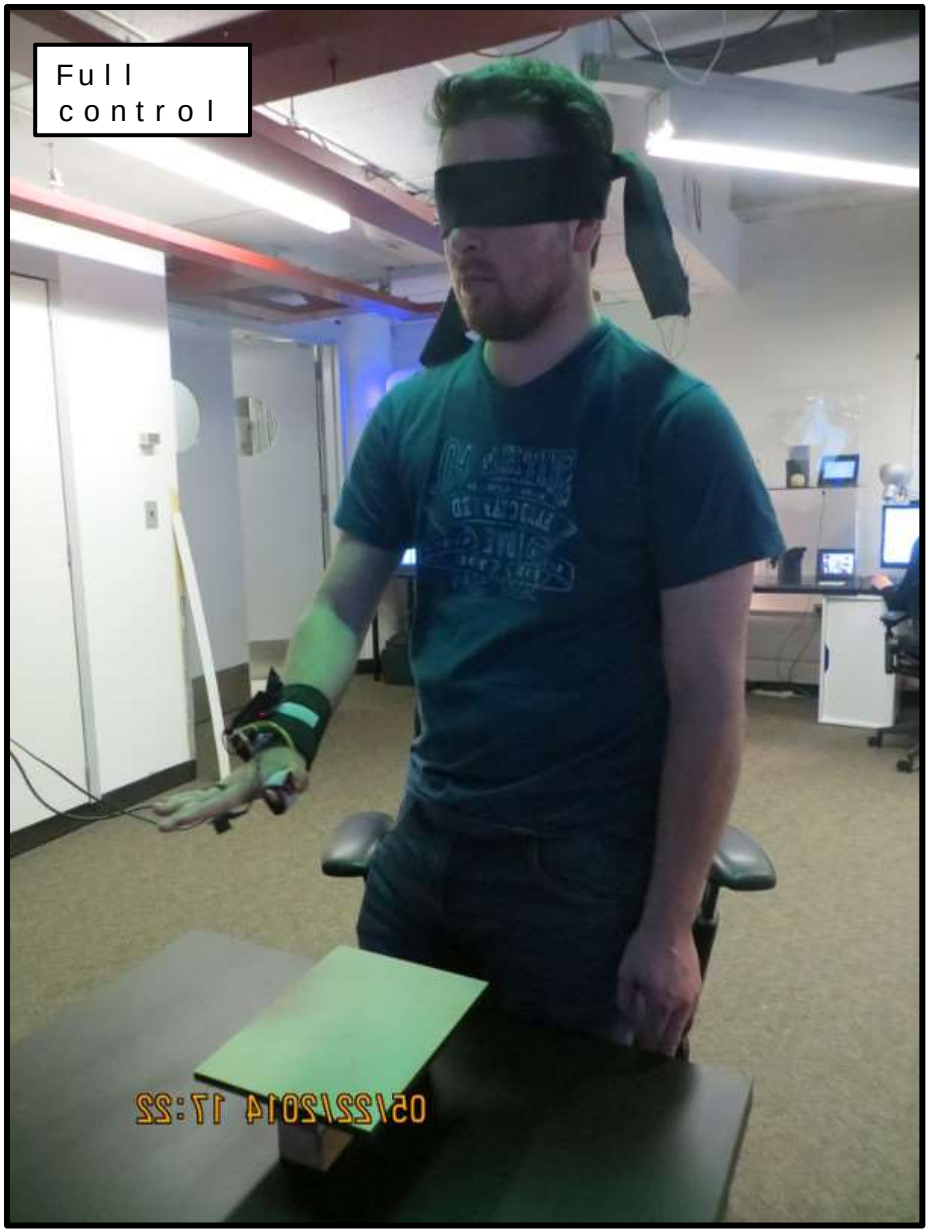
Slow, gradual, long term

Choppy but long term

Smooth but needs constant attention

Design Thinking

4. what control does the user have over the signal?



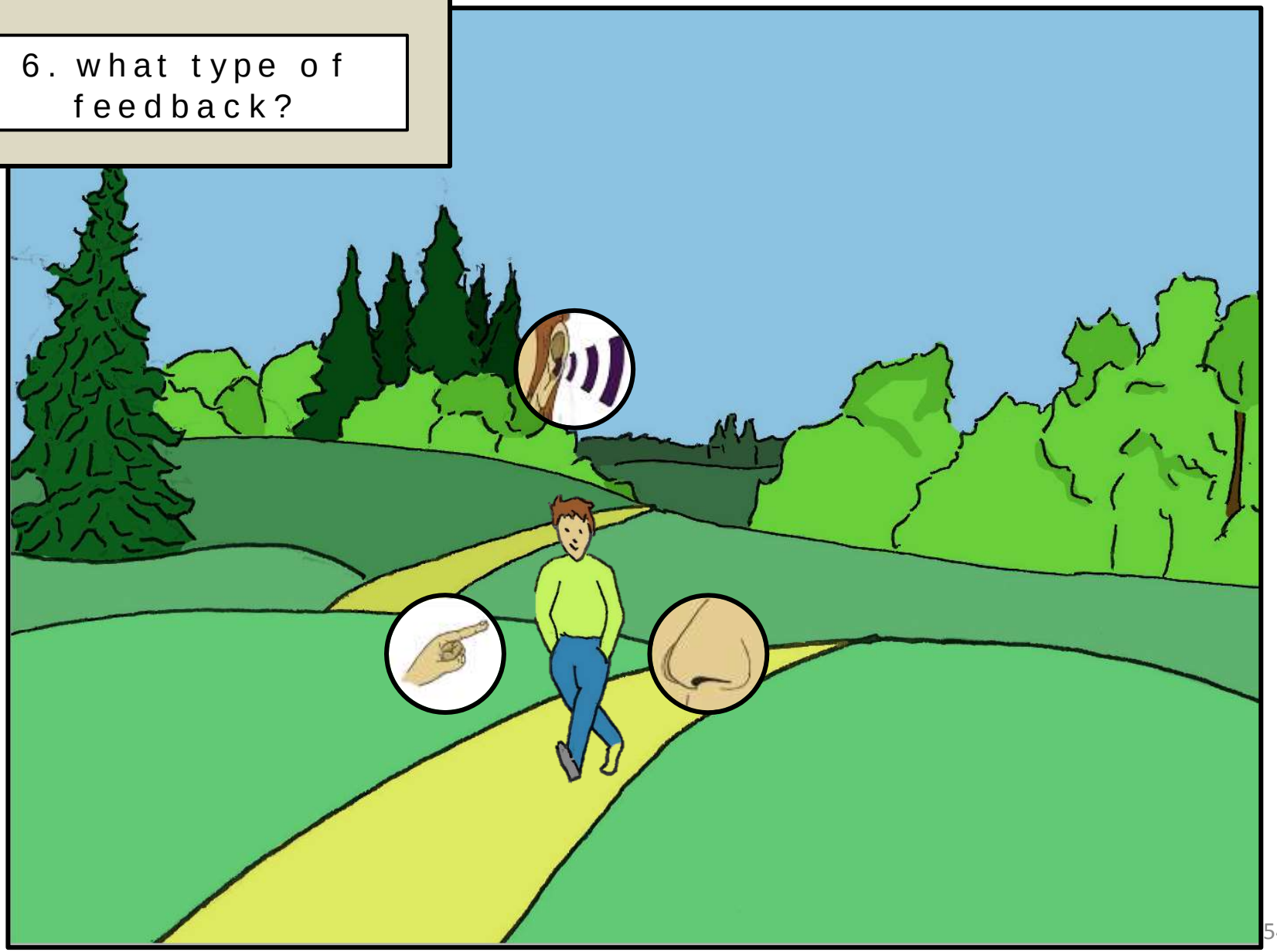
Design Thinking

5. Are there any redundancies?

Redundancies help with learning and accommodation

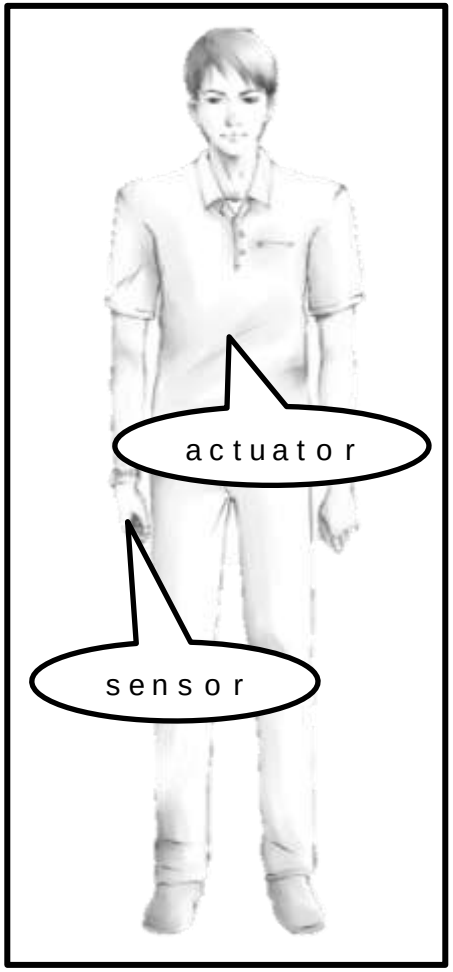
Design Thinking

6. what type of feedback?

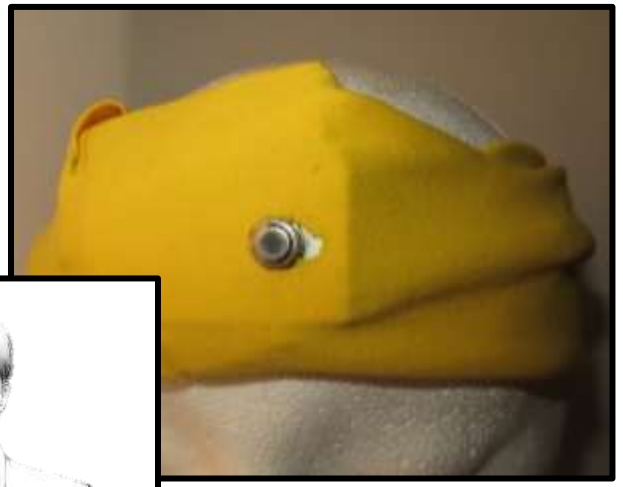


Design Thinking

7. Where to locate the sensors and actuators?



If the user can see the sensor, the sensor and actuator can be separate and independent



IF THE USER CAN'T see the sensor, the sensor and actuator must be in the same place

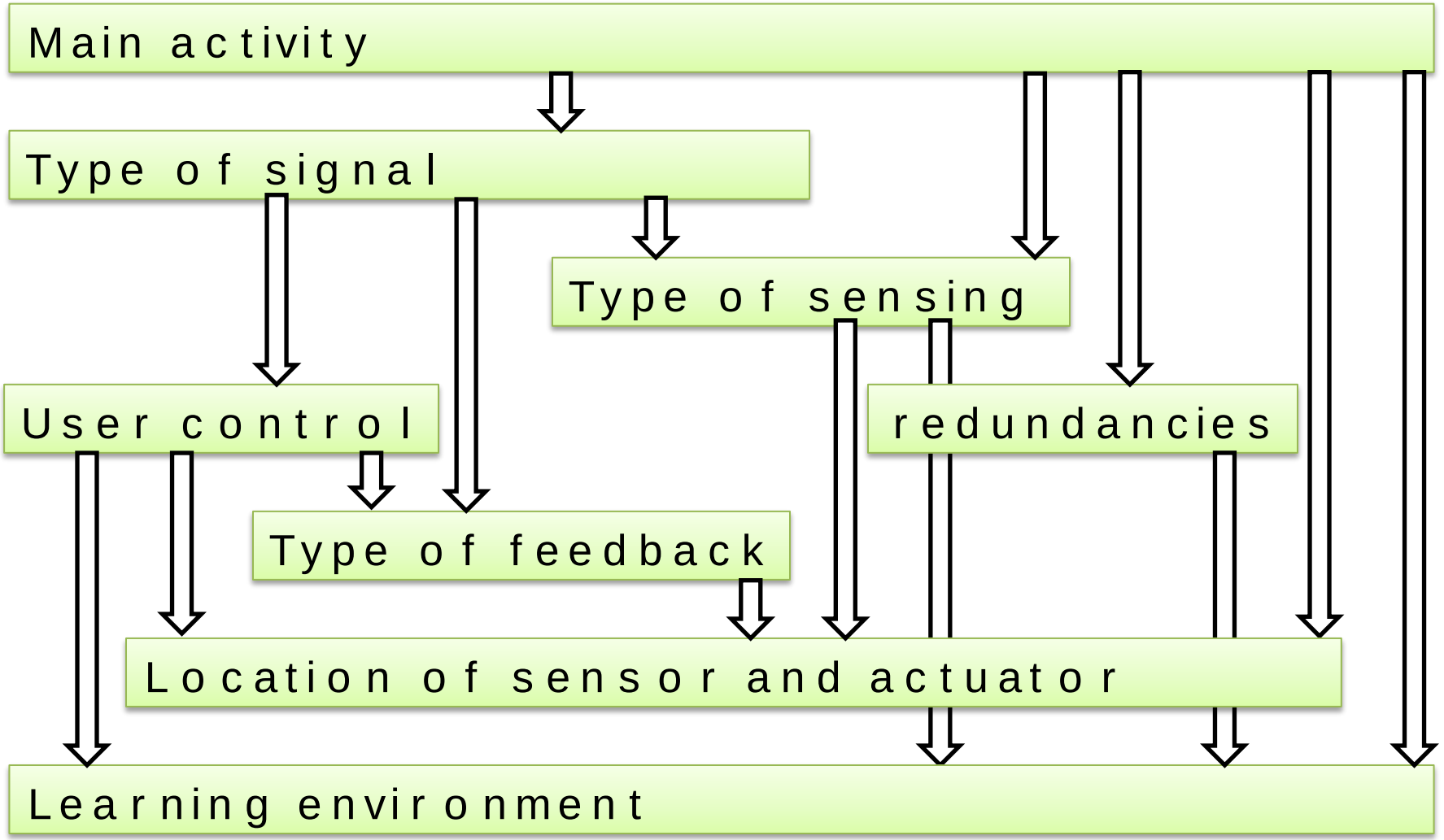
Design Thinking

8. Can we set up a learning environment?

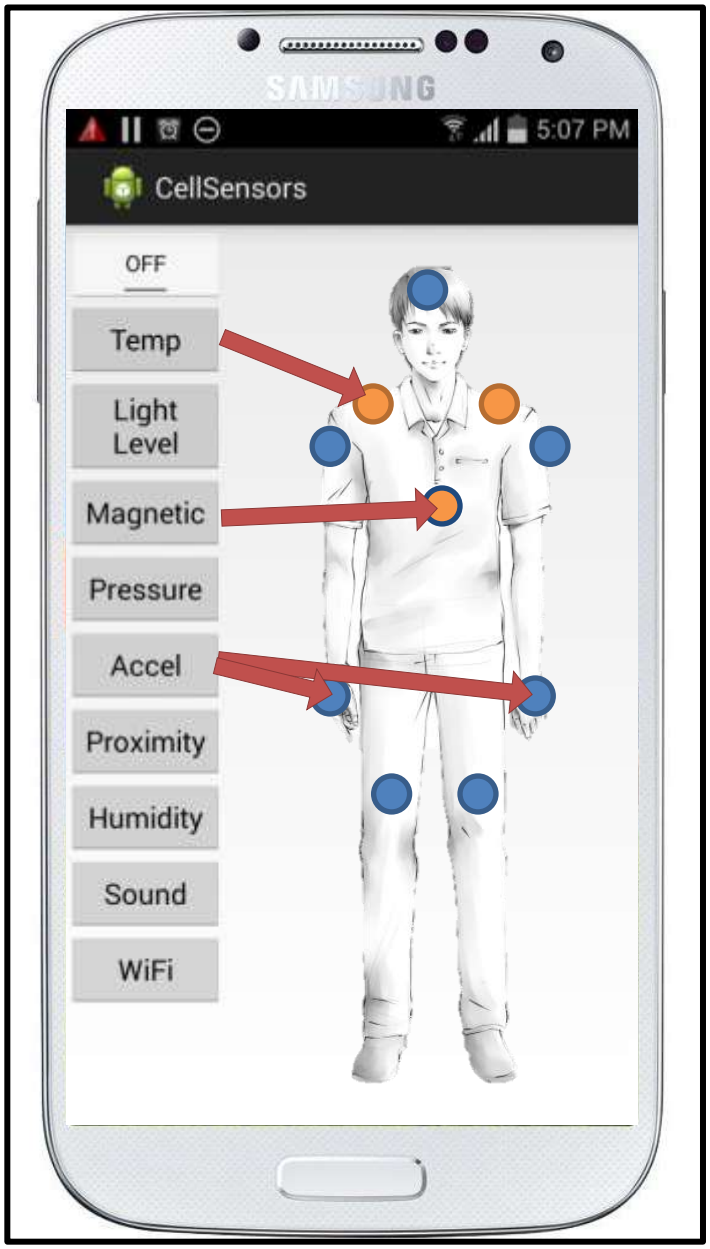
A hands on training with redundant artificial sensors

Real situation with artificial sensor only

Design Thinking

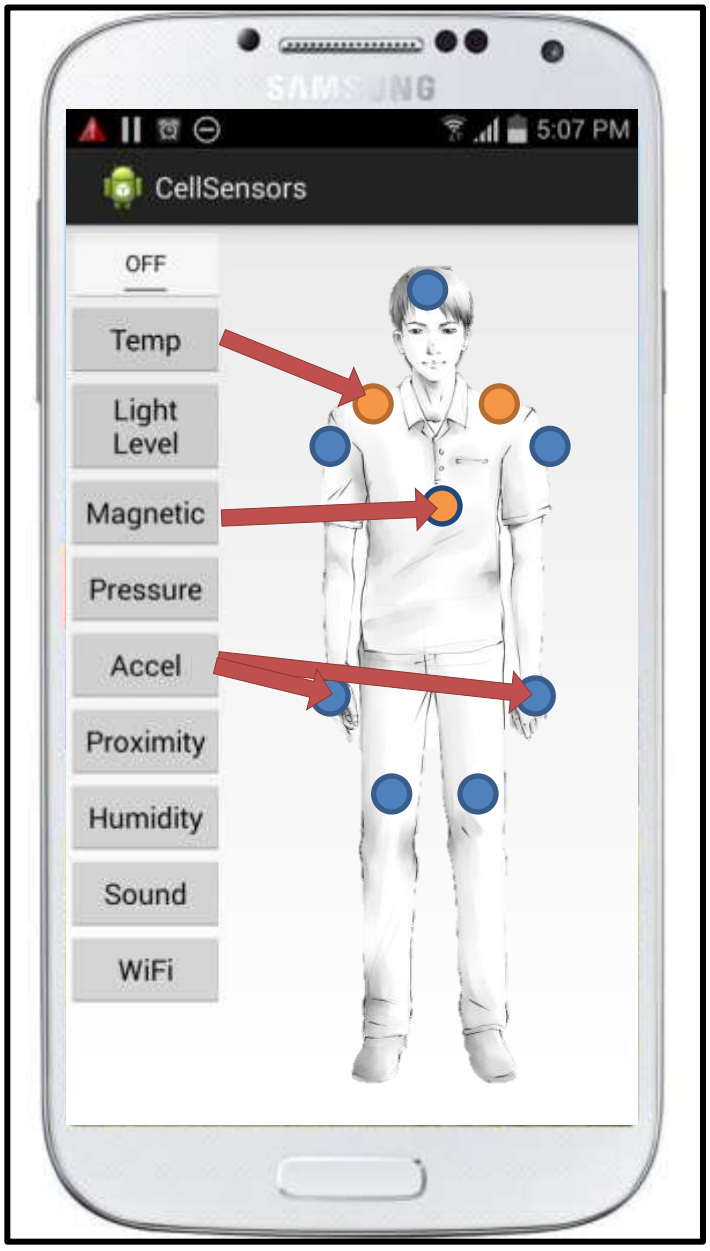


Future vision



Mobile app that will allow for connecting different sensors to actuators on your body.

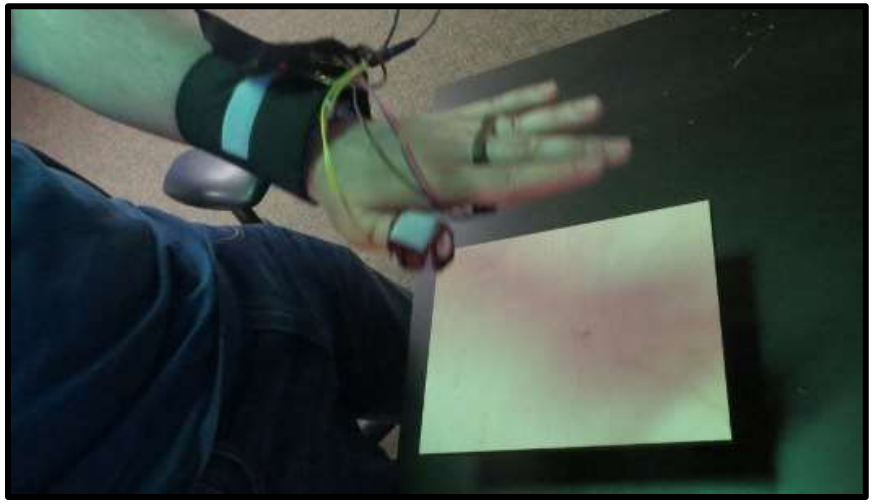
Future vision



Specialized garments will come with both sensors and actuators ready to be controlled and connected with the mobile device

Future vision

The creation of sensory experiences in the virtual world will be enforced by training in the physical world



contributions

Proven that a user can accurately use an artificial sense with a short time to learn it

Shown the ability of the brain to overcome issues with the quality of the signal or the hardware.

Shown that digital synesthesia will be a feasible interaction paradigm for a general user group

Established a set of recommendations for the implementation of artificial sensory interfaces

The end

THANK YOU...

Questions?