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Ergonomic Communication in Human-Robot-Interactions

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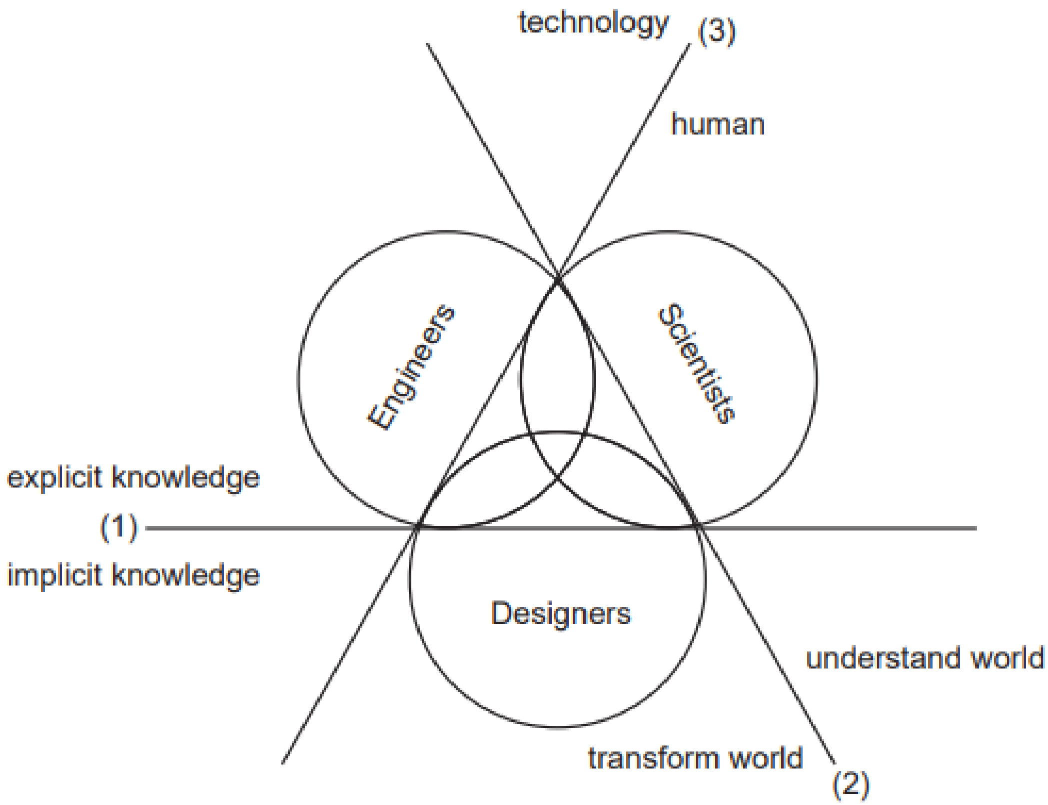
DEPARTMENT OF ARTIFICIAL INTELLIGENCE

HRI

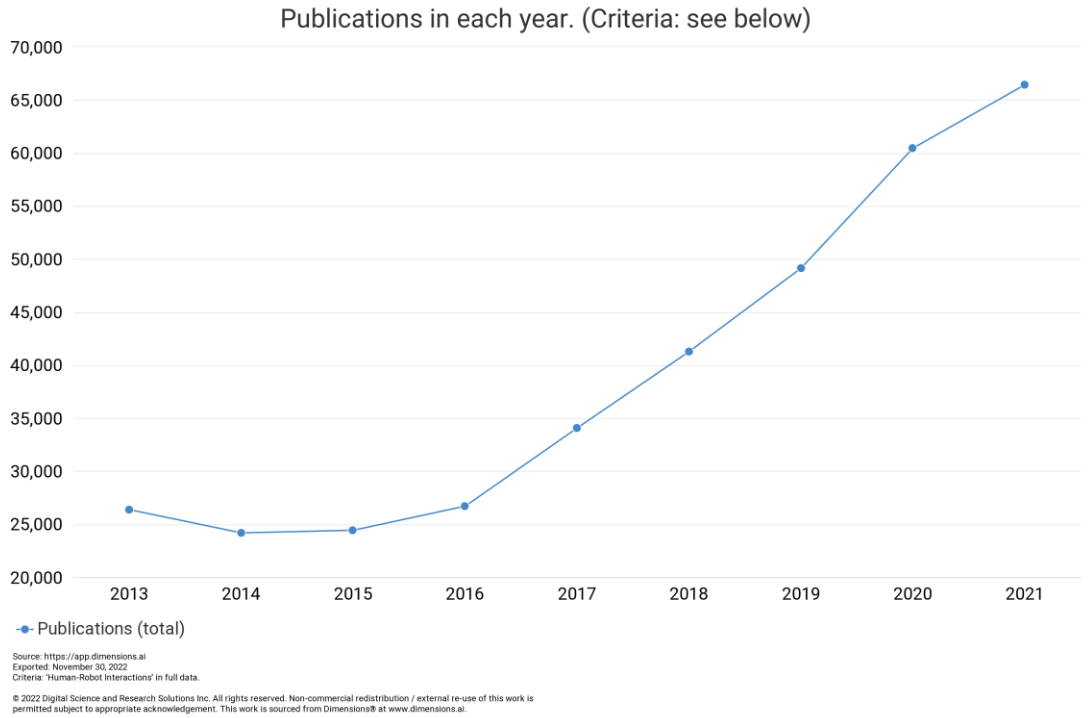
- HRI is a multidisciplinary, problem-based field
  - Mostly interested in *social robots*
  - First mention of social robot was used to describe a person that is cold and distant personality.
  - In robotics (in 1978) in the Interface Age magazine



Establishment a harmonic collaboration

- Recently higher interest

- Goal is to establish a more ergonomic / human like cooperation in human-robot teams



Source: dimensions.ai

Collaborative robots

- „By definition safe" **(physically)**
- In a collaborative cell there is no need of fences

  → Less space needed for one cell
- Increasing usage and number of applications in industrial settings
- The usage of cobots can lead to new problems in industrial setups.

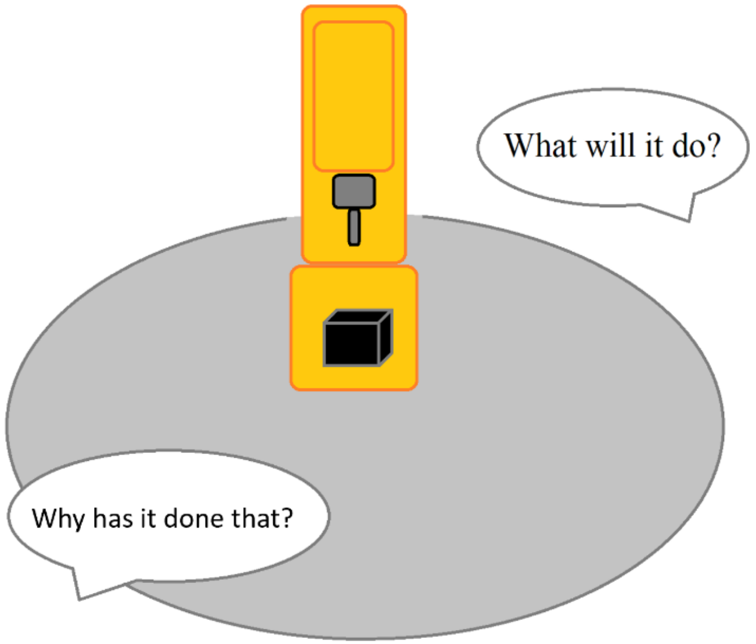
  → Untrained workforce can cause
  - Conflicts in task execution
  - can experience mental stress, or anxiety

→ Transparency can be the key

HRI methods in industrial settings

- To achieve higher performance by lowering some negative effects during a (future) Human-Robot Collaboration.

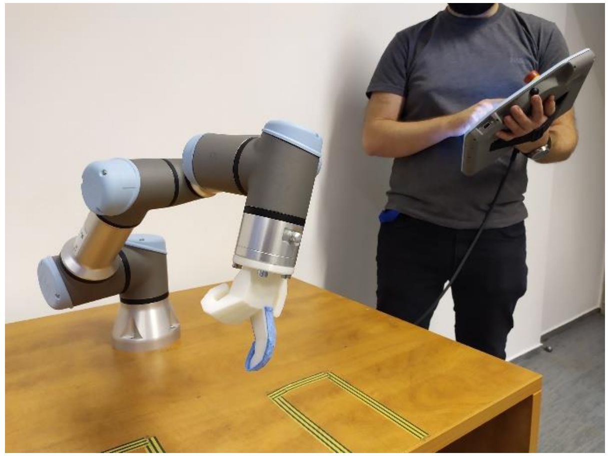
- One major sources of negative effects:
  - Most of the cases the robot is a black-box from the coworker's perspective

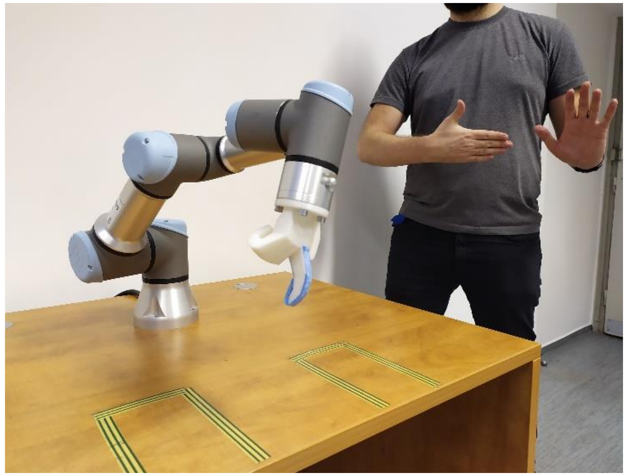


„Potential solutions"

- Understanding human cooperation ← Communication is probably crucial
  - Find out what they are communicating between each other
  - Translate it to some kind of signals
    - That are commonly understandable
    - That are robust in various environments

Moving from info – communicational to sociocommunicational channel

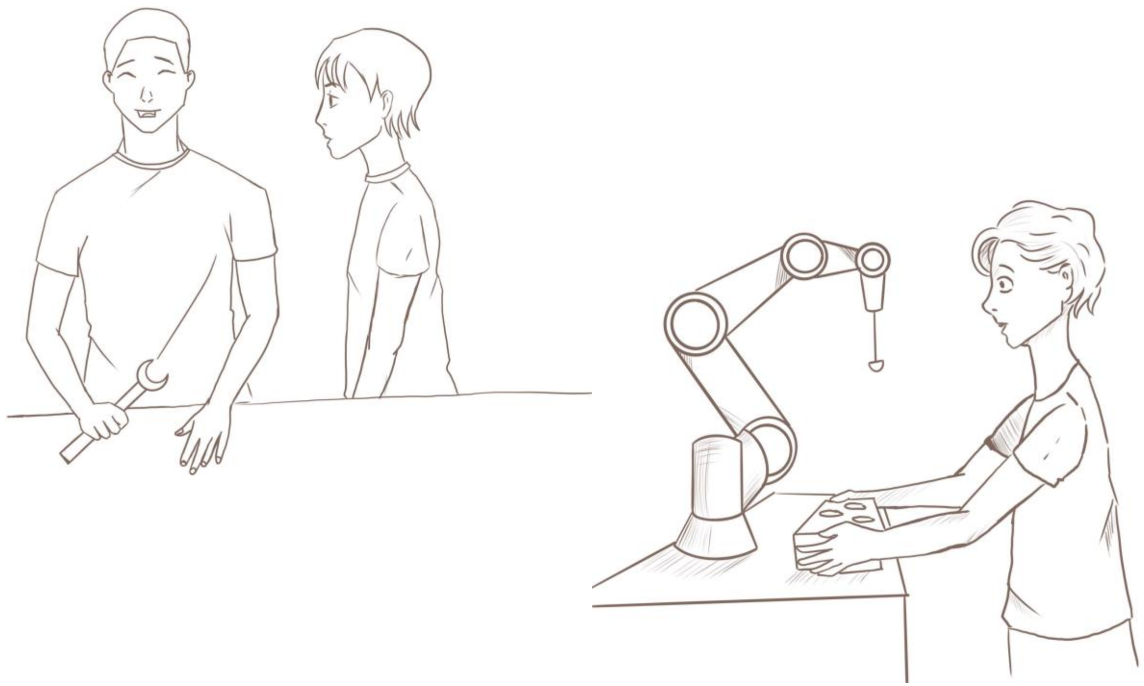




Trust is an important element in collaboration and proper communication is (one) key feature to gain trust

- Key aspects of an efficient collaboration:
  - Trust in each other
  - Proper communication

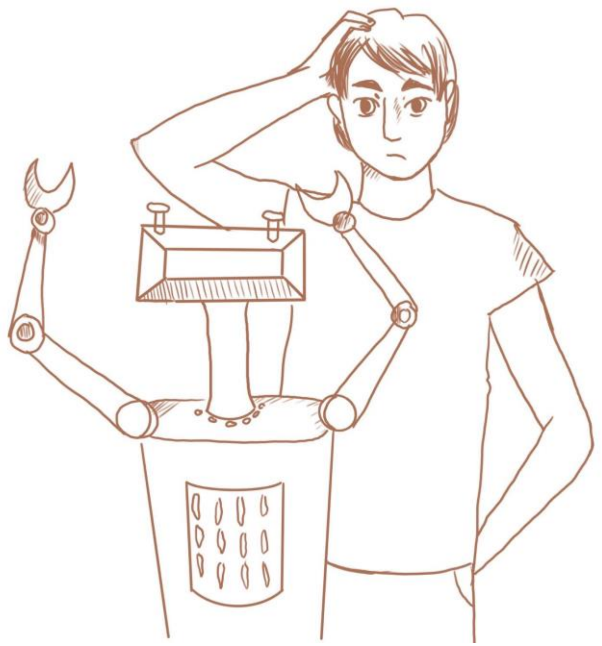
- Meta-analysis also suggests that communication has influence on trust



Courtesy of Barbara Szabó

A solely unilateral communication is not enough

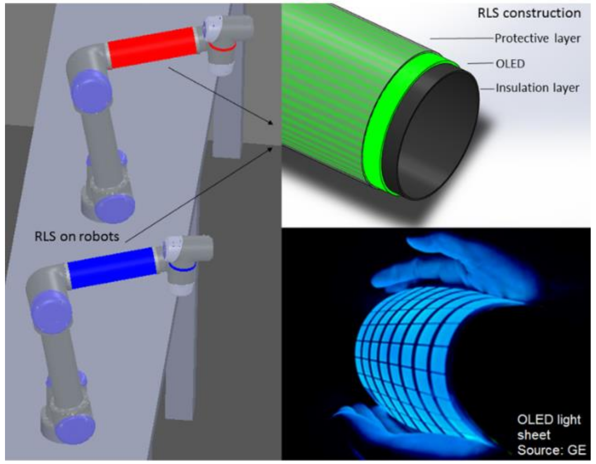
- The robot also needs to communicate its inner states
- The proper amount of complexity is needed to be adjusted according to the context



Courtesy of Barbara Szabó

Too simple communication is used currently in industrial settings

- Multiple modalities can be chosen
- Visual modality is mostly used in research and in industry as well
  - In industrial settings traffic lights are used to communicate (low depth of communication)
  - In research it is also considered to be a visual modality when the robot's movement is controlled somehow or its „gaze" etc.
- Similar idea compared to our HW with a bit different objective in [1] in parallel to our research (robot light skin)



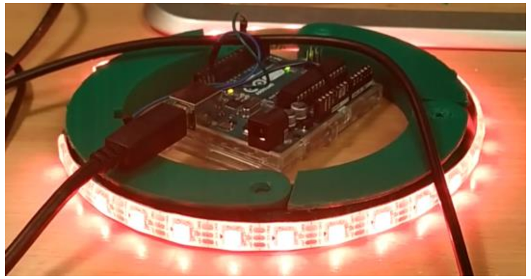
Source: [1]

Visual gestures (or signaling)

- We use the visual modality
  - Compared to sound signaling in industrial settings it seems to be less ambiguous and less dependent on the environment in most scenarios
  - Compared to the haptic modality extra equipment is not needed on the human workforce
- More flexibility is needed in the hardware to deepen the communication (in comparison to the traffic light, and the robot light skin)

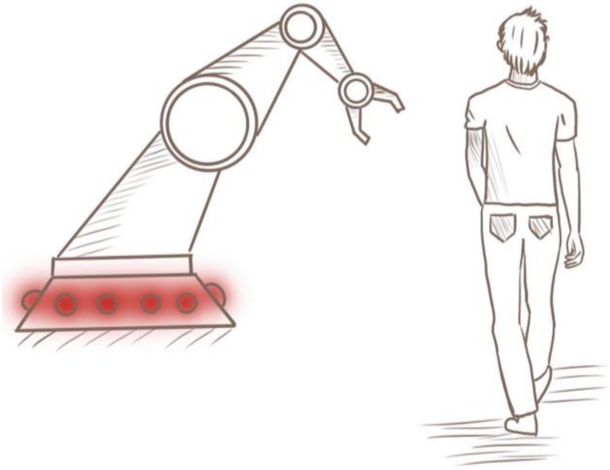
For communication we designed a simple HW

- Simple HW:
  - Microprocessor
  - LED strip (individually programmable LEDs)
  - Supporting electronics
  - Case
- Can be placed on the robot (base or at the end effector)
- 360° communication



Perceived emotions used as a supporting modality

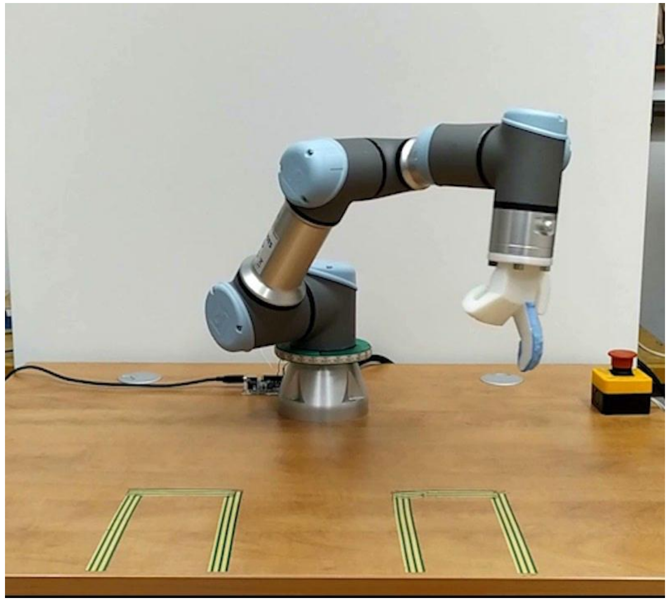
- To make the gestures more meaningful and giving them more depth, our direction is to use affective perception as supporting modality
  - E.g.: if someone is approaching the robot and this way potentially inhibit its work, the robot should communicate angry
- Human anthropomorphism of animated objects helps
  - Studies show that the right amount needs to be carefully designed

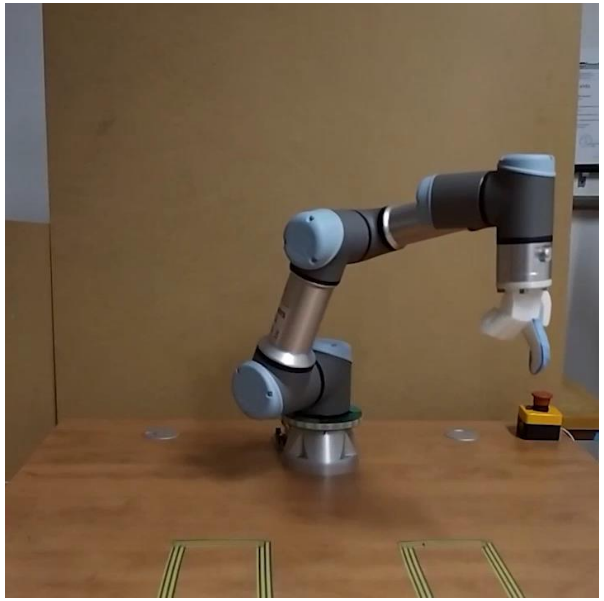


Courtesy of Barbara Szabó

A flexible method is needed for the broad experimenting of ideas

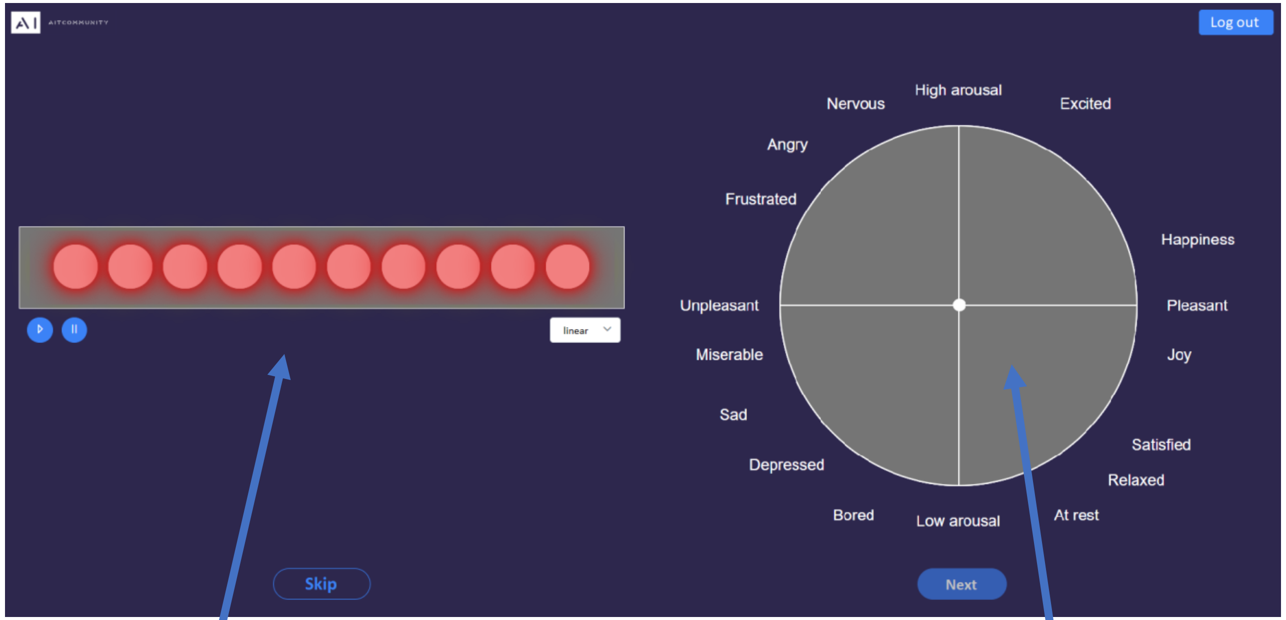
- The need of the presented method came up when we wanted to try the HW
  - Pandemic situation – on site testing was forbidden
  - Lower interest on volunteers
  - Demanding procedure





Gestures were assessed by volunteers on Russel's 2D model of affect

- Volunteers were asked to watch a gesture displayed on the LED panel
- After that they should give a feedback of their perceived emotions
- Skipping a gesture was available
- Gestures assessed by a volunteer was dependent only on the volunteer



Translation from the Hungarian site.

Animated LEDs

Feedback panel based on Russel's 2D affective model. *We also added some hints based on Russel's article. [3]*

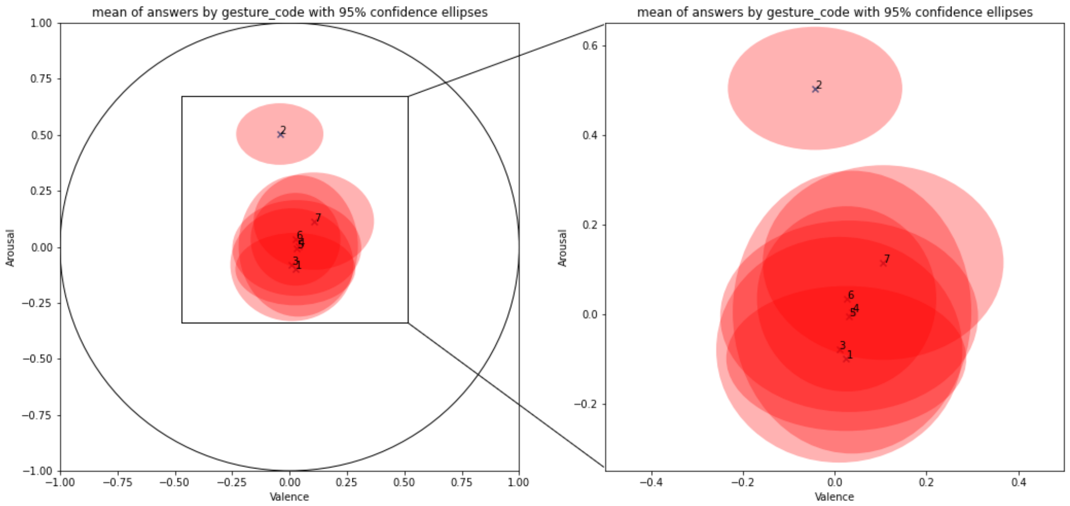
First test: We defined 5x7 gestures

Color	RGB code
White	(250, 250, 250)
Red	(230, 40, 23)
Orange	(250, 181, 5)
Green	(35, 191, 0)
Blue	(26, 100, 237)

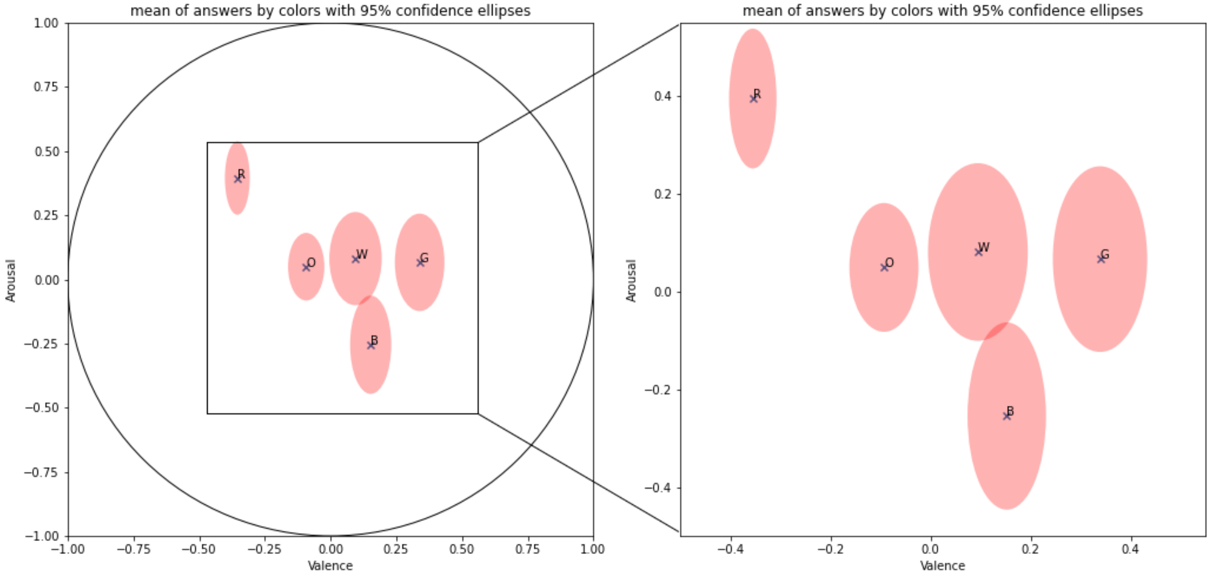
Nr.	Actions
1	0.75; 0.75 continuously
2	0.25; 0.25 continuously
3	ON
4	0.75; 0.75; 0.6; 0.75; 0.45; 0.75; 0.3; 0.75; 0.15
5	0.75; 0.75; 0.75; 0.6; 0.75; 0.45; 0.75; 0.3; 0.75; 0.15
6	0.15; 0.75; 0.3; 0.75; 0.45; 0.75; 0.6; 0.75; 0.75
7	0.75; 0.15; 0.75; 0.3; 0.75; 0.45; 0.75; 0.6; 0.75; 0.75; 0.75

- We made a gesture bank consisting of 35 gestures by mixing the 5 chosen color to the 7 kinds of flashing patterns
- Seven patterns:
  - 2 flashing patterns with constant frequency (gesture no. 1 and 2) for testing the conjecture
  - 1 pattern only lights the LEDs
  - 4 pattern with varying frequencies of the ON or OFF parts of the gesture (numbers in the table are the ON and OFF parts lengths).
- During the experiment the gestures were selected randomly from the gesture bank

Results show: Conjectures are corroborated



1, The higher frequency gesture has higher mean of arousal levels.
2, The different gestures are aligned to the arousal axis.
3, Bigger standard deviations along the valence axis than the arousal axis.



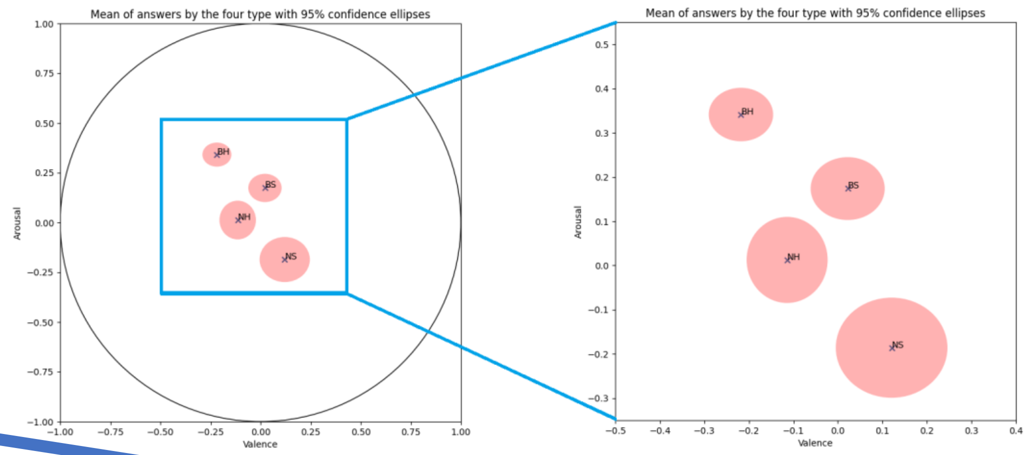
1, The different colored gestures are mostly in align with the valence axis.
2, Bigger standard deviations along the arousal axis than the arousal axis.

Second test (under publication): We defined 4 kinds of gestures

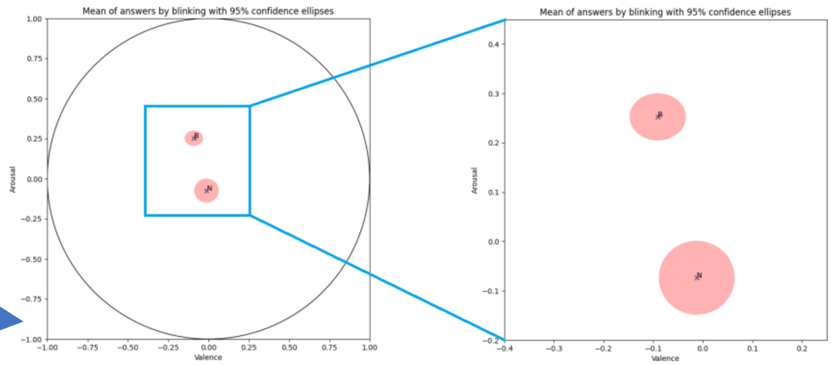
- Signaling with blinking (turning off the LEDs between color change) in their animation. B – N
- Signaling wit succeeding color that are similar / different. – H – S
- Combined into 4 categories: **BH / BS / NH / NS**

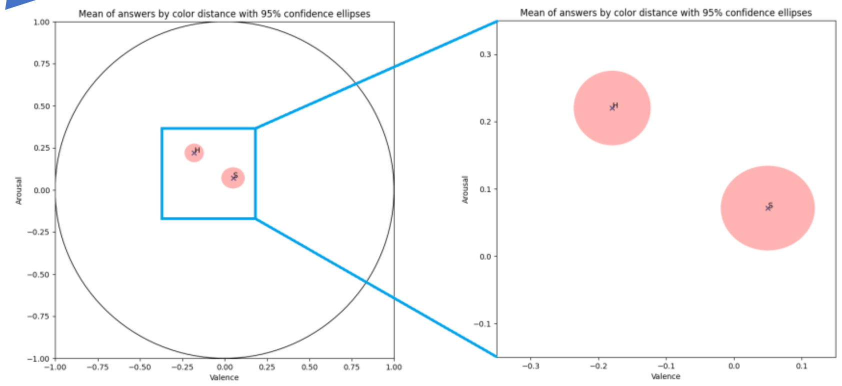
Results show: Conjectures are corroborated

- **C1:** When a signal has successive colors similar to each other, it will be perceived as a lower arousal level emotion, while in the case of big differences in the color, the perceived arousal level of the emotion will be higher.



- **C2:** When deactivating the LEDs (blinking effect) during a signal, the perceived arousal level is higher than the level when not blinking.





Not representative data, but acceptable for testing the direction’s correctness

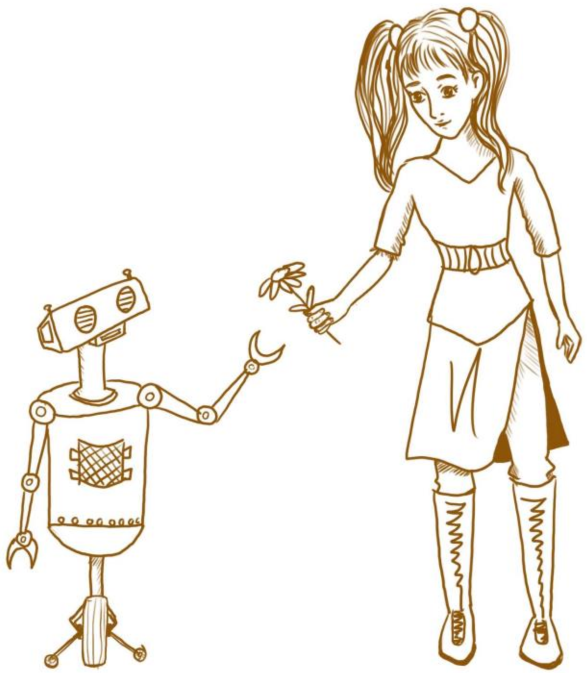
- The preliminary experiment was held for **one week**.
- **28 volunteers** were involved = not representative for a larger population but can set the right directions to search.
- **490 datapoint** was recorded.

- The second experiment was held for **3 weeks.**
- **27 volunteers** were involved.
- **578 datapoint** was recorded.

It seems that simple visual signal patterns can be interpreted as different emotions in the robot

- Probably helps:
  - Anthropomorphism
  - Empathy

- From the tests we can conclude so far:
  - Higher amount of data is needed
  - Further evaluation will be needed
    - Cross cultural effect
    - Cross platform effect
  - Simpler signaling for the effect testing



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Thank You for Your attention!

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Used sources

[1] G. Tang, P. Webb, and J. Thrower, "The development and evaluation of robot light skin: A novel robot signalling system to improve communication in industrial human–robot collaboration," Robotics and Computer-Integrated Manufacturing, vol. 56, pp. 85–94, 2019. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0736584518300553

[2] https://www.techexplorist.com/baxter-robot-blue-collar-robot/2452/

[3] J. A. Russell, "A circumplex model of affect," Journal of Personality and Social Psychology, vol. 39(6), p. 1161–1178, 1980.