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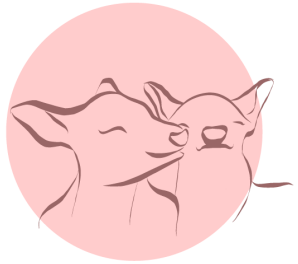


Affective Computing and Intelligent Interaction

ACII2022

Continual Learning for Affective Robotics
A Proof of Concept for Wellbeing

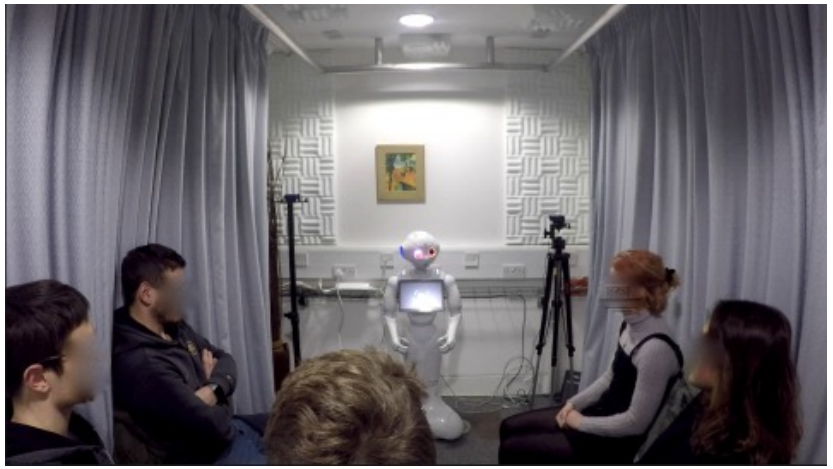
Nikhil Churamani[*], Minja Axelsson[*], Atahan Çaldir and Hatice Gunes

[*] Equal Contribution

UKRI Engineering and Physical Sciences Research Council

Affective Robots in Wellbeing Settings

(1)



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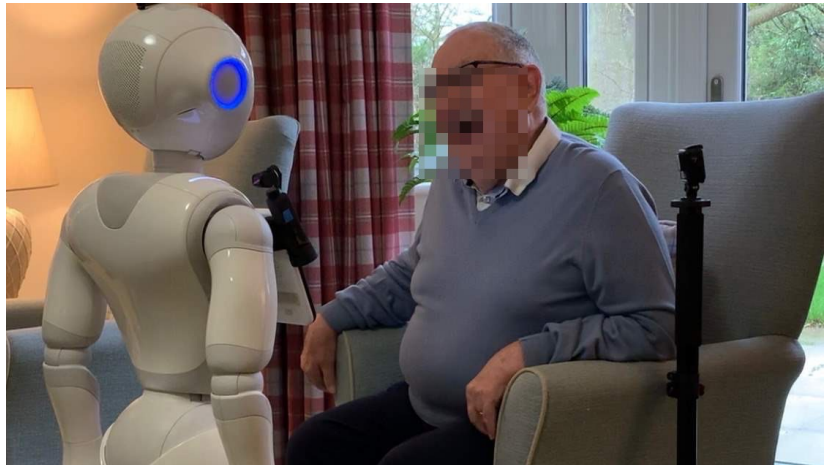

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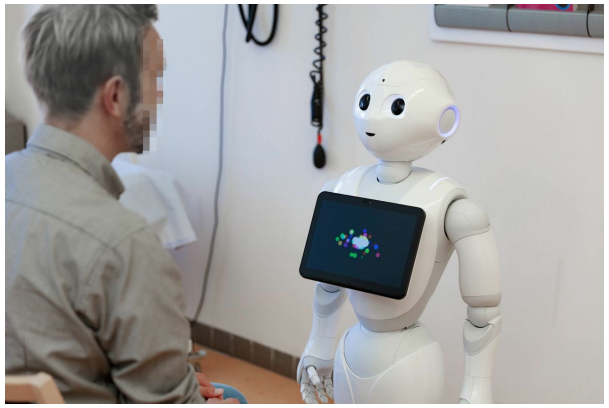
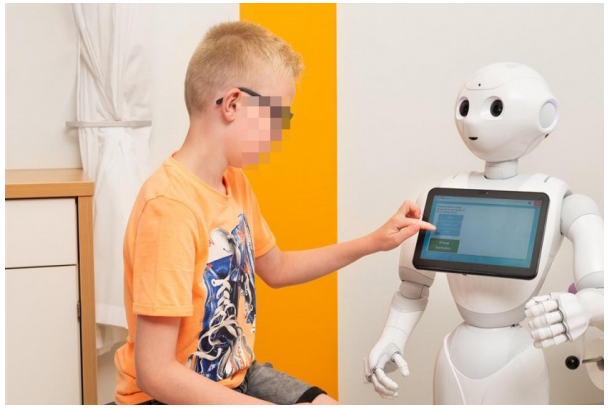
(1) http://abovewhispers.com/2016/06/14/robot-receptionists-introduced-at-hospitals-in-belgium/
(2) https://www.clarehall.cam.ac.uk/news/robotswellbeing21/
(3) https://www.thetimes.co.uk/article/robot-carers-for-the-elderly-are-now-a-reality-in-japan-but-do-we-want-them-here-mw8zpw0zd
(4) https://www.beds.ac.uk/news/2020/september/culturally-competent-robots-could-improve-mental-health-and-loneliness-in-older-people/

Need for Personalised Interactions



(a)

(b)



(c)

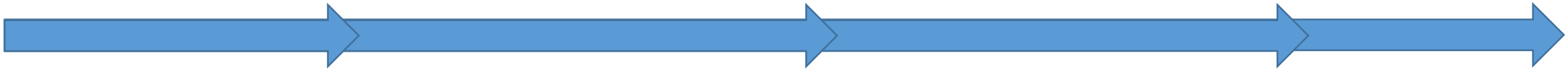
...

Equipped with Learning Models

Interact and adapt.

Extend learning with other users.

Adapt to different user demographics.



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(a) Boumans R, van Meulen F, Hindriks K, *et al* Robot for health data acquisition among older adults: a pilot randomised controlled cross-over trial *BMJ Quality & Safety* 2019;**28:**793-799.
(b) https://www.scmp.com/lifestyle/health-wellness/article/3024028/how-robot-nurses-could-help-care-worlds-elderly-and
(c) https://eindhovennews.com/news/2018/06/robot-pepper-helps-children-hospital-visits/

Towards Continual Personalisation

Traditional Approaches

- Perception models **trained** on benchmark datasets enable **generalisation** across contexts and environments.
- **Yet,** generalisation comes **at the cost** of personalised learning.
- **Costly** to retrain and update models *on-the-fly.*

(a)

Personalisation towards Individual Expression

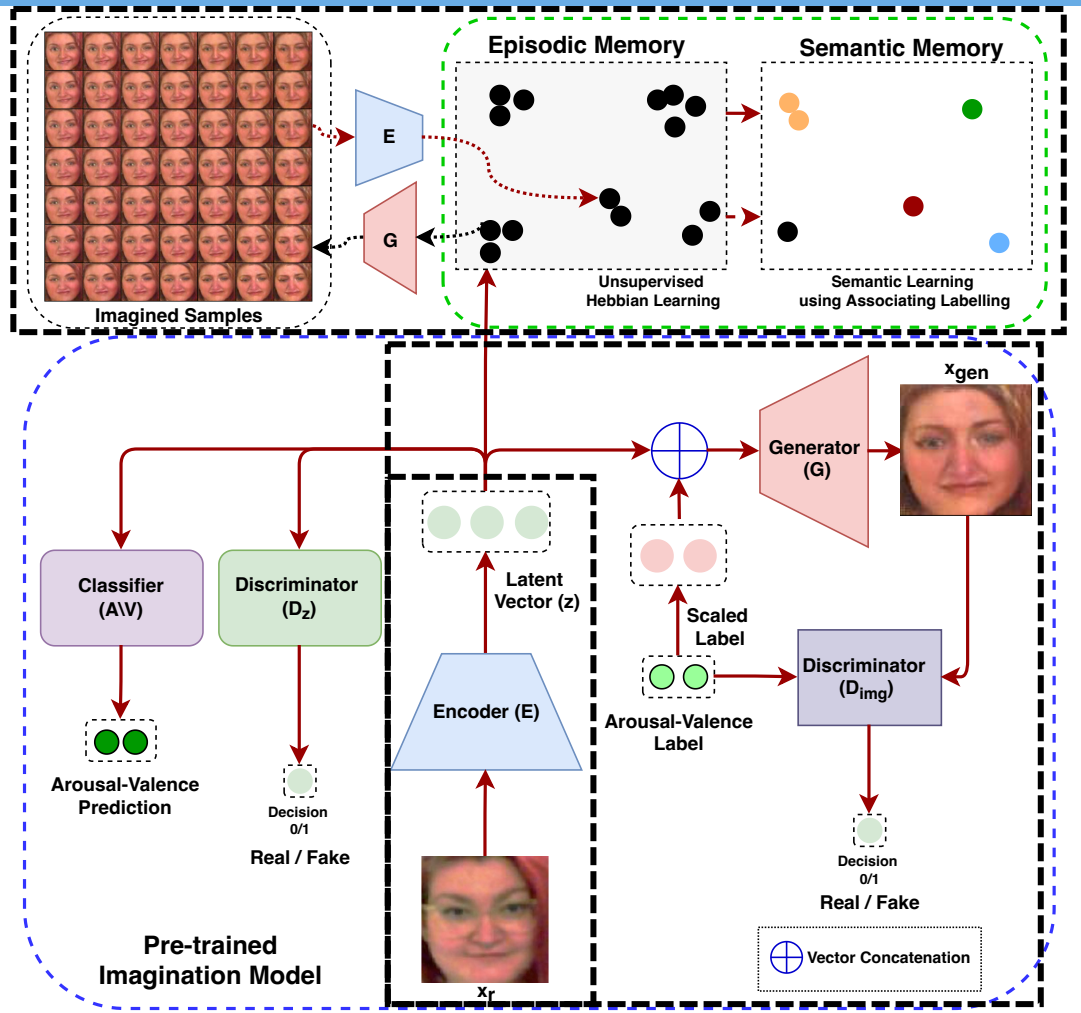
- Robots that **continually learn** and **adapt** with each user.
- **Adaptation** with **new data** acquired during **real-world interactions**.
- ***Continual Learning*** of Individual Facial Expressions to embed **continual personalisation** in robots.

(b)

(a) S. Li et al., "Deep facial expression recognition: A survey," CoRR, vol. abs/1804.08348, 2018.
(b) https://marketingland.com/wp-content/ml-loads/2016/03/emotions_ss_1920.png

Continual Learning for Personalised Affect Perception

- Participant Image encoded into a latent variable (**z**).
- Image encodings and target labels (arousal-valence) used to generate additional images.
- *Imagined* images across a range of arousal-valence labels augment learning in a dual-memory self-organizing model.
- Episodic Memory learns *unique* representations of novel experiences.
- Semantic Memory learns compact *overlapping* representations that generalise across target labels.

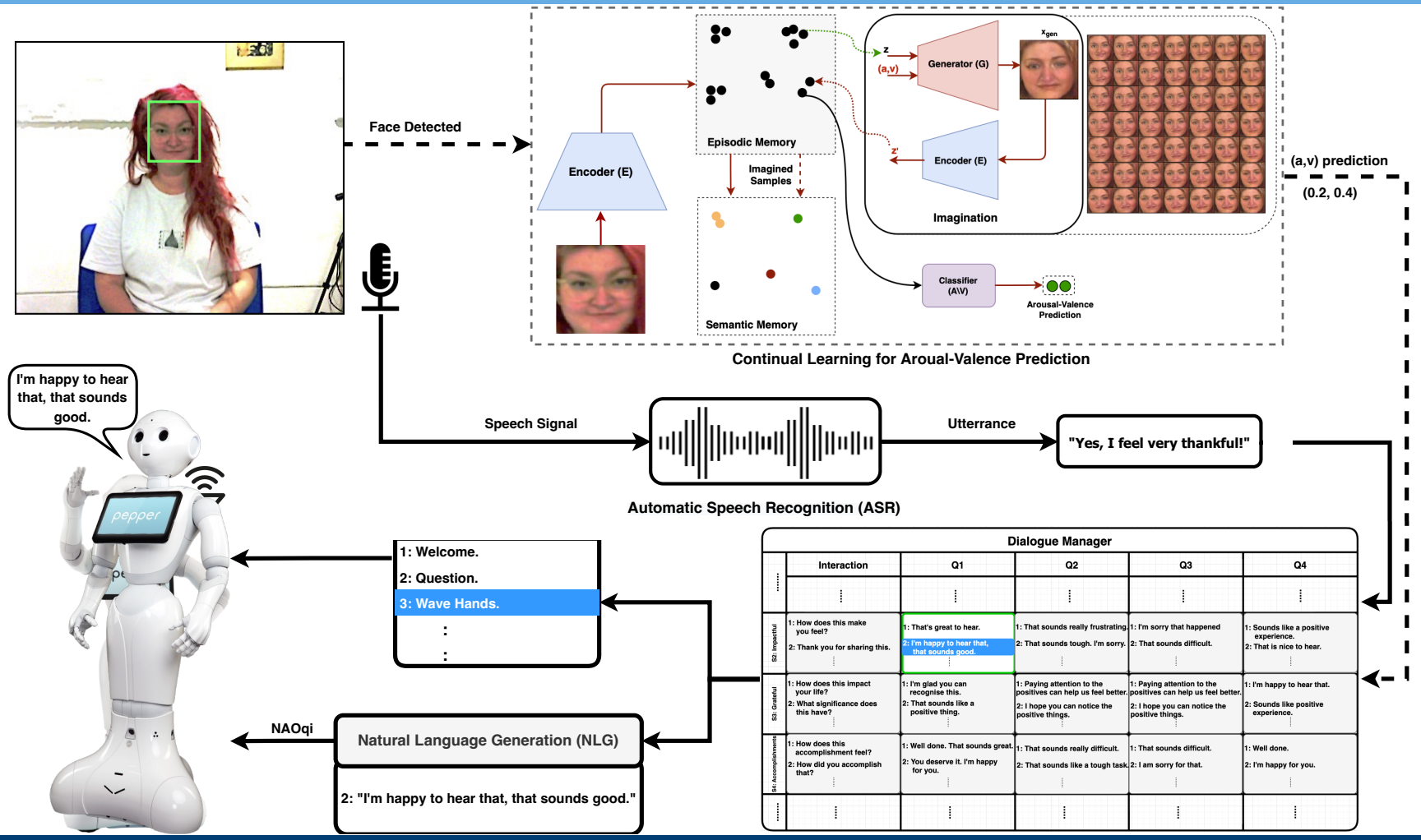


N. Churamani and H.Gunes. CLIFER: Continual Learning with Imagination for Facial Expression Recognition. In 2020 15th IEEE International Conference on Automatic Face and Gesture Recognition (FG 2020) (pp. 322-328). IEEE.

Pepper as a Robotic Coach for Wellbeing

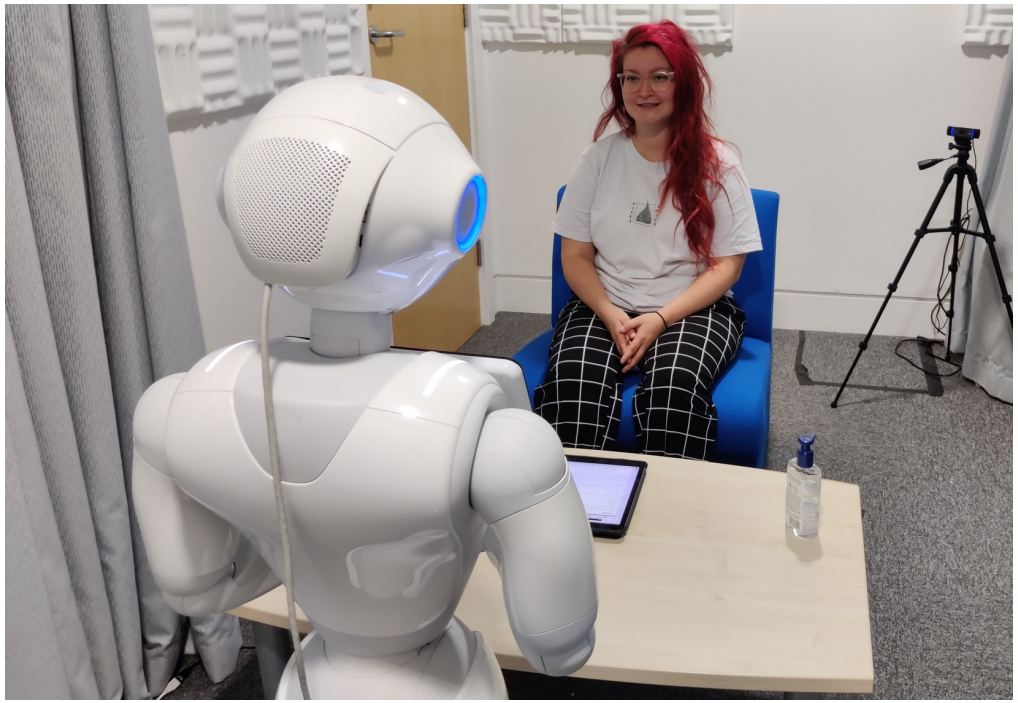
- Pepper offering Positive Psychology (PP)-based wellbeing coaching.
- Interaction Script Developed with a Professional Psychologist.
- PP-based exercises or tasks:
  - Talk about **two** *impactful* things or events from the past two weeks.
  - Focus on *gratitude* and talk about **two** things to be grateful about.
  - Focus on **two** recent *accomplishments* and the strengths applied for those.
- Participant verbal responses (yes/no responses) and facial expressions observed to model *personalised* interactions.
- Adaptation achieved by modifying the *interaction flow* based on participant behaviour.

The Proposed Framework



Experiment Set-up

- 20 Participants (12 female, 5 male, 3 not disclosed).
  - Average Age: *26.70 ± 3.68* years from *12* different nationalities.
  - *Screened* using GAD7 and PHQ9 questionnaires to ensure non-clinical population.
- *Between-subjects* study design with random assignment to one of three experiment Conditions (Coach Variants):
  - **C1 – Static and Scripted:** Robot following the pre-defined script with no consideration towards participants affective responses.
  - **C2 – Affect-based Adaptation *without* Personalisation:** Off-the shelf, *state-of-the-art* facial affect perception model used to determine participants' affective responses. Robot responses adapted based on participants' perceived affective state.
  - **C3 – Affect-based Adaptation with *Continual Personalisation*:** CLIFER-based personalised affect perception used to determine participants' affective state. Robot responses adapted based on the robot's perception.



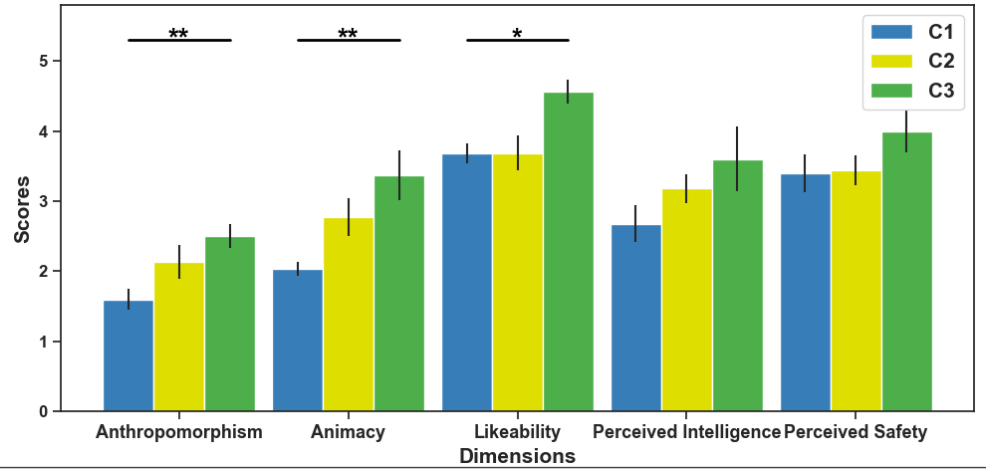
For C2: P. Barros, N. Churamani, and A. Sciutti. The FaceChannel: A Fast and Furious Deep Neural Network for Facial Expression Recognition. SN Computer Science, 1(6), 2020.
For C3: N. Churamani and H.Gunes. CLIFER: Continual Learning with Imagination for Facial Expression Recognition. In 2020 15th IEEE International Conference on Automatic Face and Gesture Recognition (FG 2020) (pp. 322-328). IEEE.

Evaluation

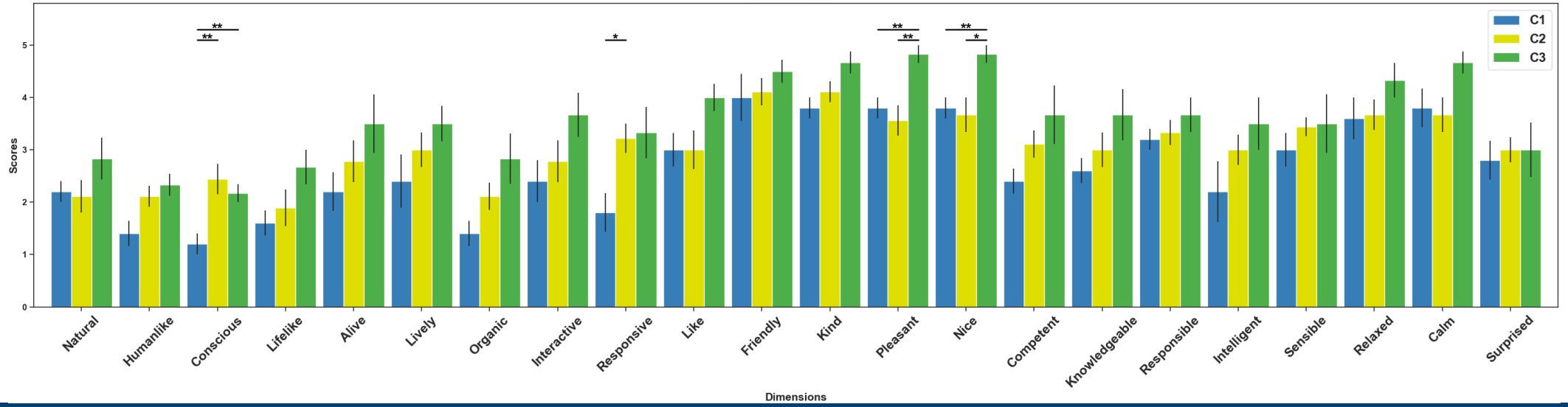
- Evaluating participants' **impressions** of Pepper as the Robotic Coach under the different conditions based on:
  - GODSPEED: Measuring *anthropomorphism, animacy, likeability, perceived intelligence* and *perceived safety.*
  - RoSAS: Measuring *warmth, competence* and *(dis) comfort.*
  - Customised Questions: Measuring whether participants felt the robot *understood what they said, how they felt* and *adapted* its behaviour accordingly.
- Mann-Whitney U Test to compare individual conditions.

H. B. Mann and D. R. Whitney. On a test of whether one of two random variables is stochastically larger than the other. The Annals of Mathematical Statistics, vol. 18, pp. 50–60, 1947.

Evaluation: GODSPEED



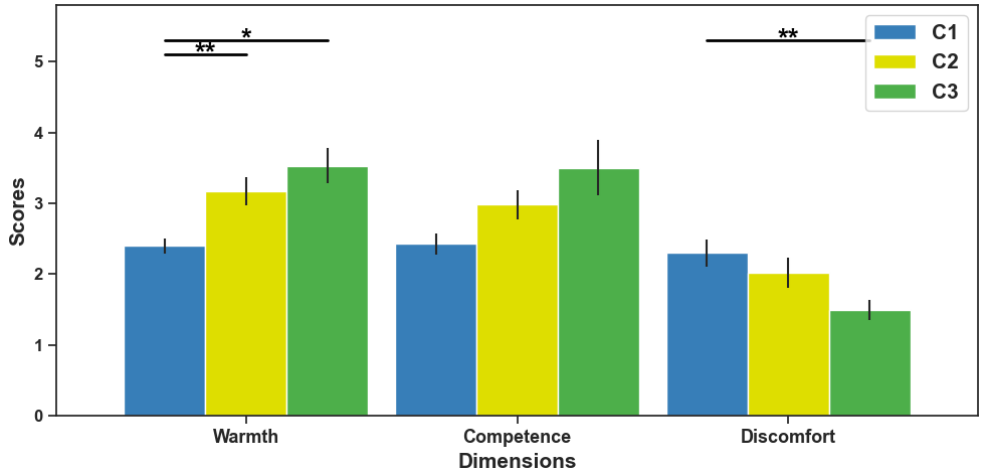
∗ represents $p < 0.05$ and ∗∗ represents $p < 0.01$.

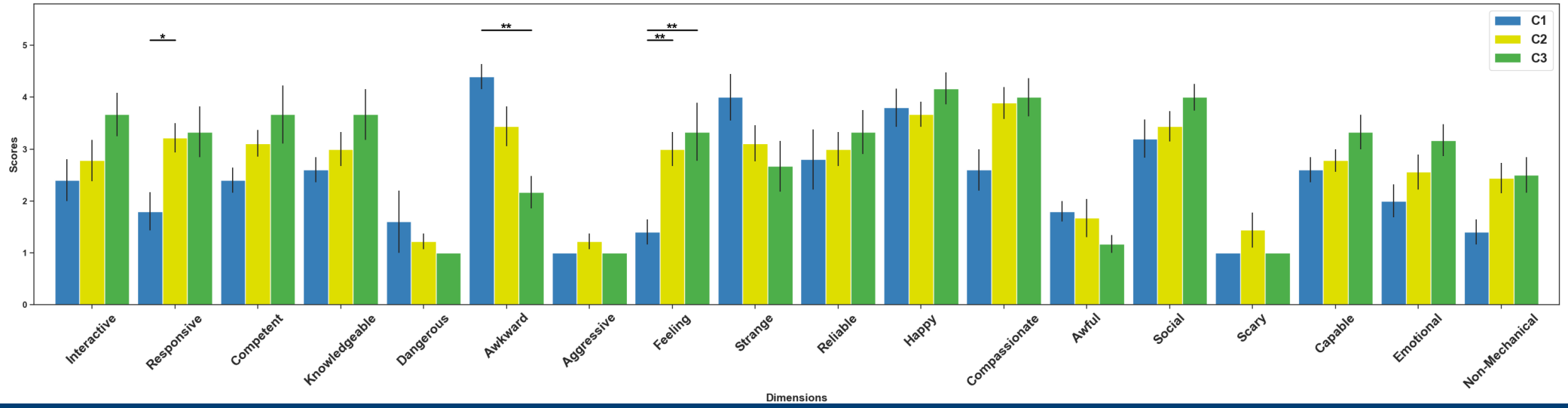


C. Bartneck, D. Kulić, E. Croft, and S. Zoghbi. Measurement in- struments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. International Journal of Social Robotics, vol. 1, no. 1, pp. 71–81, 2009.

Evaluation: RoSAS

∗ represents $p < 0.05$ and ∗∗ represents $p < 0.01$.

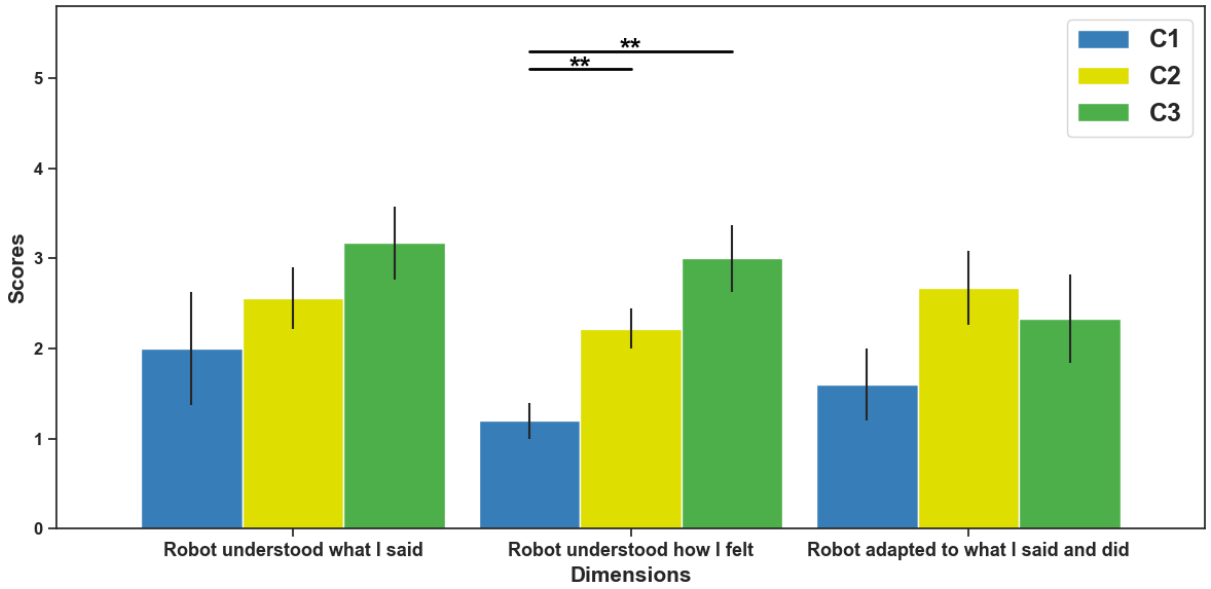




C. M. Carpinella, A. B. Wyman, M. A. Perez, and S. J. Stroessner. The Robotic Social Attributes Scale (RoSAS) Development and Validation," in Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction, 2017, pp. 254–262.

Evaluation: Customised Questions

$*$ represents $p < 0.05$ and $**$ represents $p < 0.01$.



Key Outcomes

Conclusions

- First study investigating **continual learning** to improve robot's perception of participant affective behaviour.
- **Proof-of-concept** evaluations highlight that **affective adaptation** is preferred over static, non-adaptive interactions.
- **Continual Personalisation** improves participant's impressions for *anthropomorphism, animacy, likeability, warmth and comfort.*
- **Sensitivity** to individual differences in affective behaviour allows *empathetic* interactions, particularly beneficial for wellbeing scenarios.

Next Steps

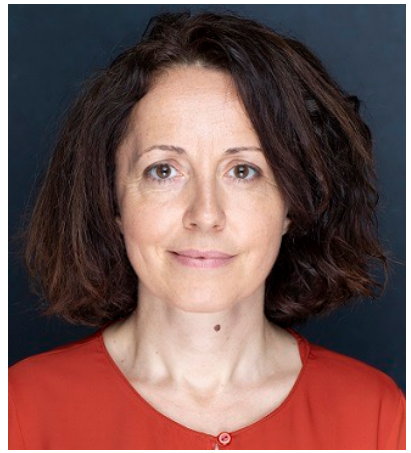
- **Multi-modal analysis** of user behaviour to improve robot perception their affective state.
- Use of **Natural Language Understanding (NLU)** for *active listening*.
- Extending the experiments to **longitudinal** settings with **repeated interactions**.
- Extending the experiments with more participants across demographic distributions with respect to **gender** and **ethnicity**.

Acknowledgement

Nikhil Churamani

Minja Axelsson

Atahan Çaldır



Hatice Gunes

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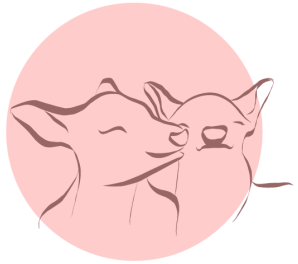

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