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Exploring Socially Assistive Robots and Sensory Feedback for Cognitive Decline Prevention

LEADERS IN IDEAS AND SOLUTIONS

Lynne Baillie, Emilyann Nault & Frank Broz (TU Delft)

EPSRC
Engineering and Physical Sciences Research Council
Grant ID: EP/S023208/1

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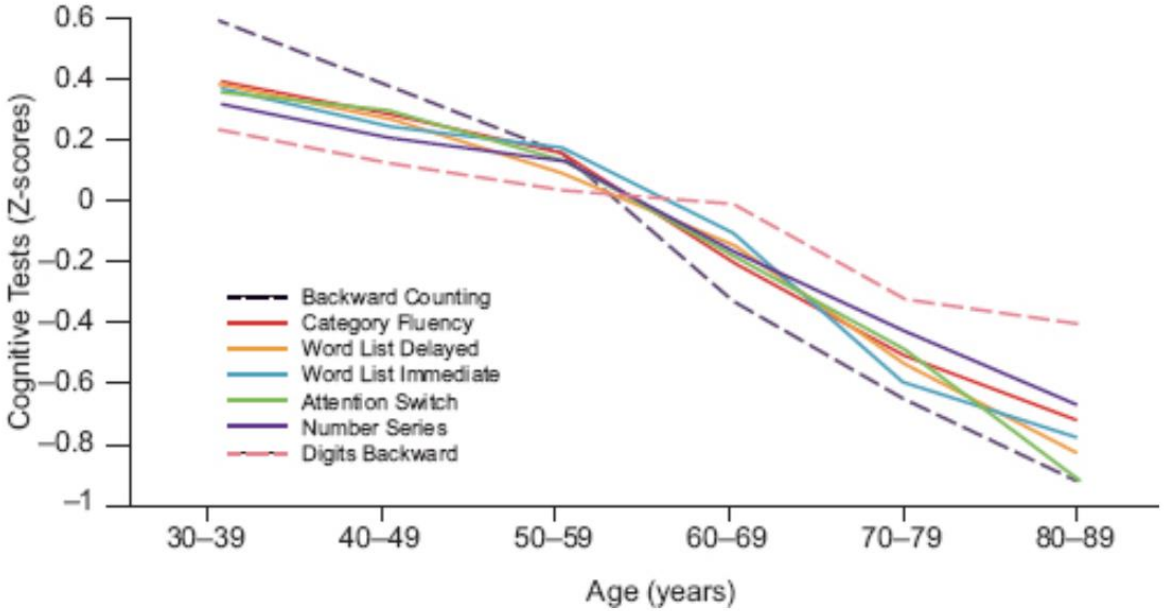
Cognitive Decline

Older adult growth rate > World population growth rate



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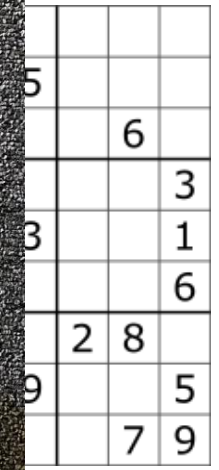

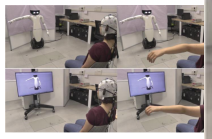

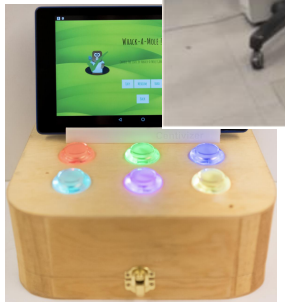

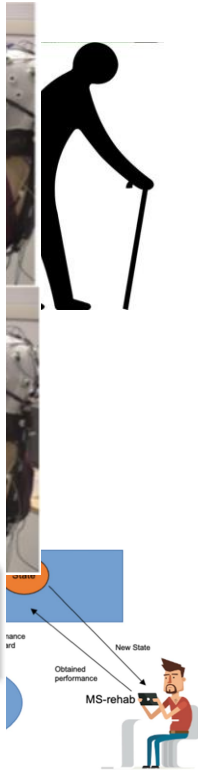

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Research Objectives

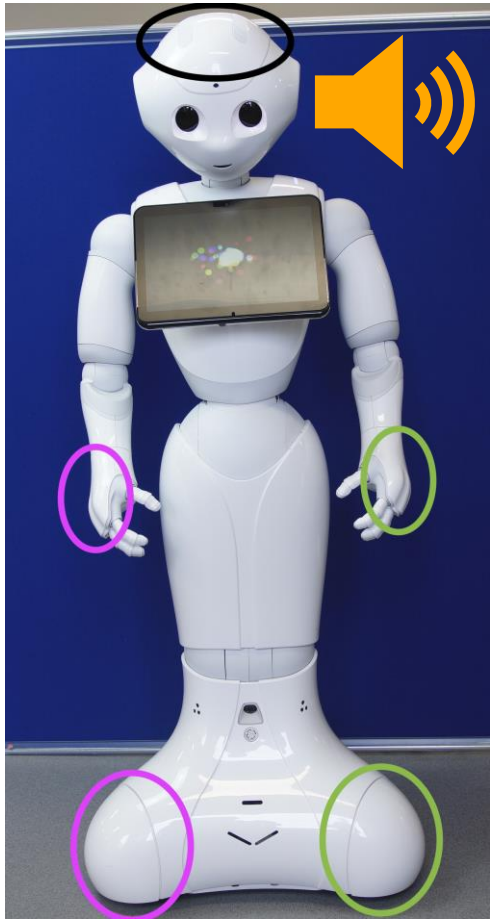
1. What is the optimal means of administering **sensory feedback** in order to optimise engagement?

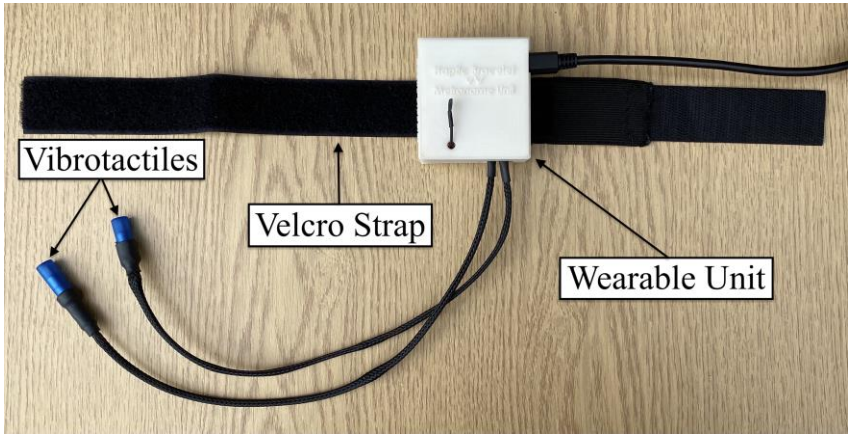
2. How can **machine learning** be incorporated to personalise the interaction in real time in order to maximise engagement?

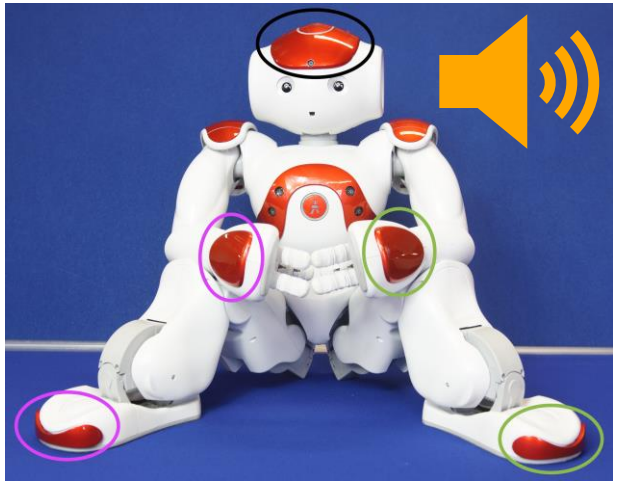
3. Does the system provide a level of engagement that leads to long-term adherence compared to the individual's current practices?

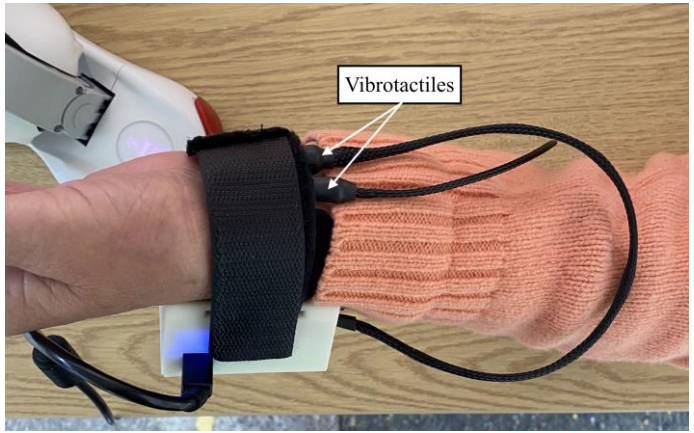
a. What **SAR embodiment** will maximise engagement in this context?

Memory Activity with Sensory Feedback









SAR images courtesy of the Interactive and Trustworthy Technologies Group

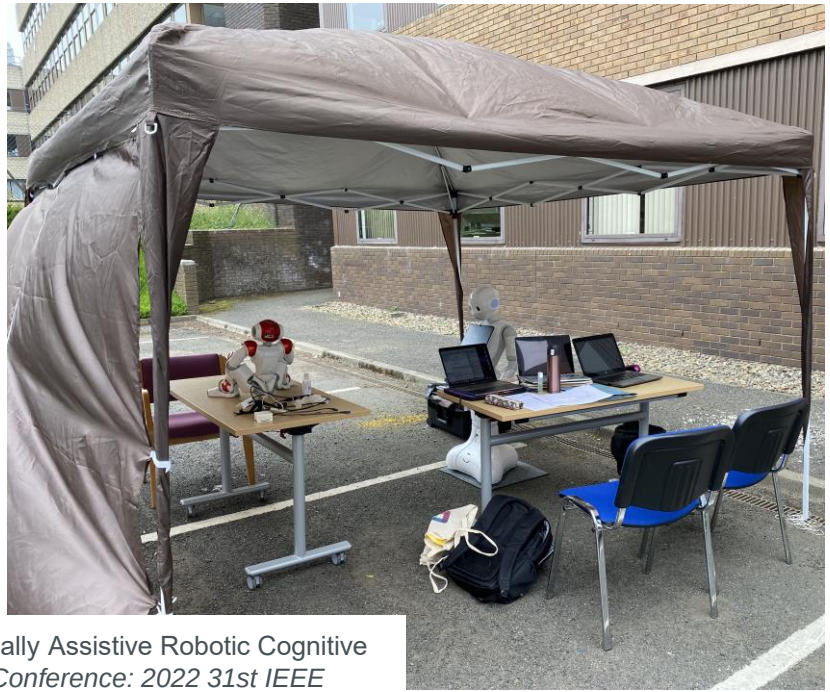
Usability Study

Methodology

- 19 older adults (M = 72 years, 15 female, 4 male)
- Within-subjects design

Assessment Metrics

- Accuracy Score
- System Usability Scale (SUS)
- NASA Task Load Index (TLX)



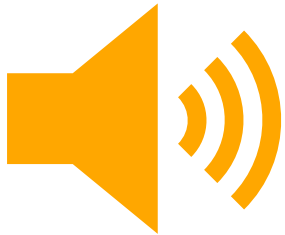
Emilyann Nault*, Lynne Baillie, Frank Broz. “Investigating the Usability of a Socially Assistive Robotic Cognitive Training Task with Augmented Sensory Feedback Modalities for Older Adults.” *Conference: 2022 31st IEEE International Conference on Robot & Human Interactive Communication (RO-MAN).*

Usability Study - Outcomes

- **Auditory feedback** had higher accuracy (*p*=0.015), usability (*p*=0.031), and was the most preferred.

  - *5/19 participants had a hearing impairment.*

  - **Feasibility study** with young adults, same trend towards auditory feedback.



E. Nault, L. Baillie, and F. Broz. "Auditory and haptic feedback in a socially assistive robot memory game." *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction.* 2020.

- The smaller, **tabletop robot embodiment** had lower workload (*p*=0.014) and was preferred.

- **Participants aged 71-82** had lower accuracy compared those 65-70.

Participatory Design (PD) Workshop

- 9 older adults
  - (M=73.5, 1 male, 8 female)
- 3 therapists
  - Occupational Therapist
  - Speech Language Pathologist
  - Clinical Neuropsychologist

Day 1:
4 older adults
3 therapists

Day 2:
5 older adults

- Each group – facilitator & scribe
- Constant Comparative Method of Grounded Theory

B. G. Glaser, A. L. Strauss, and E. Strutzel, “The discovery of grounded theory; strategies for qualitative research,” Nursing research, vol. 17, no. 4, p. 364, 1968.

My Brain Training

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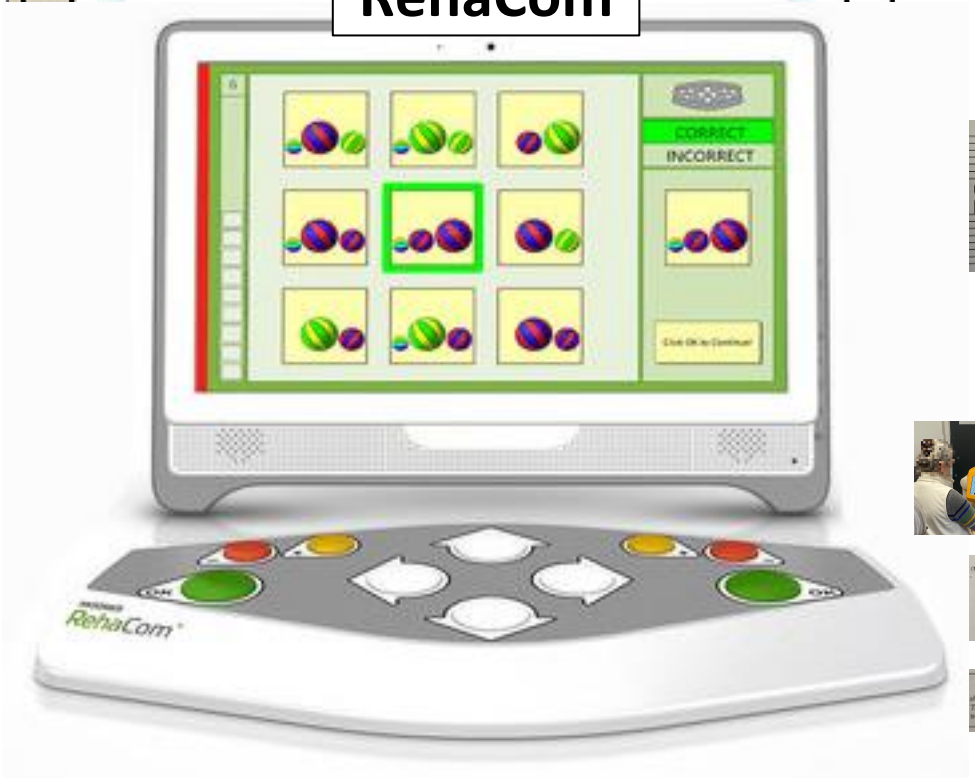
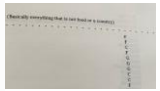
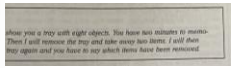
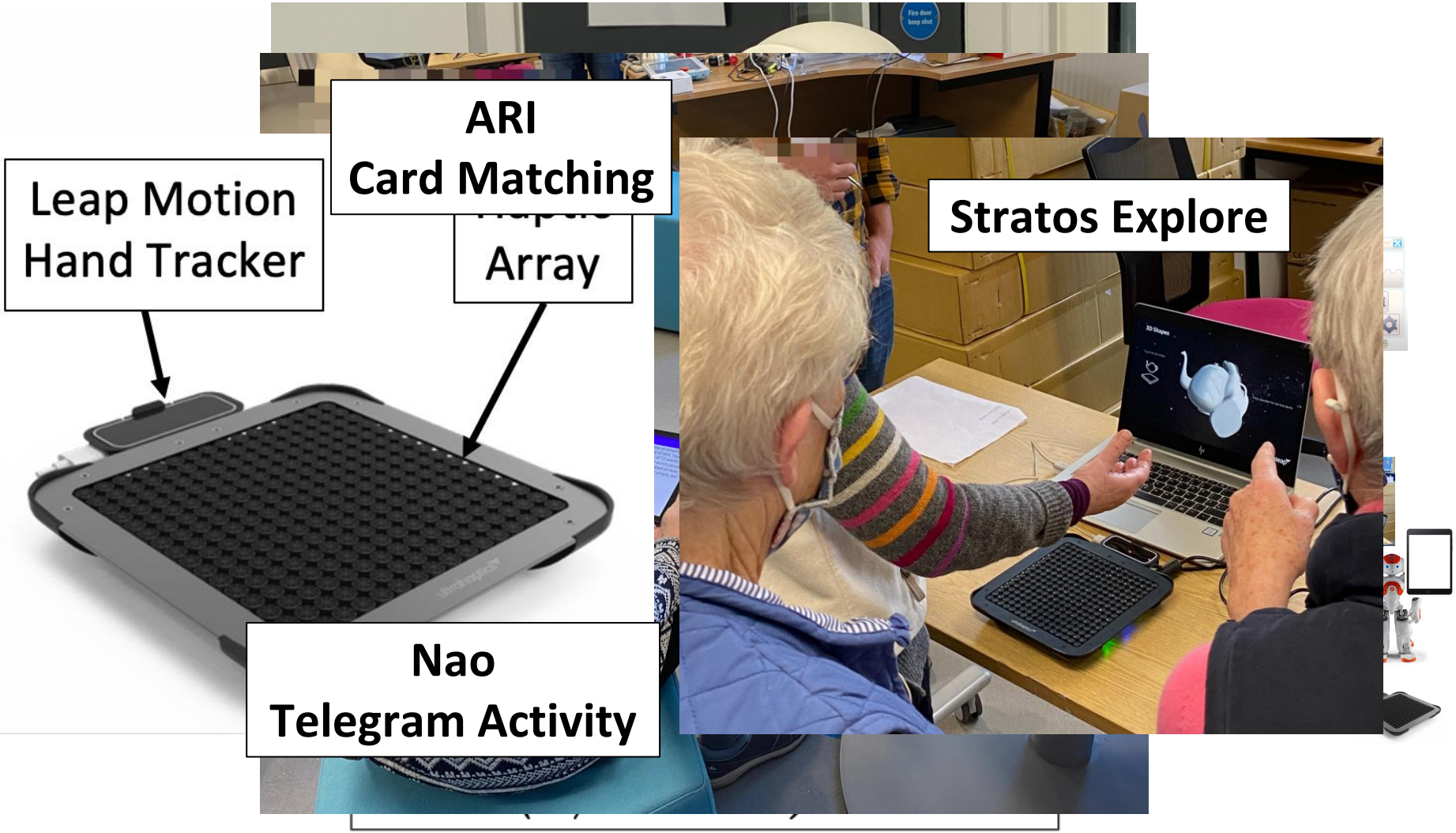







ARI
Card Matching
Leap Motion
Hand Tracker
Array
Stratos Explore
Nao
Telegram Activity

PD Workshop Protocol

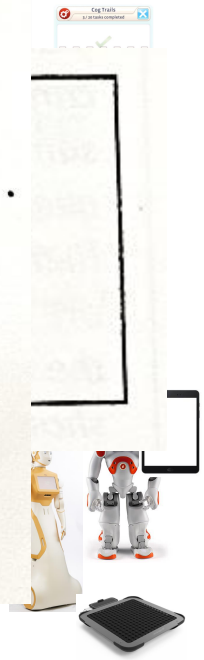
Phase	Duration
Intro d	
and Feedback	
Total (w/o breaks): 2 hours	

Category Checker

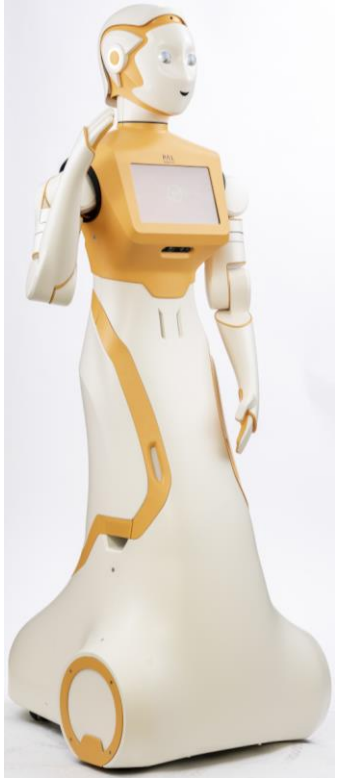
Object Recall

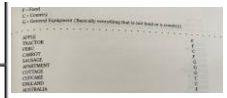
F = Food
C = Country
G = General Equipment (Basically everything that is not food or a country)

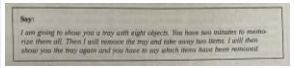
APPLE	F
TRACTOR	F
PERU	C
CARROT	F
SAUSAGE	G
APARTMENT	G
COTTAGE	G
CUPCAKE	C
ENGLAND	C
AUSTRALIA	F



PD Workshop Protocol



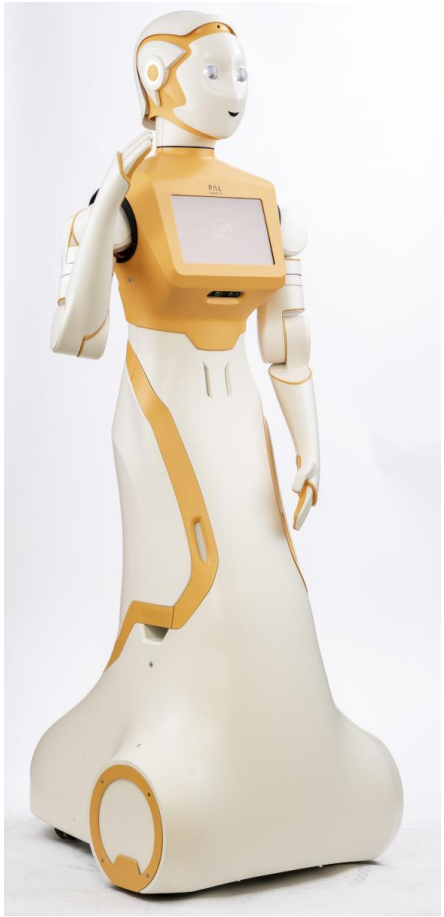




	30 mins
	30 mins
Presentation and Feedback	20 mins

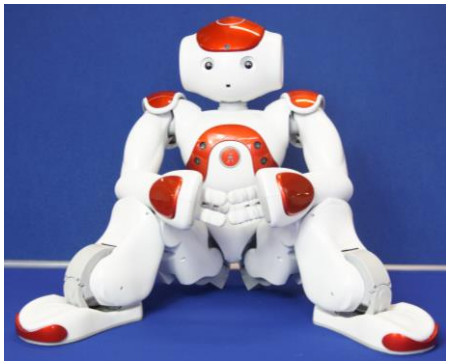
T. Tong, J. Urakami, M. Chignell, M. C. Tierney, and J. S. Lee, “Tracking cognitive decline with a serious game: Benchmarking against the mini-mental state examination,” in Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 64, no. 1. SAGE Publications Sage CA: Los Angeles, CA, 2020, pp. 6–10.

Results - SARs



1.65m

- Voice
- Tablet integration
- Speech rate



0.58m

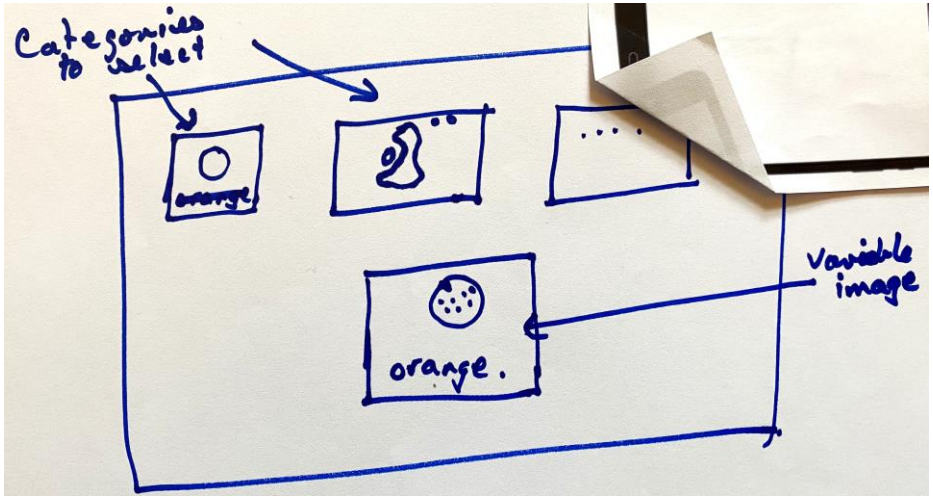
- Instructions & feedback
- Encouragement
- Prompting (speech/gestures)
- Task involvement (Competitor or companion)

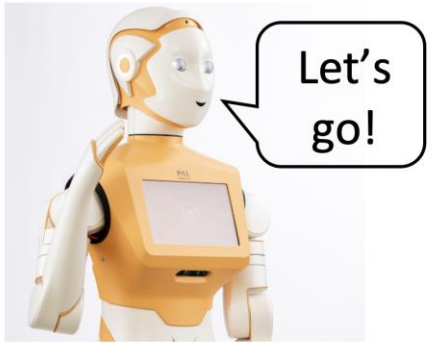
Results - Sketches to Visualisations

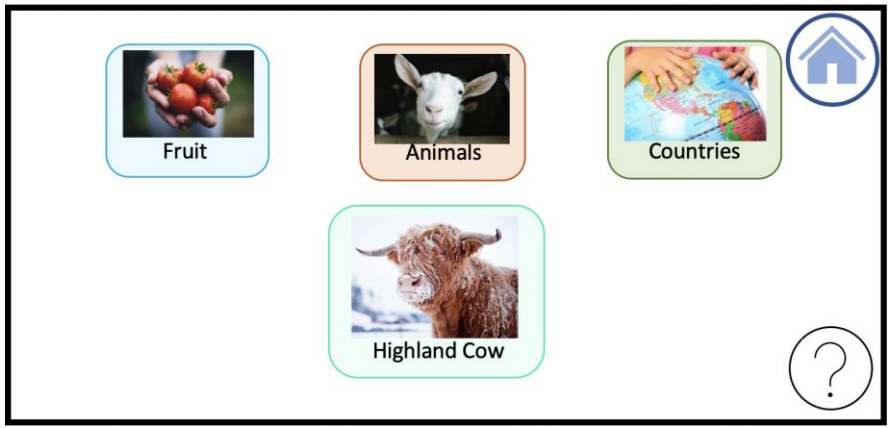
Category Checker

F = Food
C = Country
G = General Equipment (Basically everything that is not food or a country)

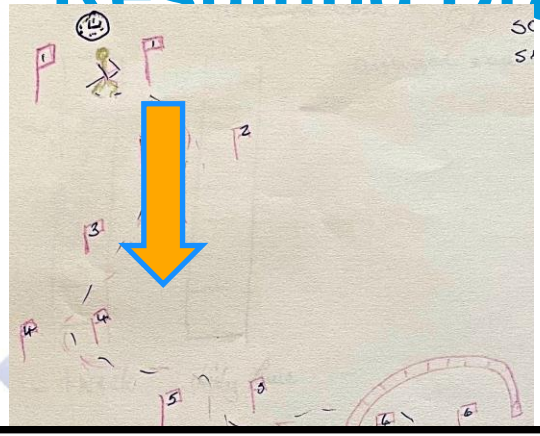
APPLE	F
TRACTOR	F
PERU	C
CARROT	F
SAUSAGE	G
APARTMENT	G
COTTAGE	G
CUPCAKE	C
ENGLAND	C
AUSTRALIA	F



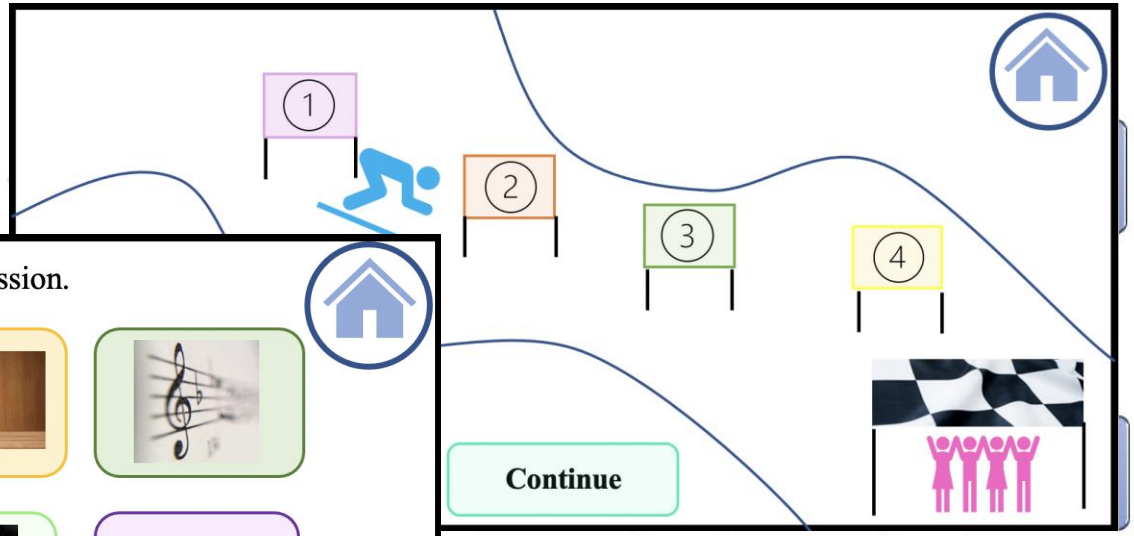




Resulting Draft of System Flowchart



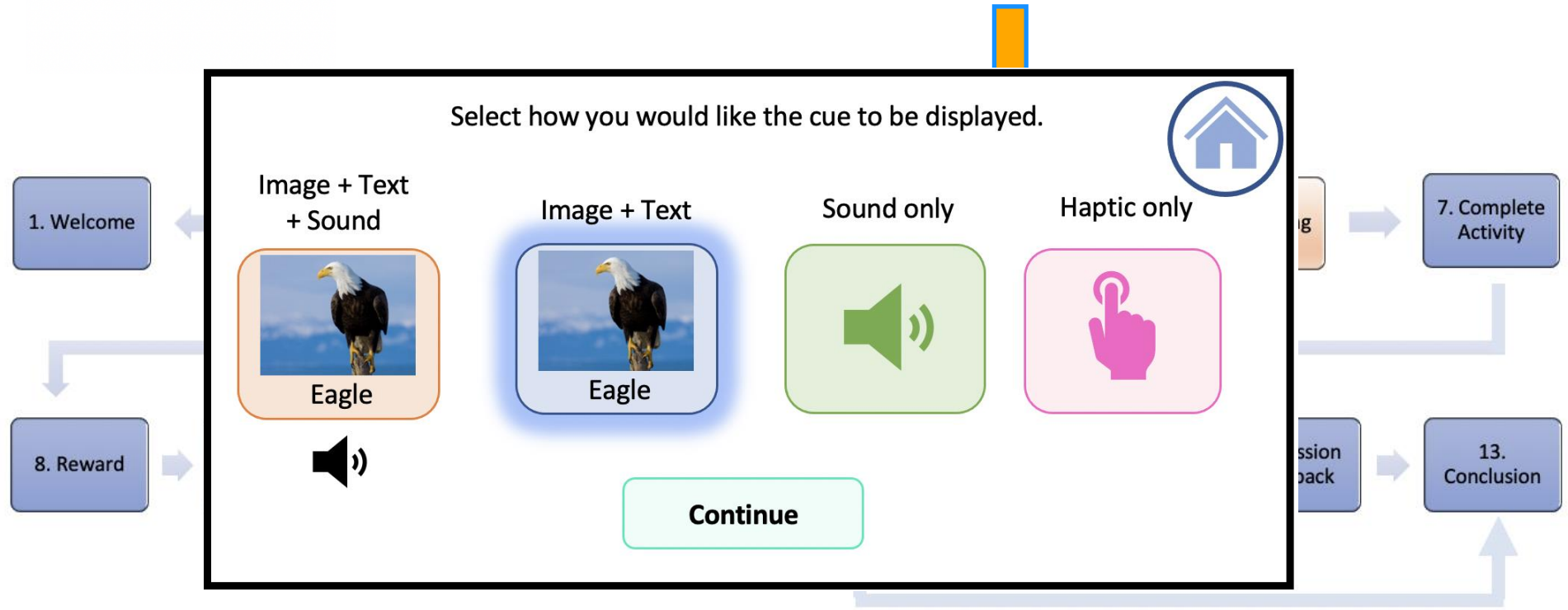
1. Welcome



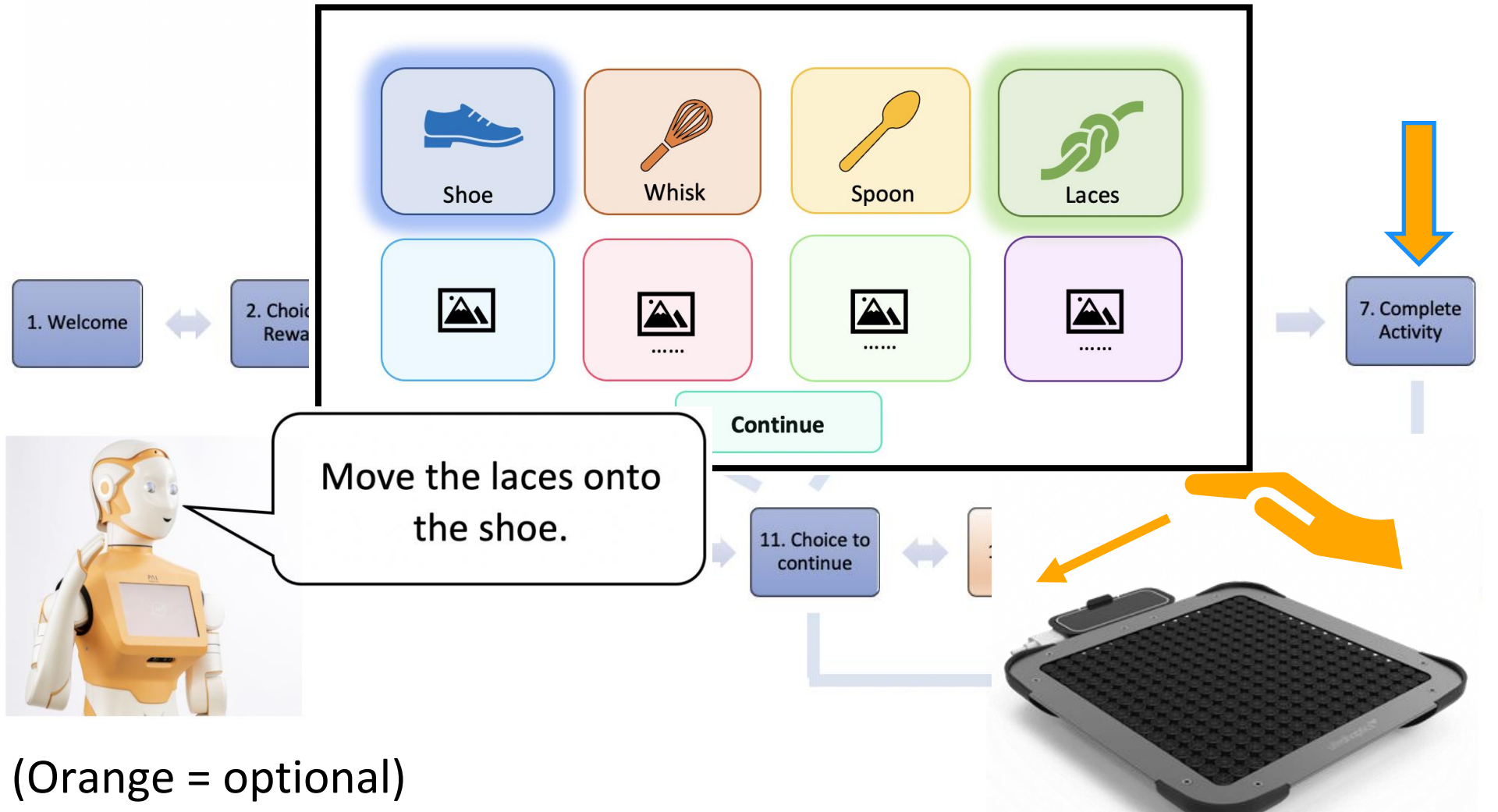
Select your rewards for this session.

Back

Continue



(Orange = optional)



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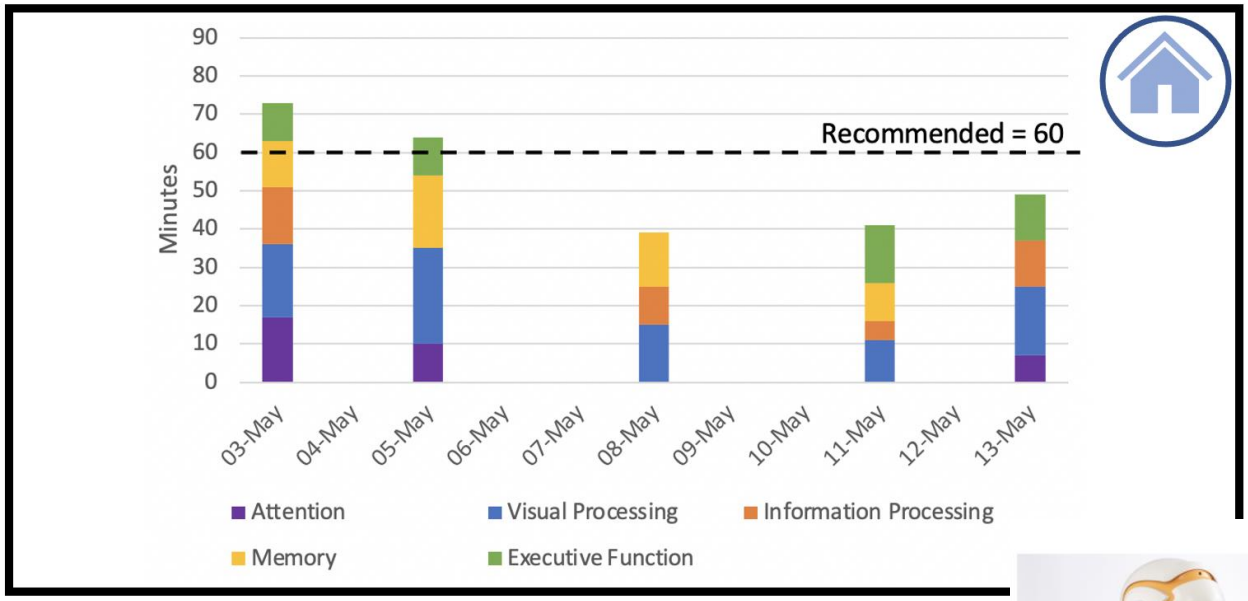

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6. Pre-rating

7. Complete Activity

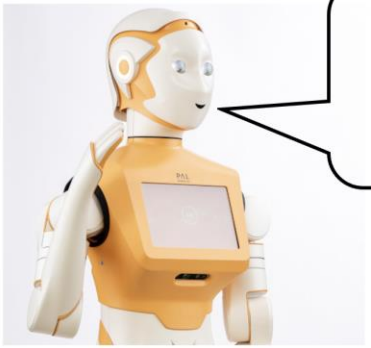
8. Reward

9. Post-rating

10. Activity Feedback Choice

10a. Activity Feedback

11. Ch cont



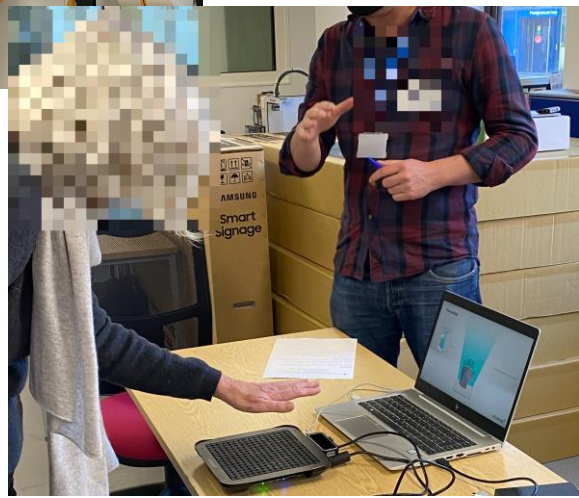
This is the longest session we've had in a while, great work!

(Orange = optional)

Future Work(1): First Prototype Evaluation

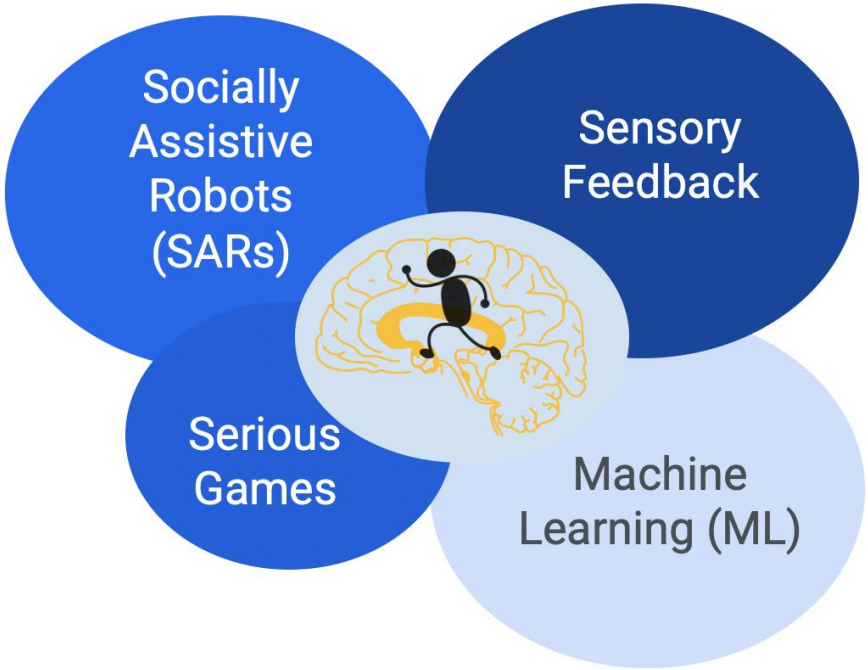
- 2 groups: Participants who did and did not participate in the PD workshop

- Implementation of the 1st prototype activities (not entire system)
- Outcomes will inform the design of the final system



Future Work (2) Long-Term Engagement Evaluation

- Implement full system
- ML to personalise based on how the interaction is progressing
- Usability evaluation in NR to test and finalise the system
- Long term evaluation: Repeated visits over 3 months in the National Robotarium



Conclusion

- Cognitive training has the potential to slow cognitive decline, which, with the growing population of older adults, could help alleviate the growing strain on the healthcare system.
- Access and engagement barriers can limit the potential impact of this therapy.
- Work completed so far:
    - a usability study regarding a basic concept for cognitive training using multimodal input via a haptic device and two robot embodiments.
    - a Participatory Design workshop that included older adults and therapists as collaborators to assist in designing an engaging cognitive training system through integrating socially assistive robots and sensory feedback.

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Questions?

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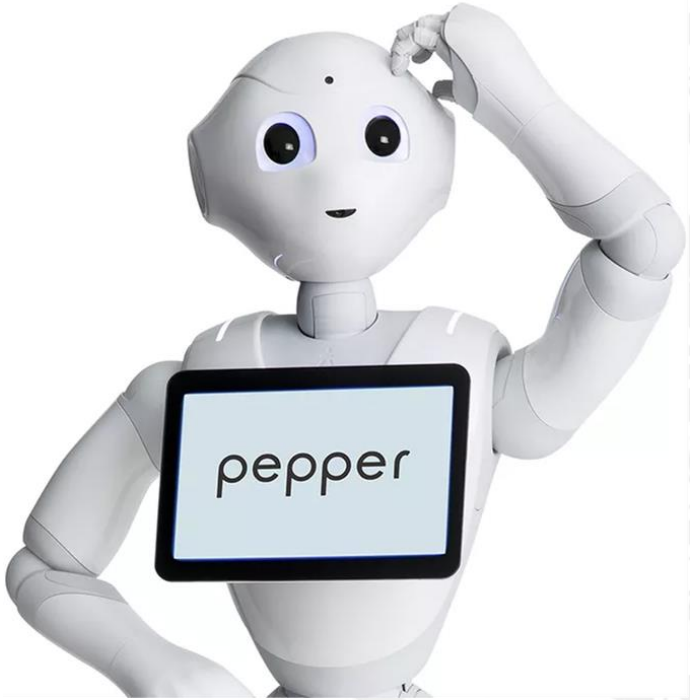

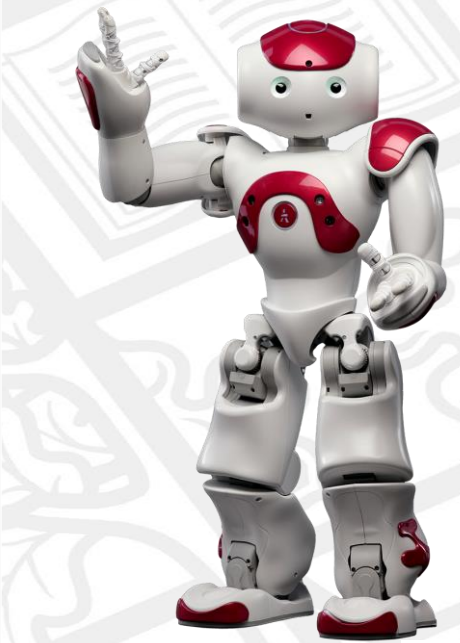

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