Personal Robots Group
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Development, Deployment and Evaluation of Personalized Learning Companion Robots for Early Literacy and Language Learning

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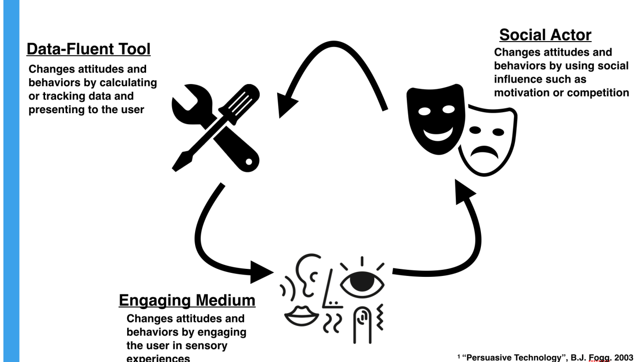
Abstract

Social robot learning companions hold great promise for augmenting parents and teachers to promote childhood learning by physically, socially, and emotionally engaging with children. One of the most important factors for language skill development is sufficient exposure to a rich variety of spoken language and vocabulary – critical precursors to learning to read. The social context of exposure is also critical to concept development and the learning experience, i.e., simply hearing language is not enough, children need to actively participate and be emotionally and physically engaged to maximize their learning gains. Through this project, we are developing **a fully autonomous, collaborative, peer-like social robot system** with effective educational activities building on top of: **multi-modal personalization algorithms** for **cognitive assessment, affective support**, and **interactive play behavior**.

Social Robots: A New Computational Medium for Practicing Language and Literacy Skills

"Functional Triad" of Persuasive Technology[1]



Social Robots score highly on all aspects of the "Functional Triad" of persuasive technology: interactive computing systems intentionally designed to change attitudes, beliefs, and behaviors

[1] "Persuasive Technology", B.J. Fogg, 2003

Scientific Background

Social robot learning companions can promote childhood learning by **physically, socially, and emotionally engaging** with children.

Language learning is "socially gated." That is, interaction with other agents improves efficiency and retention.

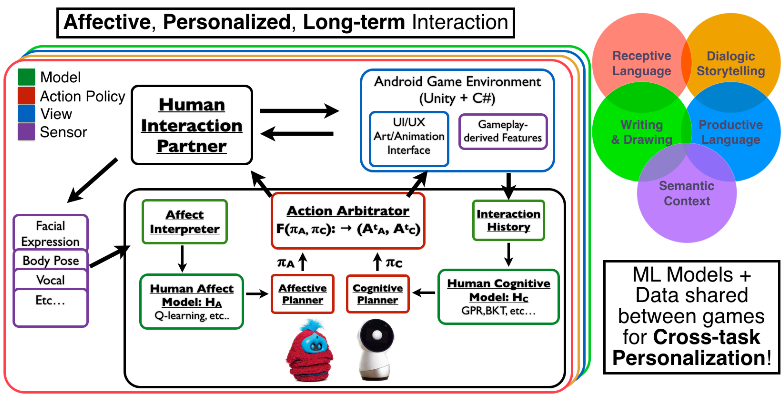
Emotions are deeply important through each step of learning: **attention, comprehension, integration**, and memory **consolidation.**

We are developing **collaborative, peer-like social robots** with effective educational activities building on top of: **personalized, multi-modal assessment and interaction models and algorithms**

Language learning is **cognitive**, **social**, and **affective**!

Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., & Gabrieli, J. D. (2018). **Beyond the 30-Million-Word Gap: Children's Conversational Exposure Is Associated With Language-Related Brain Function**. *Psychological science*, *29*(5), 700-710.

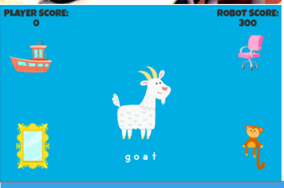
An affective-cognitive framework for interactive model learning, educational content sequencing, and



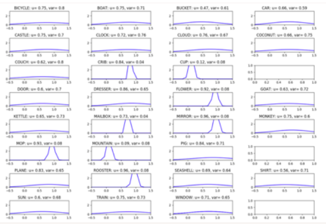
ML Models + Data shared between games for Cross-task Personalization!

RhymeRacer

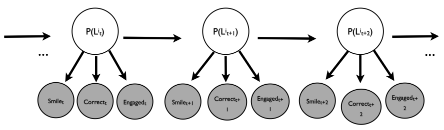
Teaching and Tracking phonological awareness through competitive play



Gaussian Process models vocabulary at word-level



Affective-BKT models rhyme-ending fluency at phonological level



Active Learning protocol personalizes content to improve data efficiency

Objective: select words with rhyme endings least likely to be known to teach

$$rhyme_{t+1} = \underset{e \in Endings}{\text{argmin}} \; P(Learned_t^e)$$

Objective: select rhyme ending with least model fit to improve model

$$rhyme_{t+1} = \underset{\theta \in \Theta}{\text{argmin}} \; LogLikelihood(\theta|D)$$

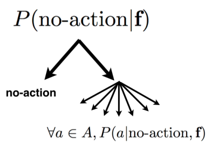
"A Social Robot System for Modeling Children's Word Pronunciation."
Spaulding, S., Chen, H., Ali, S., Breazeal, C Proc. of AAMAS 2018.

WordQuest

A collaborative, free-form vocabulary game using a mixed-initiative play model

Child and Robot collaboratively search for and pronounce words that fit a category (e.g. "vehicles", "edible")

Mixed-initiative action-selection model chooses when and how to interact



Action Space
Encourage
Re-Engage
Hint
Lesson
Answer
Prompt for Evaluation
Tease
Take Break
Skip to Next Question
and more….

Pronunciation model from RhymeRacer personalizes content difficulty

Objective: Select category based on summed posterior mean knowledge estimate of Gaussian Process word model.

$$category_{easy} = \underset{c \in C}{\text{argmax}} \sum_{w \in W} \mu_w$$

This research was supported by the National Science Foundation (NSF) under Grant IIS-1734443.