Babies can identify and respond to differences in language and social behaviors performed by a signing avatar

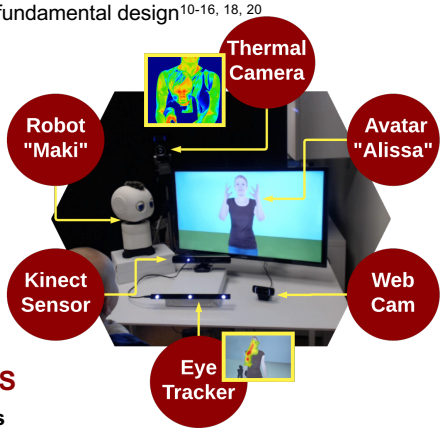
Can a Virtual Human Facilitate Language Learning in a Young Baby?

Setareh Nasihati Gilani, David Traum, Rachel Sortino, Grady Gallagher, Kailyn Aaron-Lozano, Cryss Padilla, Ari Shapiro, Jason Lamberton, and **Laura-Ann Petitto, PI***

INTRODUCTION

The RAVE (Robot Avatar thermal Enhanced language learning tool) prototype provides early language access to deaf and hearing babies who are deprived of language[14] and consequently are at risk for serious cognitive, linguistic, and social challenges later in life[9, 10, 14, 16, 18, 20]

RAVE Success Factor Inclusion of key discoveries about infant brain development and social conversations into the system's fundamental design[10-16, 18, 20]



METHODS

Participants

- N = 4, age 7-10 months, 4 hearing (1 sign-exposed)

Novel Stimuli Design

- American Sign Language (ASL) Nursery Rhymes were designed for the avatar with the specific rhythmic temporal patterning shown to match early brain sensitivity for language learning[10-15]
- Artificial agent dialogue algorithms were built to simulate Adult+Infant socially contingent conversations[8, 17]

QUESTIONS

1. Do **babies attend** to the avatar and respond to its communicative behaviors?
2. Can **babies recognize** different avatar behaviors?
3. Can an **avatar elicit** language responses from babies?

RESULTS

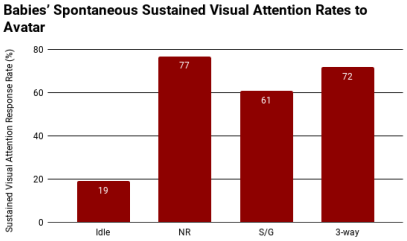


Figure 1 Babies produced sustained visual attention most to the avatar's Linguistic Nursery Rhymes and least to its Idles

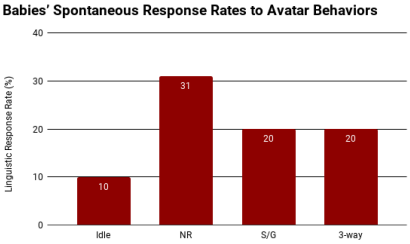


Figure 2 Babies produced linguistic responses most to the avatar's Linguistics Nursery Rhymes and least to its idles

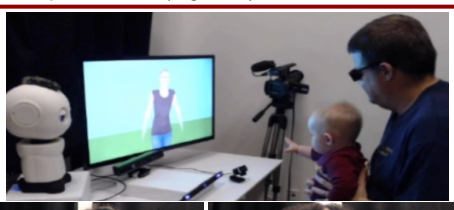
DISCUSSION

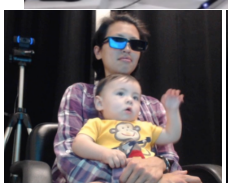
1. Babies' **attention** evidenced a preference for the avatar's linguistic and communicative behaviors over non-communicative idles, with the highest rates of attention to the Linguistic Nursery Rhymes (Figure 1)
2. Babies showed evidence that they **recognized** differences among linguistic, communicative, and non-communicative avatar behaviors (Figures 1 & 2)
3. The avatar's Linguistic Nursery Rhymes **elicited** the highest rate of baby linguistic productions (Figure 2)

CONCLUSIONS

Babies' exhibited differential attention and differential language productions to the avatar's Linguistic Nursery Rhymes over the other three categories of avatar behaviors. This suggests that our RAVE system captured

- key brain pattern sensitivities, and within the appropriate "sensitive period" in infant brain development, even though the babies did not understand the meanings of the signs
- key features of socially contingent conversations even though the avatar produced its behaviors on a screen





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Background on Human Language Development

- Human babies have peaked sensitivity to specific rhythmic temporal patterns in language within ages 6-12 months[1, 10-15, 20]. This allows them to segment, categorize, and discern the linguistic stream at the phonological level—key to early vocabulary, language, and reading success
- Utilization of the optimal rhythmic patterning with babies, ages 6-12 months, engages their brains' language processing centers[11, 13, 14]

System Details

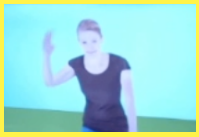
- Signing Avatar: Signs ASL nursery rhymes (NR) designed with the specific rhythmic temporal patterning of phonetic-syllabic structure in human language that infants are sensitive to within an established language learning "sensitive period" (6-12mths)[1, 11, 13, 14]
- Robot: Direct babies' attention to the Avatar
- Thermal Camera: Measures babies' emotional states to trigger different Avatar behaviors
- Eye-tracker: Measures babies' attention to system
- Thermal + Eye-tracking permitted policy design of socially contingent conversation, a necessary factor in early language learning

Four Categories of Avatar Behaviors Built into RAVE

- **Idle**: Stationary with arms at sides
- **Nursery Rhyme (NR)**: Short rhymes in American Sign Language (ASL)
- **Social Gestural (S/G):** Waves Hello, Attention wave
- **3-Way Communication:** Avatar communicates with both baby and robot simultaneously

Idle

NR



S/G

3-Way

Experimental Procedures

- Baby seated on parent's lap in front of RAVE
- Familiarization: Baby introduced to agents[7]
- Robot directs baby's attention to TV screen where Avatar produces 4 possible categories of avatar behaviors (above)
- Thermal IR Imaging camera measures baby's emotional engagement and triggers the START and STOP of the avatar's linguistic nursery rhymes containing optimal rhythmic patterning
- of Socially Contingent AI dialogue scripts with baby[8]
- Experimental time: T= ~ 4 minutes
- Video recording of baby's full range of behavioral responses to Avatar were analyzed/coded, with reliability checks (initial r=0.83, post discussion r=1.00)

Babies' Spontaneous Response Types

- **Sustained Visual Attention (SVA):** SVA to Avatar >1.00 sec
- **Linguistic:** Manual babbling, copying, proto-signing
- **Social/Gestural**: reaching, smiling, waving arms

***Corresponding Author** Dr. Laura-Ann Petitto
Laura-Ann.Petitto@Gallaudet.Edu

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References in Paper