System Fault Tolerancing and Self-Reported Usability of a Closed-Loop Robotic System for Reading Comprehension Skill Development in Children Who are Deaf or Hard of Hearing

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Introduction

- Children who are deaf or hard of hearing often suffer from low literacy and reading comprehension rates [1]
- There is a lack of easily implemented intervention for reading comprehension [2]
- Socially Assistive Robotics (SAR) can be used for reading comprehension development [3]

Methods

Participants

- 10 non-age matched, unimpaired, typically developed participants (5M, 5F, 21.2±.42)

Equipment

Fig 1. *Image of Rapiro with 3-D Printed Head and Android Phone Labeled*

- Commercially available social robot Rapiro (Fig. 1)
- Android Phone (Fig. 1)
- Kodular Software used to develop application to facilitate social interaction
  - Used to access the phone's voice recognition software, internal clock, and filing system
- System Usability Scale (SUS) [4]

Goals of this Study

- **Long-term Goal: Mitigate lack of reading comprehension interventions through use of a closed-loop social robot system**
- **Pilot study focuses on quantifying and qualifying errors made by the robot during reading interaction and also measuring perceived usability of the system**

Procedure

- AB/BA Crossover Design
- Phase One: Technology Use
- Phase Two: Reading
  - Two passages with queries (either on paper or with robot)
  - Voice Recognition used to provide feedback on answers to queries
  - Slight time delay between passages
- Phase Three: System Usability Scale (SUS) (Fig. 2)

	The System Usability Scale Standard Version	Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system.	O	O	O	O	O
2	I found the system unnecessarily complex.	O	O	O	O	O
3	I thought the system was easy to use.	O	O	O	O	O
4	I think that I would need the support of a technical person to be able to use this system.	O	O	O	O	O
5	I found the various functions in the system were well integrated.	O	O	O	O	O
6	I thought there was too much inconsistency in this system.	O	O	O	O	O
7	I would imagine that most people would learn to use this system very quickly.	O	O	O	O	O
8	I found the system very cumbersome to use.	O	O	O	O	O
9	I felt very confident using the system.	O	O	O	O	O
10	I needed to learn a lot of things before I could get going with this system.	O	O	O	O	O

Fig. 2. *Standard Version of System Usability Scaled used to measure perceived usability*

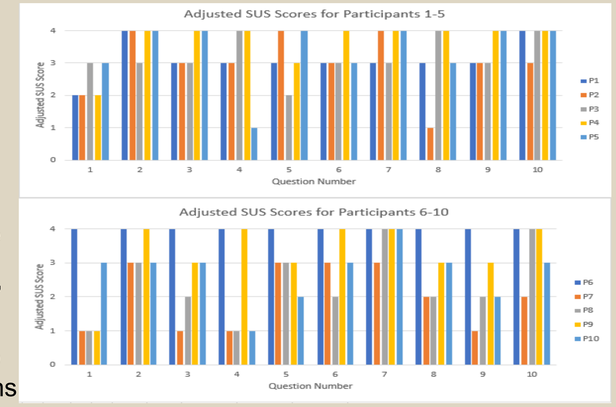
Results and Discussion

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Errors Visable to the User										
Inappropirate Cut-off	6	2	4	3	1		3	13	3	4
Delay in Speech Recognition Processing		2					2			2
Does not recognize speech and does not record	2	3		1	3	2	4	2		8
Records but does not recognize speech	1	1		2					1	
Unmatched Mouth Movements	1	1	1	1	1	1	1	1	1	1
Gives incorrect feedback/Directions			1		3		1		1	3
Not Enough Time to Respond						1	1			
Errors not Visable to the User										
Word Word Recognition	13	12	14	3	13	6	7	4	6	5
Missing Data		4	2	2			3	10	2	20
Total Visable Errors	10	9	6	7	8	4	12	16	6	18
Total Non-Visable Errors	13	16	16	5	13	6	10	14	8	25
Total Errors	23	25	22	12	21	10	22	30	14	43

Table *I. Errors Present during Pilot Testing per Each Participant*

- Low amount of visible errors
- Very few errors took place during the query portion

Fig. 3. *Adjusted SUS Scores Plotted for Each Question*



- SUS Average: 77
- Rated as a "B" on grade scale or "Acceptable" when compared to other systems

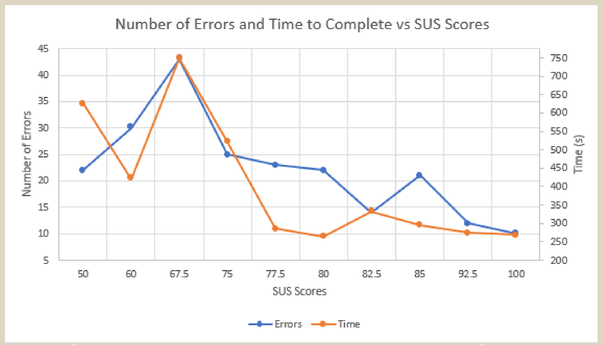


Fig. 4. *Plot of Total Errors and Time to Complete (seconds) vs Adjusted SUS Scores*

- Study suggests successful use of social robot for comprehension testing during query portion
- System found to be acceptable and falls within the 3rd quartile compared to other systems rated with the SUS [4]
- Future work will include age-matched participants & possibly an upgraded API

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[4] (2016). *Quick Statistics About Hearing*. Available: https://www.nided.nih.gov/health/statistics/quick-statistics-hearing