# Developing a Coding System for Social Robot Interactions with Patients of Motor and Cognitive Impairment


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## Introduction

- Approximately 50 million individuals worldwide suffer from dementia, a chronic, progressive syndrome [1].
- Prolonged absence of stimulation increases social isolation; this can be combated by use of social robots in treatment [2].
- Ensuring suitability for patients at all cognitive levels allows robot rehabilitation treatment to support dementia patients.
- Supporting patients at all motor functionality levels allows optimal applicability for robot rehabilitation techniques.
- Manual video coding produces authentic and robust data for analysis of clinical interactions.
- **Objective: To develop a methodical coding system for assessing video footage of human-robot interactions (HRIs) for engagement, experience, and performance between a socially assistive robot system and patients of varying motor and cognitive abilities.**

## Goals

1. Study what happens socially when cognitively impaired patients interact with a socially assistive robot
2. Investigate how to report performance on cognitive and motor assessments administered via a socially assistive robot
3. Establish metrics and coding scheme for evaluation of engagement, success, and other measures within human-robot interactions

## Social Robot Design and Assessment Tasks

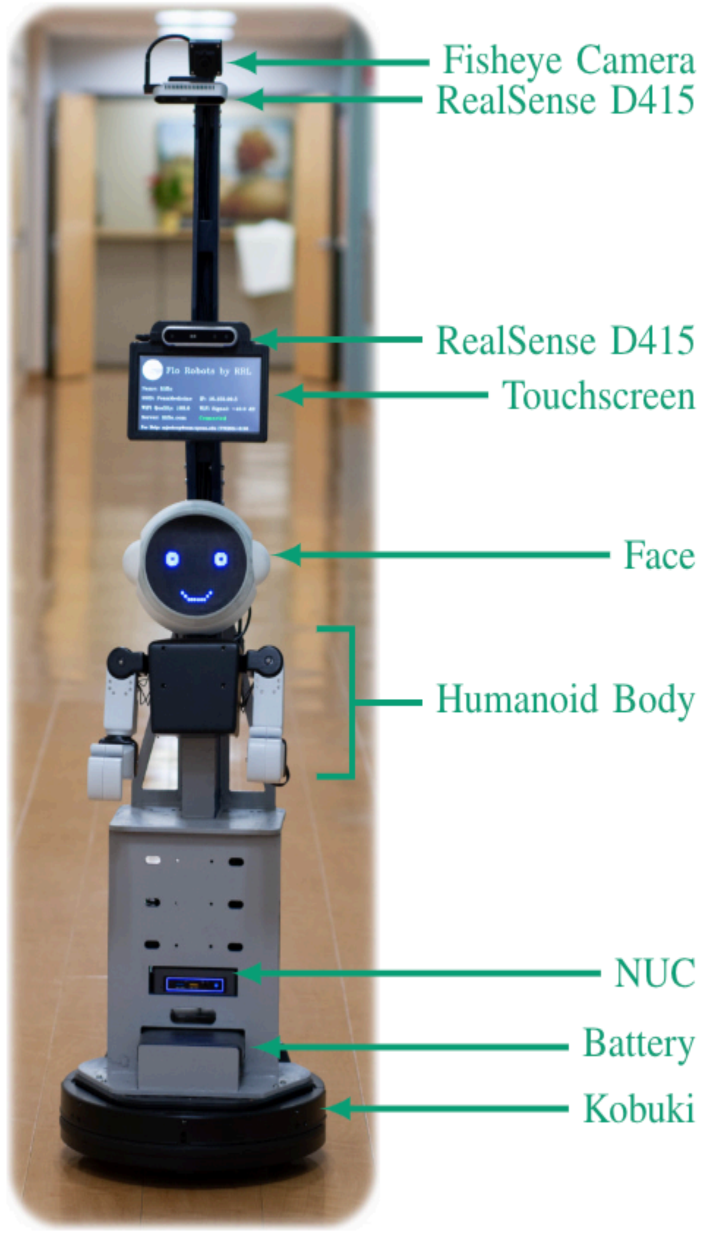


Fig 1. Lil' Flo: socially assistive humanoid robot

- Trials involved 2 assessment tasks

- Simon Says:
- Instructions for physical actions that mimic activities of daily living (ADLs)
- Tests range of motion
- Tests executive function and working memory

- Target Touch:
- Instructions to touch a sequence of prescribed colored dots on robot hands
- Tests motor function of arms and hands
- Tests working memory for instruction sequences
- Tests attention and motivation

## Methods

### CODEBOOK DESIGN PROCESS

- Video coding with a properly curated codebook addresses limitations and subjectivity associated with other analysis techniques (surveys, rating scales, etc.)
- Drew upon literature of video coding similar HRIs among similar impaired populations
- Followed industry-standard procedure for codebook development:

| | |
|---|---|
| - Cycle to repeat 2-4 times: Draft, test, refine | - Designate exhaustive codes |
| - Directly align codes with research objectives | - Eliminate redundancy or conflict between codes |
| - Have clearly-defined definitions for all codes | - Define passes coders must make |
| - Specify time dependency of codes | - Meet with coders to discuss codebook and eliminate ambiguity |

- Video Coding Protocol – Interpreting Observed Emotion (VC-IOE) Scheme [3] reflects many relevant dimensions; became suitable foundation
  - Targeted towards engagement of dementia patients in HRIs but applies to all populations
  - Accounts for **blunted affect**: reduced emotionality stemming from dementia
  - Adopted and refined dimensions on (1) verbal engagement, (2) visual engagement, (3) emotional response, (4) collective engagement
- Added dimensions on (1) observed motor limitations, (2) performance level in assessment tasks, (3) interplay of roles of robot and operator respectively

**SS** Subject's success in assessment task [time-based, code when assessment task is taking place- between whichever comes first: end of prompt or start of action, and start of next prompt] **low time-sensitivity**

A. **Performing task successfully (SU):** fully and successfully participating in assessment tasks, not requiring repetition or additional prompts (even if prompts are given in an unsolicited manner)
B. **Perform task successfully after requiring repetition (SUR):** subject performs the directions accurately after a repetition of the direction is given (via SAR or operator)
C. **Perform task successfully after requiring correction (SUC):** subject performs the directions accurately after a modification or correction is given (via SAR or operator)
D. **Unsuccessful (US):** subject fails to accurately perform the directions given
E. **Did not attempt (DNA):** subject does not attempt the directions given

*Fig 2. One of the 12 coding dimensions in the developed system with its specific time-dependency and the corresponding subcodes with individual definitions*

### ANALYZING SOCIABILITY

- Coding subjects' display of emotion for entire duration of trial (exhaustive coding dimension) reveals trends in sociability of robot
- Can be linked to cognitive and motor dimensions to stratify sociability amongst patient categories
- Comparing coded roles of robot and operator with subject emotion indicates social acceptability of robot (non-traditional rehabilitation entity)

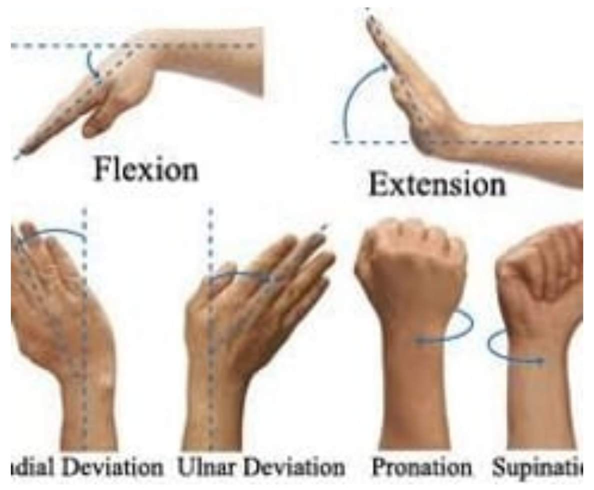


*Fig 3. Diagram of full range of motion cues in the hand* [4]

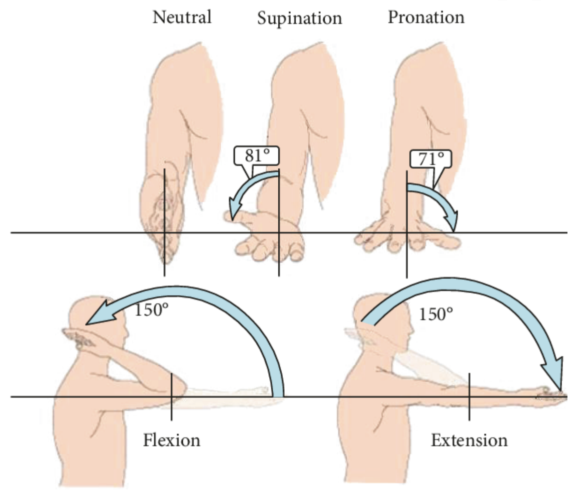


*Fig 4. Diagram of full range of motion cues in the elbow* [5]

### ANALYZING COGNITIVE FUNCTION

- Coding quantifies subjects' **emotional response**, **cognitive performance**, **ability to interact** with robot, etc. for analysis
- Reveals acceptability of robot rehabilitation methodology for patients at various cognitive levels
- Ex: linking dimensions of subject success and subject emotion provides valuable data for analysis

### ANALYZING MOTOR FUNCTION

- Limitations of **shoulder**, **elbow**, **hand**, and **trunk** are coded for in video data
- Evidence of motor limitations seen in assessment tasks
- Recording video footage allows for documentation of range of motion progress or decline

### SOFTWARE

- Video coding software Datavyu and MaxQDA were tested and compared
- MaxQDA was selected due to suitability for codebook design, ease of use

## Implementation

### CODED DATA

- Codes are dragged and dropped onto specific intervals of video footage
- Several codes can be applied to any given video segment
- Duration or frequency of codes can be extracted as data for analysis
- Coders are recommended to use several **coding passes:** focusing on 1-2 coding dimensions at a time while viewing the video footage

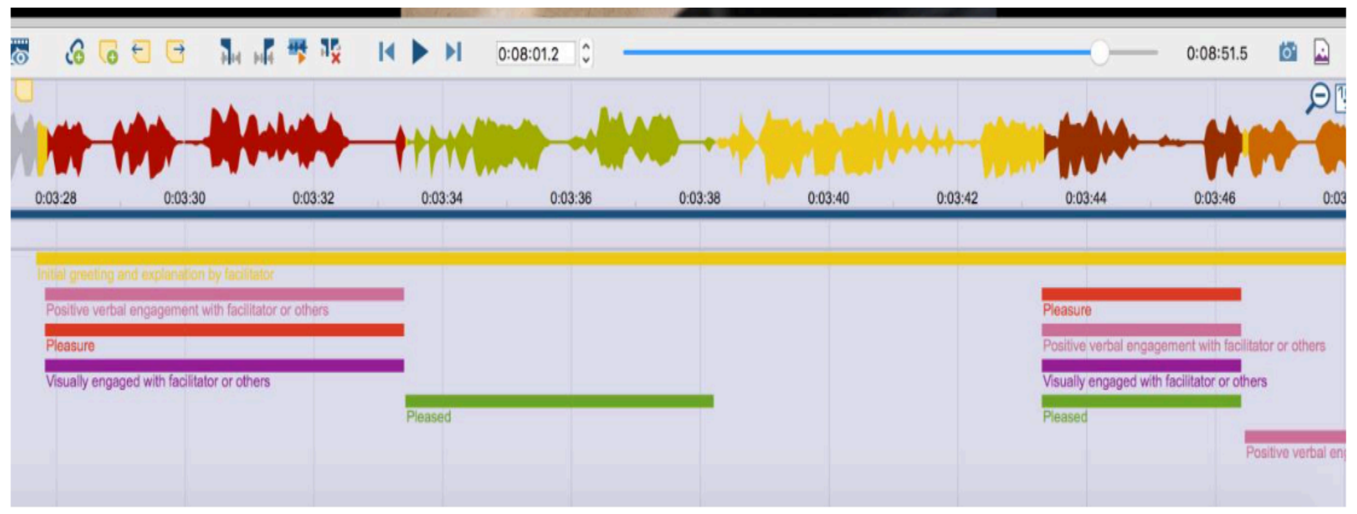

*Fig 5. Coded data on MaxQDA*

### EXPORT

- Exported coded data can be analyzed using various statistical analysis measures
- Linking coding dimensions allows for multi-faceted conclusions and testing of complex hypotheses
- Following standard coding practices allows reliable and objective data to be derived directly from human trials

### INTERCODER RELIABILITY

- To mitigate subjectivity and establish credibility, several coders must work on video data
- Metrics for intercoder reliability reveal agreement
- Must meet predetermined threshold (typically >90% agreement)

## Conclusions

- The curated codebook is now ready to be utilized for manual video coding and thus assessed for functionality and applicability to footage from trials with socially assistive robots
- The codebook can be used as a baseline to be adapted for other studies on SAR interactions, especially those involving motor and cognitive assessment tasks

## Acknowledgements


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## References


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