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Assessing Social Competences of a Robotic Conversational Agent

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By employing a multimodal approach encompassing the analysis of behavioral and physiological data, our project aims to contribute to the broader understanding of the intentional stance and the social competence of artificial agents. We strive to shed light on the intricate mechanisms underlying human-robot conversational interactions, paving the way for future advancements in this burgeoning field.

Index Terms—HRI, social cognitive neuroscience, robotics, natural conversations

I. STATE OF THE ART

Recent debates regarding the social competence of artificial agents, including conversational agents grounded in large language models (LLMs), echoes the question posed by Alan Turing in 1950 “Can machines think?” [8]. Interestingly, the “Imitation game” presented by Alan Turing doesn’t assess machines production directly but their perception by humans. As the field of robotics has experienced remarkable technological advances in the last decades, this question resonates with researchers investigating embodied artificial agents [10]. For numerous roboticists, the anthropomorphic design of these robots has been deemed sufficient for their acceptance as viable partners for humans. Nevertheless, a distinct viewpoint has emerged with insights derived from social cognitive neuroscience [9]. The Total Turing Test [3], an extension of the classic TT, is proposed to investigate the social competence of embodied conversational agents by assessing humans recognition of the artificial nature of these agents based on the ability of artificial agent to elicit social behaviours in their interaction with humans [5].

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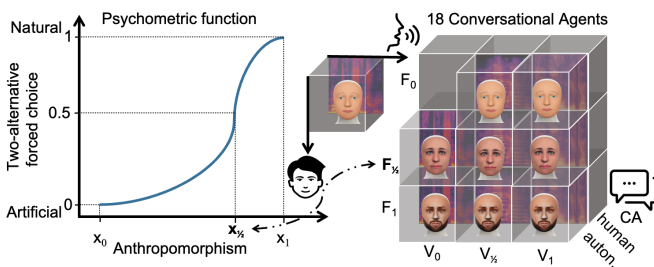


Fig. 1. Defining the 18 conversational agents used in the Total Turing Test in terms of anthropomorphism.

II. HYPOTHESES

Within this project, we aim to assess social competence exhibited by a conversational robotic head through the examination of brain activity. Our objective is to quantify the extent to which the robot elicits natural cognitive mechanisms by analyzing responses in cortical regions specialized for distinct bottom-up (auditory, visual) and top-down (context, prosody, appearance) dimensions of social interactions, namely, the appearance of the face, the tone of the voice and the speech produced, and probe the response in a number of brain areas that are directly related to the processing of these dimensions [2]: Fusiform Face Area for face perception (FFA [4]), Temporal Voice Areas for voice (TVAs [7]) but also speech perception, and in areas involved in mentalizing (the attribution of internal mental states) such as the Temporo-Parietal Junction (TPJ [6]). We then aim to quantify the social competence of the humanoid robot as the response of these areas to the parametric modulation of the three cognitive dimensions (Figure 1) controlled experimentally.

III. METHODOLOGY

A robotic head from Furhat robotics (Al Moubayed et al., 2012) is used for this corpus to analyze three different dimensions: (i) Faces (Facial expressions). We’ll use videos from a human and a robot, recorded at 30Hz, and analyzed them separately using OpenFace[1]. The OpenFace output is in .csv format and contains 1800 observations. The .csv file includes 68 facial landmarks, 17 facial AUs, 3 gaze movement features, and 6 head pose attributes obtained through pretrained models (Wood et al., 2015). (ii) Voices (Speech modulation). The denoised participant and interlocutor speech data will be segmented into inter-pausal units (IPUs) which will be defined as blocks of speech bounded by silences of at least 200 ms duration (Blache et al., 2009). Visual inspection of denoising and segmentation will be performed using Praat oral speech processing software (Boersma I& Weenink, 2001). The audio files and segmentations will be uploaded into SPPAS 1.9.9, Bigi, 2015). Face and voice stimuli will contribute to preparing a number of simple stimuli. (iii) Behavior (RA, mental states). We will develop an autonomous Robotic Agent (RA) to control the robot’s speech output using advanced language generation tools and transcriptions from the first corpus (more than 10 hours of recorded conversations within the same experimental framework). This combination will involve prompt engineering and fine-tuning to enhance the RA’s human-likeness. This might include encouraging the use of specific phrases like “I think that...” and removing references to the agent being artificial, such as “As an AI, I can’t...”. Additionally, we

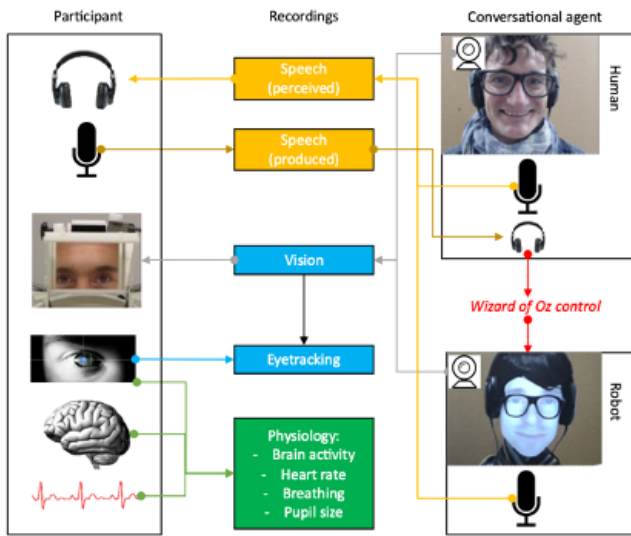


Fig. 2. Synchronized experimental recordings.

will work on personifying the agent by giving it traits like gender, a name, or a distinct personality. To facilitate a direct comparison between brain and behavioral responses to natural and autonomous RAs, we will automatically transcribe human speech and playback the robot’s speech using the same speech synthesis as the autonomous RA. The RA’s behavior will be categorized as either Human or Autonomous.

IV. EXPERIMENTAL SET-UP

The fMRI audio set-up allowed live conversation between the scanned participant lying in the scanner and the agent outside. It consisted of an active noise-cancelling MR compatible microphone (FORMI-III+ from optoacoustics) mounted on the head coil and insert earphones from Sensimetrics. This microphone allowed live exchanges as well as recordings of the speech from the participant after active denoising. Live video of the interacting agent (human or robot) is captured by two webcams. Participants’ direction of gaze was recorded (Eyelink 1000 system). Stimulus presentation, audio and video routing and recording, synchronization with the fMRI acquisition triggers and the eye tracker were implemented by Bruno Nazarian in Labview. Finally, blood pulse and respiration were recorded with built-in Prisma Siemens hardware and data format (see Figure 2).

V. EXPERIMENTAL PARADIGM

The participant initiated the conversation, instructed to talk freely with the other agent about the image and their suggestions on the topic of a cover story. One block lasted 76.2 sec and one session 8 min of continuous fMRI recording. We recorded 3 min of conversation per interlocutor and session, for a total of 24 min of conversation per participant.

VI. EXPECTED RESULTS

This project is framed in the previous research of Dr. Thierry Chaminade and would yield the first dataset of synchronized neuroimaging, physiological and behavioral data a

natural robot-human interaction with a corpus of synchronized behavioral and neurophysiological (with fMRI) conversations matched with behavioral and physiological features of human-likeness in an autonomous social robot.

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