Eye-tracking measures for Anthropomorphism in Human Robot Interaction

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ABSTRACT

We present a study that investigates the relation between anthropomorphism and gaze patterns of the observers. Anthropomorphism usually refers to attributing human-like characteristics by a human to a non-human agent/entity; in this study, the non-human entity is a robot.

We hypothesize that while observing a human-robot interaction in a particular setting, the observer develops an anthropomorphic behavior for the robot. Moreover, the resulting anthropomorphism can be correlated with the gaze patterns of the observer as well as with the recorded response of the participants about their experience of the interaction (in the form of a questionnaire), both before and after the experiment. We try to seek the answer to the question whether anthropomorphism goes beyond the shape and body features, and we indeed observe that just by the use of audio commands of different cognitive levels, anthropomorphic attitude gets affected. We obtain two other useful results. First, eye tracking serves to be an effective way for measuring anthropomorphism. Second, in our study, the standard anthropomorphism tests are also validated such as, a person who can anthropomorphize more, in general, responds to a human scene and a robot scene in a similar manner.

We observe a significant increase in the gaze fixations over the actor's head for a high cognitive scene compared to a low cognitive scene. We also achieve the result that the high cognitive interaction scenarios are capable of inducing anthropomorphic behavior more than the low cognitive scenarios.

Keywords

anthropomorphism, eye tracking, gaze patterns, robot

1. INTRODUCTION

It is widely accepted that anthropomorphism describes a set of human-like features of a robot (like shape, speech capabilities, facial expression). Lemaignan et al. [1] refer to these characteristics as the anthropomorphic design of the robot . Anthropomorphism, as described by Lemaignan et al., refers to the social phenomenon that emerges from the interaction between a robot and an user. According to Epley et al. [2], this includes for instance emotional states, motivations, intentions ascribed by the user to the robot. Anthropomorphism is seen as a special kind of social (human-like) engagement with robots. We made an attempt to analyze anthropomorphism in a *human-robot* interaction by utilizing the gaze patterns of the participants (who watched this interaction). These gaze patterns were compared to the gaze patterns for a similar *human-human* interaction setting. The "human" part of the human-robot and human-human interactions mentioned above is only in the form of an audio command and not physically present in the scene. Hence, we represent the interactions with $\mathcal{R}$ and $\mathcal{H}$ in this report for the human-robot and human-human settings respectively.

There were four hypotheses made in this experiment. We hypothesized (**H1**) that the gaze patterns can distinguish between $\mathcal{H}$ and $\mathcal{R}$ interaction scenarios. Further, this gaze pattern difference can be denoted as the distribution of gaze on areas of interest in the scene. Secondly, we hypothesized (**H2**) that the difference in gaze patterns between $\mathcal{H}$ and $\mathcal{R}$ conditions ($\delta_{\mathcal{H},\mathcal{R}}$) correlate with the participants' *initial capital of anthropomorphism* (ICA), where the ICA was measured as the sum of the ratings (responses) given by the participants to the questions of the pre-questionnaire. This means that for participants whose ICA is low, the gaze patterns should be significantly different for the $\mathcal{R}$ as compared to that for the $\mathcal{H}$ videos and vice-versa. We also hypothesized (**H3**) that the gaze patterns can distinguish between high-cognitive and low-cognitive tasks. Finally, we hypothesized (**H4**) that the cognitive priming will have an effect on the difference between ICA and *adaptive anthropomorphic perception* (AAP) *i.e.* $\Delta_{ICA,AAP}$ (where AAP is measured for the post-questionnaire in a similar way as the ICA).

We used stationary eye tracking technique for tracking the gaze patterns and "Nao"[3], a robot manufactured by Aldebaran Robotics was used in this experiment. We prepared the scripts for the robot using Choreographe. The interactions were recorded as videos and were then shown to the participants. The scenarios that were covered in the videos were aimed at eliciting the human-like or high-cognitive (HC) feelings for the robot in one setting and robot-like or low-cognitive (LC) feelings in the other setting. For example, we had a scene, where the robot is asked by the human to *"pick up the brown toy"* and in another scene, with the same video, the robot is asked to *"pick up its favorite toy"*. We tried to keep our distribution of participants uniform across all variations of the scenarios to avoid any biases to our results. The change in the feelings of participants were recorded in the form of response to two questionnaires before and after the experiment. The difference in the response of the two questionnaires was used to measure the impact the videos had on the participants.

As mentioned earlier, the human element in the $\mathcal{R}$ interaction was in the form of only a human voice, basically a command given by the human to the robot. This command (*e.g* "pick up the brown toy") was used to prime the context thereby classifying the scenario as LC or HC. Initially we had three different scenarios where the robot/human was asked:

(i) to pick up a toy
(ii) to point to a sound/noise
(iii) to show some movements (or dance)

Differing from first two scenarios, the third scenario had only one object in the video i.e. the actor (human or robot). In the first two scenarios, a participant could make gaze transitions, say, between the robot and the toys for the first scene. In contrast, in the third scene, a participant could only look at the robot showing its movements. The third scene, hence, was more related to observing the various body movements and was not helpful in identifying differences in gaze patterns based on LC and HC scenarios and therefore, we did not consider it for our study. First, a pilot experiment was conducted with a small number of participants and then a full-fledged experiment was carried out.

2. RELATED WORK

In a human-robot interaction, studying anthropomorphism would essentially mean the assessment of human's tendency to engage in a human like way with robots (that are not deliberately made to buttress such relationship). In broader terms, anthropomorphism can be understood as the phenomenon between a human and a non-human, where the human tends to attribute human characteristics to the non-human in order to establish a meaningful contact[4]. But there have been a plethora of definitions of anthropomorphism not only across but within disciplines(Duffy, 2002)[5]. Even within HRI (human robot interaction) and robotics, there has not been a single unique definition of anthropomorphism, but a variety of them. Bartneck et al. (2008, p. 74)[6] refer to it as *"the attribution of a human form, human characteristics, or human behavior to nonhuman things such as robots, computers, and animals."* Contrarily, Waytz et al. (2010)[7] apply a more psychological-cognitive view and define anthropomorphism as *"a process of inductive inference whereby people imbue the real or imagined behavior of other agents with human like characteristics, motivations, intentions, or underlying mental states"*.

Etymologically, anthropomorphism is a term composed of two Greek words : *anthropos* for "man" (or "human") and *morphe* for "from / structure" (or "shape"). Although anthropomorphism" literally would mean "human form", it should *not* be used to refer to the *form/ design* of a non-human agent. The term **anthropomorphic design** would rather be a better choice to refer to imitating human-like form / design of a robot. Bartneck and Forlizzi (2004b)[8] recommend that *form* refers not just to the physical shape of a robot but to all ascertainable parts of it. Therefore, "form" could be seen as the overall expression of the robot, that includes its shape, materials, and behavioral characteristics. Anthropomorphic form can be broadly classified, but there is no fine line dividing these categories: anthropomorphic, caricatured, functional, zoomorphic, (Fong et al., 2003a)[9].

Another key aspect in the discussion of anthropomorphism is the change in people's perception of robots over their time of interaction with robots. And as the perception changes, the tendency to anthropomorphize the robot is likely to change. Such a gap related to the perceived agency of the robot was discussed by Takayama (2012)[10]. She noticed that among people who own a robot, while some people perceive their robot as an agentic object, others feel it as only a plain machine. In order to distinguish between these two patterns and make sense out of them in relation to people's perception of robots in general, Takayama differentiated between what she calls an *in-the-moment* and a *reflective* perspective on agency. Hence, an *in-the-moment* perspective would refer to one's most immediate response/sense in a given situation. On the other hand, a *reflective* perspective would indicate one's reaction/sense of a situation based on a more in-depth consideration and contemplation (Takayama, 2012)[10].

Quite often, these two distinctions are not considered differently, leading to errors and confusions. In other words, in an initial phase of interaction with a non-human agent, people might respond "mindlessly" instead of responding consciously (Nass and Moon, 2000)[11]. Only post a due amount of time of, what is generally called as "familiarization" with the robot, one might respond in a more reflective manner instead of an in-the-moment reaction. This can be demonstrated by the fact that when participants who had interacted with a technology, were asked about whether the interaction with the technology was in a human-like way, most of them denied this which shows the reflective perspective . However, the same participants had actually reacted (in the moment of the interaction) to the system in many ways that were quite close to how they would react to people (Reeves and Nass, 1996)[12].

3. STUDY

We report on a study conducted to find the relation between anthropomorphism and gaze patterns while observing a human robot interaction.

3.1 Variables

3.1.1 Independent Variables

As stated earlier, the videos were identical in all respects but the commands used for priming in the LC and HC scenarios.

So, we had the following independent variables.

High-cognitive vs Low-cognitive. This variable was kept between subject, i.e., a participant was either shown a LC or a HC scenario, not both. So, out of the 40 participants, 22 watched the HC tasks and 18 watched the LC tasks.

Human-Human vs Human-Robot Interaction. This variable was kept within subject, *i.e.* a participant watched both human as well as robot videos for either LC or HC task. To avoid any order effect among the human and robot videos for a participant, we had an equal distribution among participants where 20 of them watched human videos before the robot videos and the other 20 watched the videos in reverse order (robot videos before human)

3.1.2 Dependent Variables

We have a dependent variable that is the difference between the ICA and AAP. This represents how much a participant has been affected by watching the videos because it reflects the difference in the response of a participant in the pre and post questionnaires.

3.1.3 Gaze variables

Areas Of Interest(AOI). Among the two scenarios, the first was one was about the robot/human picking up a toy and the second one about pointing to the noise. As seen in figure 1(b), in the first scenario, we had 10 AOIs: 1 for the actor's (robot/human) head, 2 for arms (left and right), 2 for hands, 2 for legs and 1 for torso, and also 2 for the two toys (green and brown). Similarly, as shown in figure 1(c), we had 10 AOIs for the second scenario, where the 2 AOIs for toys were replaced by two speakers that produced sound. We fetched the gaze patterns that fall into one of these 10 AOIs and analyzed the gaze distribution among them.

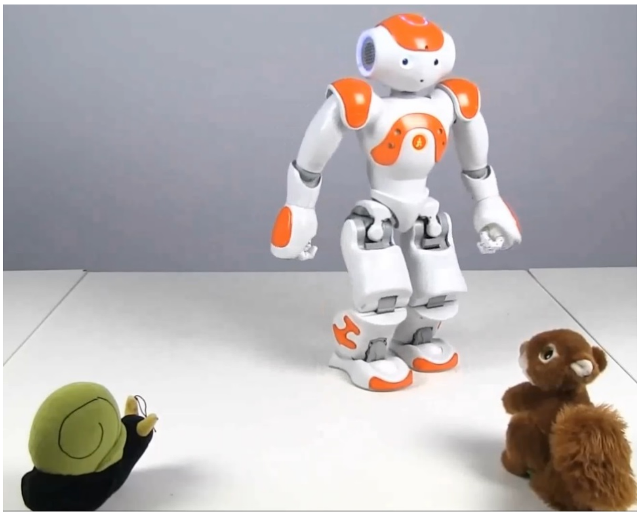
Proportion of time on the AOIs. We fetch only the gaze patterns that fall into one of these 10 AOIs and analyze the gaze distribution among them based on the proportion of time spent in viewing each of these AOIs. This helps in drawing comparisons between various objects present in the scene.

Difference in gaze patterns. An important data to be obtained here is $\delta_{H,R}$. This is calculated by taking the difference between the ratio of net dwell time of an AOI and the AOI fixation coverage summed over all the AOIs in the scene. Hence, $\delta_{\mathcal{H},\mathcal{R}}$ is expressed as a ratio in the range of 0 to 1. Similarly, the differences between gaze patterns of two participants, where one watches the LC task, given by $\delta_{low}^{\mathcal{H},\mathcal{R}}$ and the other watches the HC task, given by $\delta_{high}^{\mathcal{H},\mathcal{R}}$ are important gaze variables.

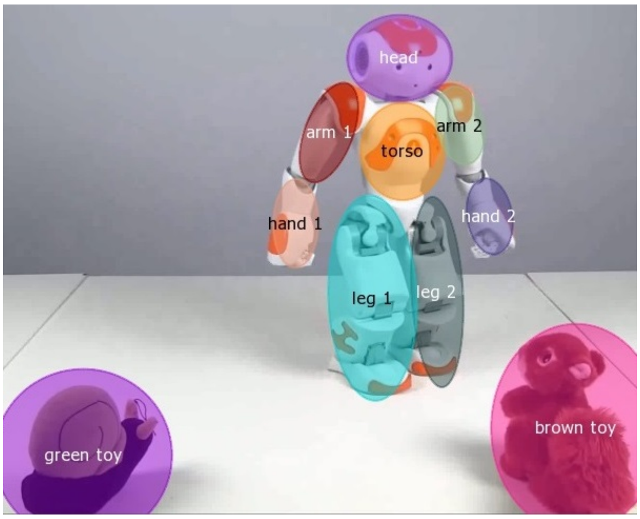
3.2 Data Collection

3.2.1 Video Stimuli

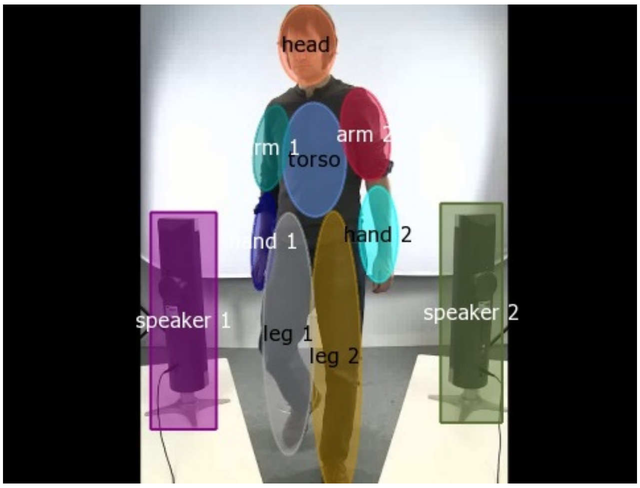
Participants were made to watch the $\mathcal{R}$ and $\mathcal{H}$ interaction videos. There were two scenarios of interaction, each for $\mathcal{H}$



(a) $\mathcal{R}$: Toy Scene (without AOIs)



(b) $\mathcal{R}$: Toy Scene (with AOIs)



(c) $\mathcal{H}$: Sound Scene (with AOIs)

Figure 1: Areas of interest (AOI)

and $\mathcal{R}$. Hence, there were a total of 4 videos to be watched by each participant. These 4 videos were replicated in 2 sets : HC and LC tasks, out of which only one was shown to a participant. The videos for a scenario were identical in all regards except that the length of human videos was 57 seconds whereas it was 110 seconds for the robot videos. This difference of duration was because of the fact that the robot usually took longer time to perform an action as compared to human. The difference in the HC and LC videos was only of the initial audio command that was given to the robot or human. For example, in a LC task, the command was *"Pick up the brown toy"* whereas in HC, it was *"Pick up your favorite toy"*. Otherwise all the videos had the same architecture starting with a human voice command followed by the response from the robot/human.

3.2.2 Questionnaires

Pre-questionnaire. The participants were asked to fill a questionnaire which had 49 questions. The responses to the questions were scaled in the 5-point likert scale, numerically ranging from -2 to 2. The questionnaire had ten questions from the 10 item big-five personality questionnaire. And then there were questions taken from godspeed questionnaire and other questionnaires. Please refer to the appendix for a sample questionnaire used in this study. The ICA was calculated as the sum of the ratings/points provided by the participants for questions 30 to 39 as these were the questions most closely resembling anthropomorphism. In this report, we refer to this questionnaire as the pre-questionnaire i.e. before the experiment, and it typically took 5 minutes for participants to fill it.

Post-questionnaire. There was another questionnaire form that was almost identical to the pre-questionnaire that the participants had to fill after watching the videos. This questionnaire typically took 3 to 4 minutes to fill and we refer to this as the post-questionnaire. A sample is provided in the appendix of this report. Based on the responses filled in this questionnaire, the AAP was calculated as the sum of the ratings/points provided by the participants for questions 17 to 26 (similar to ICA).

3.3 Course of the study

We did a pilot test using 10 participants first, and then after some modifications, we did the final experiment on 40 participants.

3.3.1 Participants

Participants on an average were around 21 years of age, with a standard deviation of 4.5 . Among 40 participants, 21 were females and 19 were males. We tried and managed to avoid having participants from Computer Science or Electronics background as they are generally perceived to have a lower anthropomorphic attitude by default. As per our questionnaire responses, we observed that the participants were not so familiar with robots and only a few out of 40 had ever owned a robot. It took approximately 15 minutes per participant for one experiment session. Each participant was invited for only one session.

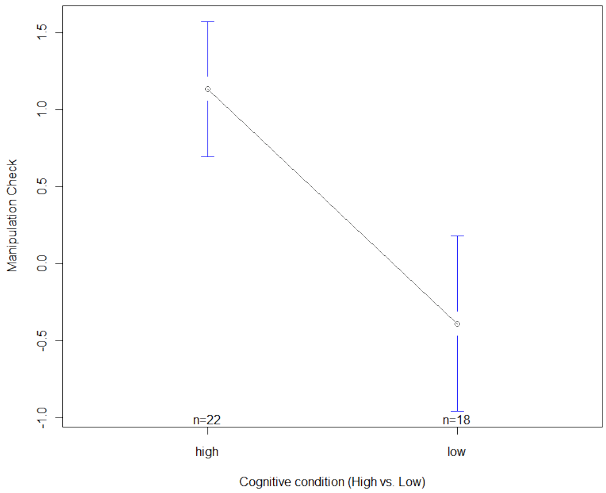


Figure 2: ManipulationCheck

3.3.2 Consent Form

Before the experiment, participants were made to read, understand and sign a standard consent form.

3.3.3 Initial Interaction

After the pre questionnaire, we kept a 2 to 3 minutes session for initial interaction, where we let the participant spend some time with Nao[3]. The purpose of this interaction was to familiarize the participants with the robot and mitigate the novelty effect, so that they do not get surprised seeing a robot for the first time in the videos.

3.3.4 Pre-questionnaire

Participants were asked to fill the 49 questions questionnaire right after the initial interaction.

3.3.5 Videos

After filling the pre-questionnaire, participants watched the $\mathcal{R}$ and $\mathcal{H}$ interaction videos.

3.3.6 Post-questionnaire

After watching the videos, participants were asked to fill the post questionnaire, which was the last step in the procedure of this study.

3.3.7 Reward

Each of the participants were given a reward equivalent to CHF 10.

4. RESULTS

Based on the experiments conducted on 40 participants in the $\mathcal{H}$ and $\mathcal{R}$ interactions across LC and HC conditions, we have the following results. (The detailed statistics and code used for obtaining the results are available here : *https://github.com/chili-epfl/anthropomorphism-eyetracking*)

4.1 General Biases

While testing for all the 4 hypotheses, we observed no significant bias with respect to age, gender , EPFL status, familiarity with robot and robot ownership of the participants, i.e., there was no correlation found between these factors and the gaze patterns in the videos.

4.2 Manipulation check

In our post-questionnaire, we had a question asking the participants about whether the video has a robot kind of task or a human kind of task on a scale of -2 to 2 where -2 refers to robot kind of task. As can be seen in figure 2, we got a significant correlation in this manipulation check (F[1,36] = 20.42, $p < .01$) which means that the participants that were shown the LC videos identified the task as the robot-like and participants watching HC videos perceived the tasks as more human-like.

4.3 H1: Gaze patterns for Human vs Robot

Among the 10 AOIs, we grouped the AOIs corresponding to the actor into 4 categories : Head, Arm (containing both arms and hands), Torso, Leg(containing both legs). And this is the result that we obtained from the ANOVA between gaze patterns on the AOIs versus the $\mathcal{H}$ and $\mathcal{R}$ conditions :

head: the fixations on the head for the $\mathcal{H}$ scene were observed to more than that for the $\mathcal{R}$ scene (F[1,36] = 6.60, $p < .05$)
arm : the fixations on the arms for the $\mathcal{H}$ scene were also greater than that for the $\mathcal{R}$ scene (F[1,36] = 18.65, $p < .01$)
leg : the fixations on the legs were much lower for the $\mathcal{H}$ scene as compared to the $\mathcal{R}$ scene (F[1,36] = 2.89, $p < .1$)
torso : the fixations on the torso was more for the $\mathcal{H}$ scene than for the $\mathcal{R}$ scene (F[1,36] = 3.54, $p < .1$)

4.4 H2: Difference in gaze patterns vs ICA

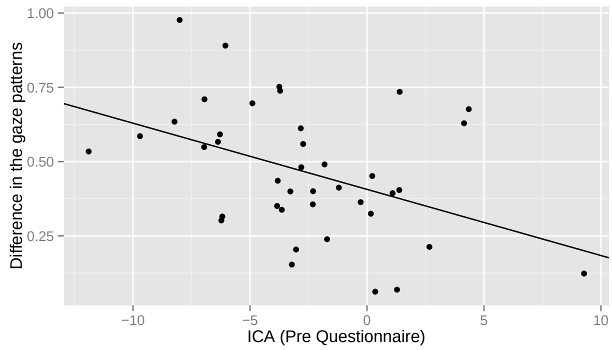
We got a significant correlation between $\delta_{\mathcal{H},\mathcal{R}}$ and the ICA. As can be seen in figure 3(a), there is a significant negative correlation between the two quantities (Pearson Correlation Coefficient = -0.42, $p < .01$).

4.5 H3: Gaze patterns for high vs low cognitive condition

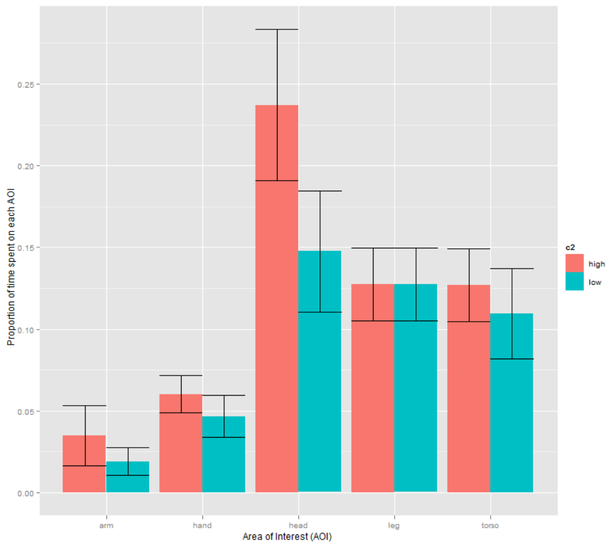
This test was done only for $\mathcal{R}$ scenario as the $\mathcal{H}$ case is by default a source of HC condition, hence, would not make a big impact in changing the patterns across the LC and HC conditions. Based on ANOVA results, taking just the 5 AOI groups (head, arms, hands, torso, legs) for the robot in both LC and HC conditions, the fixations on the head in the HC condition was found to be significantly higher than that in the LC condition (F[1,36] = 4.55, $p < .05$). For all other AOI groups, the fixations across LC and HC were almost the same. Figure 3(b) shows the distribution of proportion of time spent gazing on the 5 AOIs for LC and HC conditions.

4.6 H4: Difference between ICA and AAP versus High/Low

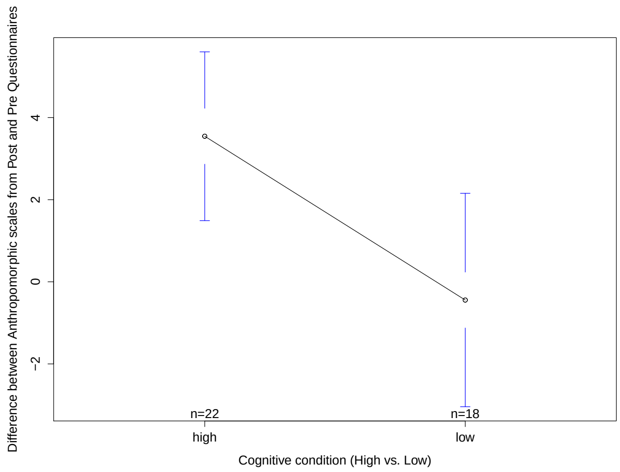
ANOVA between $\Delta_{ICA,AAP}$ and the category of cognitive task *i.e.* HC or LC tells us that $\Delta_{ICA,AAP}$ is greater for HC tasks than that for the LC tasks (F[1,36] = 6.54, $p < .05$). The results are shown in figure 3(c).



(a) Difference in gaze patterns vs ICA



(b) Gaze patterns for high vs low condition



(c) Difference between ICA and AAP versus High/Low

Figure 3: Hypotheses H2, H3, H4

5. DISCUSSION

Based on the results that we obtained, we can now verify our four hypotheses. For the first hypothesis where we state that the gaze patterns can distinguish between $\mathcal{H}$ and $\mathcal{R}$ interaction scenarios, we get greater amount of fixation on the head, arms and torso for the $\mathcal{H}$ scenario as compared to the $\mathcal{R}$ scenario. This can be explained by the fact that human is by default perceived as a high cognitive agent compared to a robot. Hence, the proportion of time spent on looking at the head is more in case of human videos as compared to robot videos. But the trend is opposite for legs. This might be explained by the fact that the participants are fascinated by the joints on the robot's legs *i.e.* the novelty effect. Overall, this result weakly validates our hypothesis.

In the second hypothesis, where we claim that $\delta_{\mathcal{H},\mathcal{R}}$ should correlate with the participants' ICA, we obtain in our results, a significant negative correlation between the two quantities. From the negative correlation, we can understand that if ICA is high, it means that the *human likeliness ascription* (HLA) is high (which means that there is a greater tendency to anthropomorphize) which indicates that $\delta_{\mathcal{H},\mathcal{R}}$ should be low. This supports our hypothesis and can be explained by the fact that if HLA is high for a participant, then even the $\mathcal{R}$ videos are quite human-like for such participant.

The third hypothesis where we state that the gaze patterns can distinguish between HC and LC tasks, can also be supported by our results. As can be seen in figure 3(b), the proportion of time spent by participants on looking at the head is significantly higher in HC task as compared to LC task. When participants ascribe more anthropomorphic features to robot, they look more at the head than when they ascribe less anthropomorphic features.

Finally for the fourth hypothesis where we state that the cognitive priming will have an effect on $\Delta_{ICA,AAP}$, as seen in the results, $\Delta_{ICA,AAP}$ for participants that watched the HC task is greater than that for the participants who watched LC task. This proves the fact that HLA was induced by the videos and in fact, the HC tasks impose a greater HLA on the minds of participants than the LC tasks. This shows the typical priming effect of the audio command given in the beginning of the video and highlights the variation in HLA based on the interaction scenario (LC versus HC) thereby supporting our hypothesis.

We analyze the gaze distribution in this study only based on the AOI net dwell times . Apart from this, the gaze transition among AOIs can be another way of fetching gaze patterns which is not used in this study.

6. CONCLUSION

In our experiment, we created two kinds of scenarios each for $\mathcal{H}$ and $\mathcal{R}$ interaction and just by changing the audio commands (priming effect), we replicated these videos to create a HC and a LC scene. We recorded the gaze patterns of the 40 participants who were made to watch these videos and also the participants were asked to fill two questionnaires before and after the experiment. These data were analyzed and compared to our four hypotheses. We hypothesized that one who anthropomorphizes more would have a similar reaction to $\mathcal{H}$ and $\mathcal{R}$ conditions, and also that in the HC case, a participant's fixations would be more on the head of the actor as compared to that in the LC case. We also hypothesized that the HC scene would induce more anthropomorphic attitude than the LC scene. We found that the results were successful and supported our hypotheses. We also had another scenario where the robot/human was asked to move/dance, but this scenario had only one object (*i.e.* the actor) showing movements, and hence participants would focus more on seeing the movements leaving behind the cognition aspect, which made it difficult to differentiate between the LC and HC cases and, therefore, we discarded this scenario from our analysis.

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APPENDIX

You have 5 minutes maximum to fill this questionnaire. If the meaning of a question is unclear to you, please leave it out.
This questionnaire is anonymous.

1. **Age** ________
2. □ Female □ Male
3. **How familiar with robots do you consider yourself?**
   Not familiar at all □—□—□—□—□ Very familiar
4. **Do you own a robot?**
   - □ No
   - □ Yes, a toy robot
   - □ Yes, a household robot (like a robot vacuum cleaner)
   - □ Yes, another type of robot: ________________

I see myself as...

5. **Extraverted, enthusiastic** Disagree strongly □—□—□—□—□—□—□ Agree strongly
6. **Critical, quarrelsome** Disagree strongly □—□—□—□—□—□—□ Agree strongly
7. **Dependable, self-disciplined** Disagree strongly □—□—□—□—□—□—□ Agree strongly
8. **Anxious, easily upset** Disagree strongly □—□—□—□—□—□—□ Agree strongly
9. **Open to new experiences, complex** Disagree strongly □—□—□—□—□—□—□ Agree strongly
10. **Reserved, quiet** Disagree strongly □—□—□—□—□—□—□ Agree strongly
11. **Sympathetic, warm** Disagree strongly □—□—□—□—□—□—□ Agree strongly
12. **Disorganized, careless** Disagree strongly □—□—□—□—□—□—□ Agree strongly
13. **Calm, emotionally stable** Disagree strongly □—□—□—□—□—□—□ Agree strongly
14. **Conventional, uncreative** Disagree strongly □—□—□—□—□—□—□ Agree strongly

Please rate your impression of robots on these scales:

15. **Fake** □—□—□—□—□ **Natural** □ No opinion
16. **Machinelike** □—□—□—□—□ **Humanlike** □ No opinion
17. **Unconscious** □—□—□—□—□ **Conscious** □ No opinion
18. **Artificial** □—□—□—□—□ **Lifelike** □ No opinion
19. **Moving rigidly** □—□—□—□—□ **Moving elegantly** □ No opinion
20. **Dislike** □—□—□—□—□ **Like** □ No opinion
21. **Unfriendly** □—□—□—□—□ **Friendly** □ No opinion
22. **Unkind** □—□—□—□—□ **Kind** □ No opinion
23. **Unpleasant** □—□—□—□—□ **Pleasant** □ No opinion
24. **Awful** □—□—□—□—□ **Nice** □ No opinion
25. **Incompetent** □—□—□—□—□ **Competent** □ No opinion
26. **Ignorant** □—□—□—□—□ **Knowledgeable** □ No opinion
27. **Irresponsible** □—□—□—□—□ **Responsible** □ No opinion
28. **Unintelligent** □—□—□—□—□ **Intelligent** □ No opinion
29. **Foolish** □—□—□—□—□ **Sensible** □ No opinion

Do you agree or disagree with the following sentences:

30. **Robots can be curious**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

31. Robots can be friendly
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

32. Robots can be fun-loving
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

33. Robots can be sociable
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

34. Robots can be trusting
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

35. Robots can be aggressive
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

36. Robots can be distractible
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

37. Robots can be impatient
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

38. Robots can be jealous
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

39. Robots can be nervous
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

40. Robots can be broadminded
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

41. Robots can be humble
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

42. Robots can be organized
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

43. Robots can be polite
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

44. Robots can be thorough
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

45. Robots can be cold
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

46. Robots can be conservative
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

47. Robots can be hard-hearted
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

48. Robots can be rude
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

49. Robots can be shallow
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

Thank you for your participation!

You have 5 minutes maximum to fill this questionnaire. If the meaning of a question is unclear to you, please leave it out.
This questionnaire is anonymous.

1. **In your opinion, the three tasks that you watched were more:**
   A robot kind of task □—□—□—□—□ A human kind of task

<u>Based on the videos</u> you have watched, please rate your impression of robots on these scales:

2. **Fake □—□—□—□—□ Natural** □ No opinion
3. **Machinelike □—□—□—□—□ Humanlike** □ No opinion
4. **Unconscious □—□—□—□—□ Conscious** □ No opinion
5. **Artificial □—□—□—□—□ Lifelike** □ No opinion
6. **Moving rigidly □—□—□—□—□ Moving elegantly** □ No opinion
7. **Dislike □—□—□—□—□ Like** □ No opinion
8. **Unfriendly □—□—□—□—□ Friendly** □ No opinion
9. **Unkind □—□—□—□—□ Kind** □ No opinion
10. **Unpleasant □—□—□—□—□ Pleasant** □ No opinion
11. **Awful □—□—□—□—□ Nice** □ No opinion
12. **Incompetent □—□—□—□—□ Competent** □ No opinion
13. **Ignorant □—□—□—□—□ Knowledgeable** □ No opinion
14. **Irresponsible □—□—□—□—□ Responsible** □ No opinion
15. **Unintelligent □—□—□—□—□ Intelligent** □ No opinion
16. **Foolish □—□—□—□—□ Sensible** □ No opinion

<u>Based on the videos</u> you have watched, do you agree or disagree with the following sentences:

17. **Robots can be curious**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
18. **Robots can be friendly**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
19. **Robots can be fun-loving**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
20. **Robots can be sociable**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
21. **Robots can be trusting**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
22. **Robots can be aggressive**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
23. **Robots can be distractible**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
24. **Robots can be impatient**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
25. **Robots can be jealous**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion
26. **Robots can be nervous**
    Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

27. Robots can be broadminded
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

28. Robots can be humble
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

29. Robots can be organized
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

30. Robots can be polite
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

31. Robots can be thorough
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

32. Robots can be cold
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

33. Robots can be conservative
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

34. Robots can be hard-hearted
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

35. Robots can be rude
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

36. Robots can be shallow
Disagree strongly □—□—□—□—□ Agree strongly □ No opinion

Thank you for your participation!