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ORIGINAL ARTICLE

Comparing differences of trust, collaboration and communication between human-human vs human-bot teams: an experimental study

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ABSTRACT

As machines enter the workplace, organizations work toward building their collaboration with humans. There is a limited understanding in litearture of how human-machine collaboration differs from human-human collaboration. Using an experimental design the study aimed at studying differences in trust, collaboration and communication between the two teams: humans and bot and humans-only teams. Due to limited availability of bots that express collaboration this set up was chosen. The findings highlight the differences in communication and collaboration between humans and bots as teammates. There were no differences in trust experienced by humans. The originality of the research is that it focuses on collaboration as a process and outcome rather than the team's performance.

Keywords: Human-bot; trust; collaboration; communication.

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INTRODUCTION

Today, machines loaded with intelligence (artificial intelligence, machine learning, etc.) emulate the ability to think, reason, learn, and perform tasks like humans (Russell & Norvig, 1995; Grosz & Stone, 2018). Various fields rely on the guidance of these machines to make crucial decisions, like selecting job applicants for job postings (Von Krogh, 2018), health care (Yu et al., 2018), and judicial and law (Nissan, 2017) to name a few examples. Machine's inputs collaborate with human inputs to make decisions that exceed either capabilities (Wang et al., 2016; Kamar, 2016). This collaborative structure enables curated intelligence for higher efficiency (Malone, 2018; Wilson & Daugherty, 2018).

Today, machines significantly contribute in managing organizations (Daugherty et al., 2019; De Cremer, 2020), thus forcing management to relook at their design and explore forms of collaboration with humans (George et al., 2020).The most commonly used form of machine with intelligence is a bot. They can be found in many organizations and personal setups.

When humans and machines collaborate, several team-like structures emerge where machines function as independent members (Appenzeller, 2017; Shrestha et al., 2019; Lee et al., 2012; Demir et al., 2015). The machine contributes to group tasks by producing actions and coordinating activities through communication, developing trust, and commitment (Harbers et al., 2014).

This collaboration between humans and machines can lead to new emerging behaviours with mixed-initiative (Bansal et al., 2019; Puranam, 2021). Even with the growing interest in human-machine collaboration, there is still much to learn about them as teammates (Seeber et al., 2020). Previously, the human-machine team was primarily studied for the overall performance of the team, where humans would typically have a supervisory role and technology would have a low-level capacity (Guzman & Lewis, 2020). The presence of a machine as a teammate could influence the dynamics, thereby impacting the performance of the team (Guzman & Lewis, 2020; Demir et al., 2020; Fiore & Wiltshire, 2016).

Understanding the influence on trust, and communication of human and machines while collaborating can be helpful in designing future human-machine teams. The previous work was primarily in computer science, with only minor contributions from management and social science (Glikson & Wolley, 2020). There is a need for an interdisciplinary, human-centric approach that considers the needs of human perception and behavioural response to social and relational aspects of this team (Shank et al., 2019).

The present study aims at exploring differences in human-team behaviour to human-bot teams. It intends to explore if the human-human team interaction is similar to that of the human-bot team. An experimental design was used to understand the influence of teammates being a bot or human on trust, collaboration, and communication. This research will aid in understanding the role of communication and trust in collaboration teams, which will aid in the design of future human-machine teams (Seeber, 2020; Walliser et al., 2019).

THEORETICAL BACKGROUND

As we move away from the human vs machines debate, this synergy has "Intelligence augmented", where the intelligences of both are put together for effective decisions (Malone, 2018; Jarrahi, 2018; De Cremer, 2020). Studies suggest that several factors can influence human-machine collaboration, and it cannot be categorized as all or none (Brandstetter et al., 2014; Shiomi & Hagista, 2013). Researchers in the field of computer science within the laboratory setup have drawn comparisons between human and human-machine teams to better understand this collaboration and highlighted the differences in collaboration and coordination (Demir et al., 2018; Walliser et al., 2019; Hertz et al., 2019). Spence et al. (2014) have shared that the knowledge of interaction with a bot influences the perception of humans. Even before interacting with the bot, they discovered a decreased liking and increased uncertainty. This influence is not limited to interaction but also impacts team behaviour and outcome, where both collaborate as teammates (Demir et al., 2018). Humans demonstrated to experience challenges in planning their activities and anticipating their teammates' needs when partnering with machines (Demir et al., 2018). The perceived expertise of the machine influences the usage of the machine and thus impacts collaboration (Zhang et al., 2021).

For collaboration to succeed, trust also plays a critical role in human-technology adoption (Przegalinska et al., 2019; Glikson & Wolley, 2020). Using the machine's inputs is evidence of trust in them (Madhavan & Wiegmann, 2007; Lee et al., 2013). In many lab-based studies, humans highly trust machines that provide decisions (Demier et al., 2020; Dietvorst et al., 2015). It is critical to emphasize that there is a greater tendency in many situations to over-rely on machines and become complacent in their advice, a phenomenon known as automation bias (Goddard et al., 2012; Parasuraman & Manzey, 2010). Recent works show that with increased exposure to new forms of technology, anthropomorphic differences bring no changes in trust and in how humans treat machines as social actors (Alarcon et al., 2021). Xie et al. (2019) highlighted that trust in machines could not be calibrated alone, as human needs (and use) are multi-faceted across different contexts. As a result, there is a significant need to understand human-machine interactions in terms of how people trust, use, and interpret their advice (Prahl & Swol, 2017).

Studies in human-computer interaction and human-robot interaction share evidence of decreased interaction (Lee & Liang, 2015). Researchers have highlighted these differences due to the interactive strategies adopted with partnering with machines (Amalberti et al., 1993; Shechtman & Horowitz, 2003; Demir et al., 2019; Walliser et al., 2019). This reduced interaction could be due to lower perceived attractiveness toward the machine (Spence et al., 2014). In addition, there is an impact on humans' social behaviour when interacting with other humans (Spence et al., 2019). Humans tend to focus more on building social relationships with human teammates (Shechtman & Horowitz, 2003). When teammates are machines, there is less focus on sharing information, with a lowered expectation of contribution from the teammate (Demir et al., 2018). Rich interaction between team members is critical for outcomes that lead to collaboration (Chen & Barnes, 2014). Mou and Xu (2017) highlighted that when interacting with machines, humans are less open, more agreeable, and experience greater anxiety (Mou & Xu, 2017).

Research question 1: *How is level of trust experienced in human-human collaboration in comparison to human-machine collaboration?*

Research question 2: *How does human-human collaboration differ from human-machine collaboration?*

Research question 3: *How does communication in human-human collaboration differ from human-machine collaboration?*

METHODS AND DATA

Study participants

The sample comprised students registered with the Delhi Technological University, New Delhi, India. There were 120 participants in the experiment who were randomly assigned to the two experimental teams. The participants included 58 females (48.3%) and 62 males (51.6%). The participants' age ranged from 18 to 30 years, with a mean of 21.1 (SD=2.46). Participants received attendance credit for taking part in the study. There were 56 (46.6%) students from undergraduate programs, 48 (40%) from postgraduate programs, and 16 (13.3%) from PhD programs.

Procedure

Study Design

An experimental design was used in the study, where two teams were created namely condition 1 and condition 2. After the participants consented, they were randomly assigned to condition 1 or 2. In each condition, there were two members. The two members were not aware of who the other participant was. In condition 1, both team members were informed that they were collaborating with another human. In condition 2, they were informed that they collaborated with a machine (bot). In either of the conditions, they were interacting with a human. In condition 2, the participants were also told that the bot used in the study was not designed to respond to irrelevant questions and could only accept input concerning an ongoing task. The particular setup was chosen due to the limited availability of bots that can demonstrate collaboration skills. Also, the presence of another human would make the interaction more human-like than scripted. Also the study was a pilot setup for further exploration of humans and machines.

To interact with team members, the online collaborative platform Slack (https://slack.com/intl/en-in/) was used. The pair was studied as a team, as they shared a goal and would work towards achieving it. A channel was created in which different identities of User 1 (team member 1), User 2 (team member 2), and the experimenter were created. There were other terminals for Users 1, 2, and the experimenter, and they operated from separate rooms. The task required the team to collaborate and label the images after reaching a consensus. Three images (Appendix B), psychological illusions, were selected. The images selected were chosen as they created ambiguity, and there would be more than one response to each image. The task also did not require any pre-set skills, so neither humans nor a perceived machine could be considered experts in performing the task.

As the participants were at the terminal, the experimenter shared the individual instructions in each condition. After viewing each image, a conversation ensued in the chat, where the goal was to reach a consensus based on the discussion. Once they finalized the label, the experimenter shared the following image. After labeling the three images, the participants were asked to complete a post-task questionnaire. The post-task questionnaire included two sections –demographics and measures of team behaviour. The post-task questionnaire was collected on google docs. Post the experiment, the participants were informed that they were interacting with another human than a bot.

Tools and Data Analysis

Trust

An adapted version of Merritt's trust scale (Merritt, 2011) was used to measure trust between team members. There were 6 items on the trust scale (e.g., "*I have faith in what my teammate is telling me*") at a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree). The Cronbach's alpha for the trust scale was 0.723. None of the teams were reverse-scored. The higher trust refered to higher trust with the machines.

Collaboration

The interaction between human-human and the human-bot was studied using the process and the decision made by the teams. The interaction between the members was studied. If the final response chosen included the participation of both teammates and was different from their initial proposition, the outcome was considered a collaborative outcome. Collaborative outcomes were coded as 2. When either of the partners agreed to the proposition of the other without discussion or deliberation, it was a non-collaborative outcome. Such conditions were coded as 1. To reduce subjectivity, three different coders were used to code each outcome. The majority of code for a given image was the accepted code.

Communication

All the messages shared during the task were recorded. The communication between team members was studied using the duration of the interaction and the number of words used in the interaction (Hill et al., 2015; Lortie & Guitton, 2011). Further, the content of the messages was reviewed, and all the pre-task and irrelevant messages were filtered out. The task-related discussion in the team was categorized into three groups: rapport building (acknowledgement, greeting, and understanding of the problem), task-based discussion (idea generation and discussion for building on ideas and suggestions), and clarification seeking (opposition and asking for rational ideas). The coding and categorization of the message were done with three different coders. The message that received the maximum vote was included in that category.

Control Variables

To ensure the effectiveness of the manipulation, some variables were controlled.

Past experience with technology

The participants checked if they had experienced or used chatbots in the past. The variable was assessed using a single item, "*Have you in the past used a chatbot?*" The response to the item was recorded in a yes or no response.

Satisfaction

The participants' satisfaction with being part of the team was assessed. An adapted version of Bushe and Coetzer's (1995) scale for satisfaction with membership was used. There are 3 items on the scale (being a team member was a positive experience). The Cronbach alpha for the scale was 0.83.

Interacting with a bot

To assess if the participants believed that they interacted with the bot in the experimental group, participants were asked a single item ("*Did you believe that you were interacting with a bot?*"). The response to the item was recorded as yes or no.

RESULTS AND DATA ANALYSIS

Using SPSS, independent sample t-tests were conducted to evaluate the difference in collaboration between the participants in the experimental (human-bot team) and the control group (human-only team).

Research question 1 assessed the differences in the level of trust experienced by the teams. There was no significant difference in the two dimensions of the two groups. The t-test was not statistically significant for trust (t= 1.012, p=.315, d=.21).

Research question 2 assessed the differences in the level of collaboration experienced by the teams. There was a significant difference between the two teams. The t-test was statistically significant for collaboration (t= 1.72, p=.044, d=.36), as presented in Table 1 (see Appendix A).

Research question 3 measured the differences in communication between the two teams. The t-test was statistically significant for the duration of the interaction (t=2.20, p=.031, d=.49) (Table 2, see Appendix A) and words exchanged (t=2.413, p=.018, d=.53) (Table 2, see Appendix A) between the members. Further, the messages were analyzed, and we found a statistical difference in rapport building (t=2.35, p=.021, d=.52) and clarification seeking (t=2.52. p=.045, d=.35). There were statistically more messages exchanged in the human-human team than in the human-machine team. The members focused more on rapport-building and clarification-seeking in the human teams as they completed the collaborative task. There were no statistical differences in the number of messages exchanged between the two teams regarding task-related discussion (t= .942, p=.231, d=.18). The results are presented in Table 2 (Appendix A). Some examples of rapport-building tasks included ("*Let's get this done*!"; '*so we have to label together. the pics*') and clarification seeking ("*I don't see an old man in the pic, where do you see it?*"; "*I don't think there is any young couple in the pic*").

DISCUSSION

The study seeks to understand team differences between humans and bots. The results found greater collaboration exhibited in human teams with increased communication and usage of words and greater duration of interaction with the team member. The communication emphasized rapport building and clarification seeking in the human team. There was no significant difference in team behaviour with respect to trust. The findings are in agreement with past studies highlighting the difference between human-machine teams and human-human teams (Demir et al., 2019; Spence et al., 2019).

The first research question assessed the difference in trust experienced by humans in different teams. The result found no differences in the level of trust experience. The findings are supported by media equation studies (Nass & Moon, 2000; Reeves & Nass, 1996), which propose machines are seen as social actors and humans share the same level of social responsiveness to them in team setups (Groom and Nass, 2008). Furthermore, Edwards et al. (2016) and Spence et al. (2019) have shared similar results with bots where there were no perceived differences in the credibility of the machine. Thus humans do consider machines a credible source to partner with in decision making tasks.

The second research question looked at the differences in the collaborative outcomes of the two teams. Collaboration was considered when there was participation by both team members, and over time they mutually agreed on a decision different from their initial proposed decision. The result found more collaboration with human partners than with bots. In tasks of high uncertainty, where humans cannot claim expertise, decision moves in the direction of the machine, as they are presumed to have the expertise (Elson et al., 2018), as seen in the human-bot team. Shaikh and Cruz (2019) highlighted how machines reduce collaboration and interaction in teams, especially when there is a time restriction.

The third research question compared the differences in communication between the two teams. The communication pattern was assessed with the duration of interaction and the number of words used. The result found a significant difference in the usage of words and duration of interaction between the two teams. There was less interaction in the human-machine team than in the human team. The subcategories of communication were analyzed on rapport building, task-related discussion, and clarification seeking. There was a significant difference in communication for rapport building and clarification seeking. Studies on human-computer interaction or human-robot interaction also share evidence of decreased interaction (Lee & Liang, 2015). There is evidence of greater identification with the human partner than with a machine (Pena et al., 2017; Shechtman & Horowitz, 2003). Research in linguistics has shown shorter messages and differences in content and vocabulary when interacting with machines (Hill et al., 2015).

For human and machine collaboration, there is a need for a scientific understanding of the most effective way humans and machines can come together as teammates (Sebeer, 2020). In fact, there are differences in collaboration and applying the principles of human-human interaction to human-bot can not be effective. The results show that humans consider machines credible information sources and readily collaborate with them to complete the task. However, it is critical to note that this collaboration can impact on the team's communication and performance. Therefore, the communication and interactive interfaces between humans and machines should be cautiously designed.

LIMITATIONS AND FUTURE DIRECTIONS

There are some limitations in the present study. The study was carried out in a laboratory setting with a small sample and thus has limited generalizability. To propose a machine and human collaboration it would be great if the IdeaSquare lab at CERN could run such experiments on large samples with significant variability in the sample with respect to age, education, and gender to help understand how collaboration can work with larger masses.

It would be interesting to see how this collaboration plays out in terms of the actual development of a bot capable of assisting with decision-making tasks. Also, studies involving higher stakes regarding rewards or penalties for performance on the task should be carried out, as high stakes can influence the pattern of interaction and the dynamics of collaboration. Studies exploring a focused, goal-directed task that demands collaboration between humans and machines independent of their capability would help understand the social cues segregating the human-machine team from the human-human team.

CONCLUSIONS

This study aimed to compare the human-bot teams to the human-human teams as they collaborate. The findings highlighted the acceptance of bots as teammates but cautioned about some differences in this collaboration. The perception of collaborating with a bot influences human behavior. There are differences in communication and collaboration in human-bot teams as they engage in a task, with reduced interaction between members, leading to greater conformity to the machine's suggestion. The present study is a small step in understanding human-bot collaboration as we adopt machines in different decision-making setups

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Appendix A

Table 1. Independent sample t-test analysis of the measures.

	Experimental Conditions					
Dependent Variable	Human-Human (60) Mean (Sd)	Human-Machine (60) Mean (Sd)	t-value	df	Sig.(2-Tailed)	Cohen's d
Collaboration	17.80 (3.53)	15.25 (3.19)	2.32	118	0.044	.36
Trust	19.25 (2.96)	18.62 (2.53)	1.01	118	0.315	.21

Source: Primary Data, *Sig. at 0.05

Table 2. Independent sample t-test analysis of communication measures.

	Experimental Conditions					
Dependent Variable	Human-Human (60) Mean (Sd)	Human-Machine (60) Mean (Sd)	t-value	df	Sig.(2-Tailed)	Cohen's d
Words	206.97 (145.86)	138.87 (102.86)	2.41	110.09	0.018*	.53
Duration	25.75 (20)	17.55 (12.39)	2.20	105.09	0.030*	.49
Rapport Building	25.32 (13.77)	19.07 (9.56)	2.35	109.50	0.021*	.52
Task-related discussion	27.43 (15.42)	25.57 (15.73)	0.942	111.40	0.231	.18
Clarification seeking	22.84 (14.44)	13.06 (6.85)	2.52	107.70	0.034*	.35

Source: Primary Data, *Sig. at 0.05

Appendix B

Image 1 (Source: Hill, W. E. (1915). My wife and my mother-in-law. Puck, 16, 11)

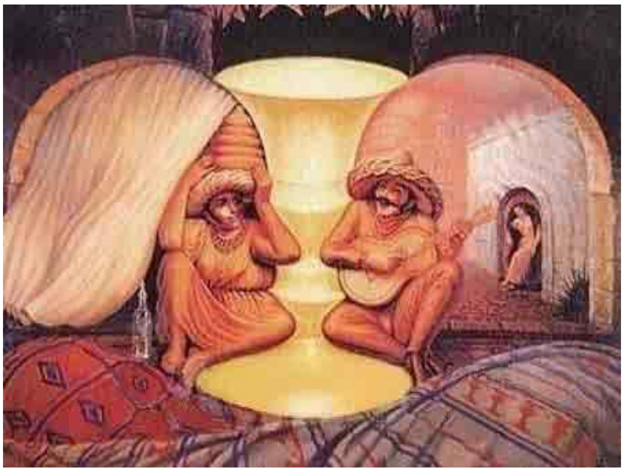

Image 2 (Painting of Octavio Ocampo. Always Forever)

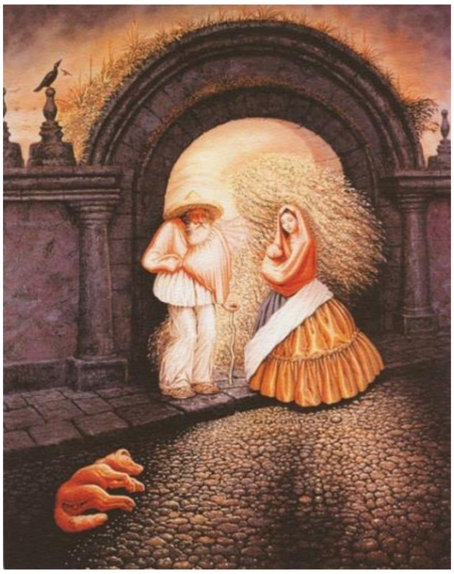

Image 3 (Painting of Octavio Ocampo. General's Family)