Dyadic Stance in Natural Language Communication with a Teachable Robot

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ABSTRACT

Learning companion robots can provide personalized learning interactions to engage students in many domains including STEM. For successful interactions, students must feel comfortable and engaged. We describe an experiment with a learning companion robot acting as a teachable robot; based on human-to-human peer tutoring, students teach the robot how to solve math problems. We compare student attitudes of comfort, attention, engagement, motivation, and physical proximity for two dyadic stance formations: a face-to-face stance and a side-by-side stance. In human-robot interaction experiments, it is common for dyads to assume a face-to-face stance, while in human-to-human peer tutoring, it is common for dyads to sit in side-by-side as well as face-to-face formations. We find that students in the face-to-face stance report stronger feelings of comfort and attention, compared to students in the side-by-side stance. We find no difference between stances for feelings of engagement, motivation, and physical proximity.

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1 INTRODUCTION

In interactions between two or more individuals, participants often adopt specific spatial formations with one another to effectively communicate and maintain attention towards a shared focus. Kendon defines stances between individuals that allow them to focus their attention on a shared space with "equal, direct, and exclusive" access to be *F-formations* [4]. The most common F-formations for two individuals are face-to-face (also called vis-a-vis), side-by-side, and L-shape. This work examines the affect of F-formations in a robotic learning companion setting, where the robot's lower body is stationary. Recent work suggests that the stance of robotic learning companions can affect student behavior and performance [3]. Other studies have examined the effectiveness of having a robot implicitly reconfigure the social space through specific movements [6], while others have taken explicit action by having the robot make verbal requests to shape the scene [2]. In this study, we compare two human-robot dyad formations, face-to-face and side-by-side, to understand how the stances affect *social* qualities of the interaction: comfort, attention, engagement, motivation, and appropriateness of physical proximity.

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2 LEARNING COMPANION ROBOT

The platform for this experiment is a NAO robot, called *Nico*, that interacts with students as a learning companion. Learning companions that are capable of social interaction have the potential to influence motivation and increase learning [5]. Students interact with Nico using spoken natural language in a learning-by-teaching style. During the interaction, Nico takes initiative in the dialogue, asking students for help (e.g., *"How do I figure out how much paint to mix?"*). Students respond by explaining their reasoning to Nico (e.g., *"We want six cans of green paint so we mix three cans of yellow paint and three cans of blue paint because..."*). Nico responds with actions such as updating the tablet interface, upper-body gestures such as scratching its head, and spoken dialogue.

3 EXPERIMENT

We conducted a Wizard-of-Oz style experiment with 20 female participants (mean age = 20). Participants sat a desk with Nico and a tablet UI in one of two configurations: side-by-side (N = 10) and face-to-face (N = 10). Figure 1 illustrates the two configurations and shows an example of the NAO robot learner with a peer teacher in a side-by-side configuration.

Each session consisted of four problem-solving dialogues as well as a pre- and post-survey. Student participants were told that their goal was to help Nico solve a set of mathematics problems related to ratios. Prior to the interaction, students were provided worked-out problem solutions and time to prepare. The Wizard controlled

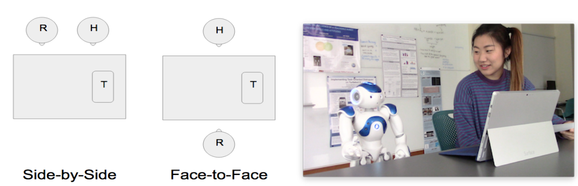

Figure 1: Participants tutored the learning companion robot in either a side-by-side or a face-to-face stance (R=robot, H=human, T=tablet).

Nico from a separate room; they had a pre-programmed selection of dialogue prompts (e.g., *"Okay, now we multiply?"*) and gestures (e.g., a shrug or a cheer) at their disposal, as well as the ability to input additional lines when necessary.

Survey questions administered after the teaching session gauged participant attitudes towards comfort, attention, engagement, motivation, and physical proximity during the interaction. The questions were adapted from [1]; answers were on a Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- Comfort
  - **Q1** I feel comfortable interacting with robots
  - **Q2** I felt comfortable interacting with Nico
- Attention
  - **Q3** I paid close attention to Nico
  - **Q4** Nico paid close attention to me
- Engagement
  - **Q5** I felt that Nico was involved in our conversation
  - **Q6** I felt that Nico was interested in what I had to say
- Motivation
  - **Q7** I felt motivated to teach Nico
- Physical proximity
  - **Q8** Nico was at an appropriate distance from me

The statement, "I feel comfortable interacting with robots" (Q1), was asked in the pre-survey as well as the post-survey.

4 RESULTS

Our post-session survey results suggest that the different dyadic stance configurations impact feelings of comfort and attention, but do not impact feelings of engagement, motivation, or appropriateness of proximity. For the survey questions pertaining to comfort (Q1, Q2) and attention (Q3, Q4), participants in the face-to-face configuration reported higher average agreement than participants in the side-by-side configuration. This is shown in Figure 2 (top). In contrast, no differences between groups were found for the survey questions pertaining to engagement (Q5, Q6), motivation (Q7), and proximity (Q8). This is shown in Figure 2 (bottom).

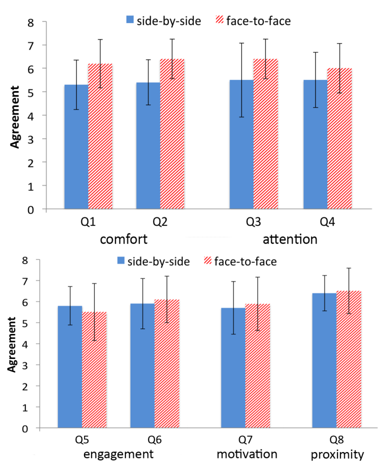

Figure 2: Post-session self-reported levels of agreement where 1=strongly disagree, 7=strongly agree ($N = 20$). Participants in the face-to-face group report stronger feelings of comfort and attention (top). There was no difference between side-by-side and face-to-face groups for feelings of engagement, motivation, and proximity (bottom).

Notably, we also observe a difference between groups for individuals' pre- vs. post-session agreement with the statement "I feel comfortable interacting with robots" (Q1). As shown in Figure 3, participants in the side-by-side group had almost no change ($post - pre = 0.19$) in their reported agreement, whereas participants in the face-to-face group had an increase ($post - pre = 1.2$) in their level of agreement from pre-session to post-session.

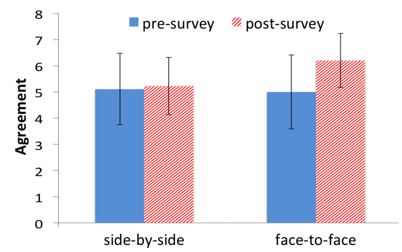

Figure 3: Comparison of pre- and post-session self-reported comfort level when interacting with robots (Q1). There is almost no change for the side-by-side group, whereas the average comfort level increases for the face-to-face group.

5 CONCLUSION

In a Wizard-of-Oz experiment with our learning companion robot, we compared student attitudes of comfort, attention, engagement, motivation, and physical proximity for two dyadic stance formations: face-to-face and side-by-side. While face-to-face stances are prevalent in human-robot interactions, side-by-side stances are prevalent in human-human peer tutoring interactions. Our results suggest that varying stance between these two configurations affects some self-reported attitudes—comfort, and attention—while not affecting other attitudes—engagement, motivation, and appropriate proximity. Additionally, our findings suggest that comfort interacting with robots may increase over time in the face-to-face configuration. Given that student comfort and attention are important for successful learning companion interactions, we recommend maintaining face-to-face configurations for this style of learning companion interaction.

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