Comparison of Lexical Alignment with a Teachable Robot in Human-Robot and Human-Human-Robot Interactions

Yuya Asano, Diane Litman, Mingzhi Yu, Nikki Lobczowski, Timothy Nokes-Malach, Adriana Kovashka, and Erin Walker
University of Pittsburgh

Introduction

Motivation

• Speakers build rapport in the process of aligning conversational behaviors with each other.
• Rapport entwined with a teachable agent while instructing domain material has been shown to promote learning.
• Multi-party interactions involving an agent remain to be explored with more sophisticated automated measures.

Goals

• Apply sophisticated lexical alignment measures derived from initiation and repetition of shared expressions to educational dialogues.
• Extend them to quantify to what extent a speaker is actively involved in the establishment of shared expressions independent of their partner.
• Compare how individual learners align with the teachable robot Emma and how alignment relates to rapport with her in a collaborative human-human-robot (H-H-R) setting versus in a one-on-one human-robot (H-R) setting.

Methodology

Data Collection

• 40 Undergraduates taught ratio problems to Emma over Zoom individually (H-R condition) or in pairs (H-H-R condition).

Measures for analysis

• Rapport with Emma: six-point Likert scale survey questions
• Disentanglement of each transcript in the H-H-R condition: 2 Emma-student dialogues (used for analysis) and 1 student-student dialogue
• Lexical alignment measures:
  • Initiated Expression of Speaker S (IE_S):
    \[ \frac{\text{# expr. initiated by S}}{\text{# of expr.}} \]
  • Expression Repetition of Speaker S (ER_S):
    \[ \frac{\text{# tokens from S in new or existing expr.}}{\text{# tokens from S}} \]
  • Expression Initiator Difference (IED): IIE_S1 – IIE_S2
  • Expression Establishment by Speaker S (EE_S, our proposed measure):
    \[ \frac{\text{# tokens from S used to establish new expr.}}{\text{# tokens from S}} \]

Example Emma-student dialogue

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emma</td>
<td>Now that I know how long one battery will last, can you help me figure out how many batteries I need total?</td>
</tr>
<tr>
<td>Emma</td>
<td>Emma initiated a shared expression &quot;can you&quot;, and Student A established it.</td>
</tr>
<tr>
<td>Student A</td>
<td>Okay, Emma. Can you convert the number of days to the number of hours?</td>
</tr>
<tr>
<td>Student A</td>
<td>Student A also I know how long I’ll be gone in days, but how long the battery lasts is in hours. So first I should change the days to hours?</td>
</tr>
<tr>
<td>Emma</td>
<td>Yes, Emma. That’s correct.</td>
</tr>
</tbody>
</table>

Hypotheses & Results

Difference in individual’s alignment between H-R and H-H-R

H1: Individuals in H-H-R align less with Emma than in H-R.
→ Supported for repetition (i.e., ER_Student was lower in H-H-R) but not for establishment (i.e., no difference in EE_Student).

Correlations between alignment and rapport

H2: Students feel more rapport with Emma when they align with her more (H2-a), she aligns with them more (H2-b), and alignment is more symmetric (H2-c).
→ H2-c was supported, and H2-b was partially supported (only for establishment). Our results imply the opposite of H2-a.

Conclusion

Learners’ lexical alignment with a teachable agent may not always indicate rapport with it, unlike alignment theories based on human-human interactions.

Discussion

H1

• Lower ER_Student in H-H-R: Students in H-H-R might have updated their conceptual pacts from the ones they previously built with Emma while discussing problems with each other before talking to her.

H2

• Positive correlations between Emma’s alignment and rapport align with findings in human-human interactions.
• Negative correlations of students’ alignment and IED with rapport:
  1. Students might have begun with an asymmetric alignment process (more establishment) due to her expected limited linguistic capacity.
  2. As they saw Emma is human-like with successful communication, they might have felt more rapport with Emma and changed their strategy to the one they use for humans (more symmetric and less establishment).

Future work

• Explore roles of H-H portions of the H-H-R interactions in their H-R portion.
• Investigate the effect of miscommunication as an intermediate variable on the negative correlations between rapport and learners’ alignment
• Extend the measures to multi-party settings without disentanglement.