The Relationship Between Modality and Metacognition While Interacting with AutoTutor

Jeremiah SULLINS\textsuperscript{a,1}, Moongee JEON\textsuperscript{a}, Sidney D’MELLO\textsuperscript{b} and Arthur C. GRAESSER\textsuperscript{a}

\textsuperscript{a}Department of Psychology, University of Memphis, USA
\textsuperscript{b}Department of Computer Science, University of Memphis, USA

Abstract. In this paper we explored the relationship between metacognitive statements and learning gains with students’ typed and spoken interactions with an intelligent tutoring system, called AutoTutor. Analyses revealed that students who entered their contributions via speech showed a significantly higher proportion of metacognitive statements (e.g., I’m not following, I understand). There was a significant negative correlation between metacognitive statements and posttest scores on both typed and spoken interactions. Students with low prior knowledge expressed more metacognitive statements than did students with high prior knowledge. Therefore, metacognitive expressions reflect the learners’ knowledge deficits as opposed to improved knowledge monitoring from greater subject matter knowledge.

Keywords. Intelligent tutoring system, metacognition, input modality

Introduction

Studies examining the potential learning gains from intelligent tutoring systems (ITSs) have rarely explored the effects of user modality (spoken vs. typed input) on learning (but see [1, 2] for exceptions). In this study, we compared the students’ typed versus spoken input in an ITS with natural language dialogue called AutoTutor [3].

Additionally, another area of interest among intelligent tutoring system researchers is the influence of metacognition on learning. Metacognition is simply defined here as thinking about thinking. The status of a student’s metacognitive state is sometimes reflected in explicit expressions during tutorial dialogue, such as: “I don’t follow”, “I’m lost”, “Now I get it!” These overt metacognitive expressions were analyzed in the tutorial dialogues of AutoTutor.

This study investigates the influence of input modality on students’ metacognitive expressions while interacting with AutoTutor on the subject matter of computer literacy. More specifically, we explored three questions. First, do students who input their contributions via a keyboard express more (or fewer) metacognitive expressions compared with students who input their contributions via speech? Second, do students who express more metacognitive expressions differ significantly on posttest scores

\textsuperscript{1} Jeremiah Sullins. 202 Psychology Building, Psychology Department, University of Memphis, Memphis, TN 38152, USA. E-Mail: jsullins@memphis.edu
compared to students who express fewer metacognitive expressions? Third, do students with higher prior subject matter knowledge on computer literacy express more or fewer metacognitive expressions?

A small number of studies have investigated the influence of input modality on students’ interactions with ITSs [4]. Some researchers postulate that spoken entry is inferior to typed entry. For example, according to cognitive load theory [5] individuals have a limited working memory so they can process a limited amount of information at any given time. During the composition of spoken responses, students may lose track of what they say and get bogged down in correcting miscommunications, all of which would burden working memory. In contrast, students can see what they type, readily correct typing errors, and otherwise off-load the constructed messages to an external memory.

On the other hand, other researchers claim that spoken input is superior to typed input. For example, students who interact with ITSs through spoken dialogue have been known to show an increase in self-explanations [6]. If students who input their contributions via speech have been shown to display a higher amount of self-explanations, then it is possible that they would show a higher amount of other learning strategies, namely tracking their knowledge and expressing metacognitive statements.

Some researchers have reported no significant differences in learning between spoken versus typed input with ITS’s [1]. In the study by Litman et al. [1], students worked with two ITSs on the topic of physics. Analyses revealed no significant difference in learning gains between the two communication modalities. These findings suggest that the amount of metacognition displayed between the two groups (spoken vs. typed) would be comparable.

1. Methods

Participants were 24 undergraduate students (10 men and 14 women) at a large public university who received either course credit or monetary compensation for their participation. In a repeated-measures design, all participants were assigned to each of the three conditions: speech input, text input, and control. These three treatments were assigned through counterbalancing to one of three topics in computer literacy: hardware, operating systems, and internet. For the typed input condition, participants interacted with AutoTutor and entered their input via a keyboard. In the speech condition, participants entered their input through a head mounted microphone. Thus, each student participated in two tutorial interactions, one with speech-based input and one with text-based input. The order in which students used these input methods (speech first and text second, or text first and speech second) was counterbalanced across participants. All participants were also assigned to a control condition for one of the three subject matters; for this condition they received no tutorial intervention or instruction.

For the current analysis, two trained graduate students examined the log files which contained tutorial dialogue transcripts collected from the student interactions with AutoTutor (both spoken and typed). The total number of student turns across both interactions totaled 2,300. The two graduate students individually examined each individual student turn and classified all metacognitive statements (e.g., “I don’t know”, “I get it”, “I don’t follow”). The total number of metacognitive statements across both interactions totaled 340, or 15% of the turns.
2. Results & Discussion

We explored whether there were any significant differences in the number of metacognitive statements between the typed dialogues and spoken dialogues. The spoken dialogue condition exhibited a higher proportion of expressions in the metacognitive category, $t(22) = 4.05$, $p < .05$. Table 1 shows means and standard deviations. Participants were given two (pre test and posttest) 24-item four foil multiple choice tests to assess learning gains. The tests were designed to assess deep levels of knowledge. Correlations were computed between metacognitive statement proportion scores and posttest scores. Analyses showed a significant negative correlation between metacognitive statements and posttest scores for the typed input, $r (23) = -.42$, $p < .05$, and the spoken input, $r (23) = -.35$, $p = .05$. The low-knowledge students expressed more metacognitive statements than did the high-knowledge students, $F (1, 21) = 4.24$, $p = .05$. This occurred in both input modalities, as shown in Table 1.

Table 1. Means (SD) for metacognitive statements as a function of input modality and prior knowledge

<table>
<thead>
<tr>
<th></th>
<th>Low prior knowledge</th>
<th>High prior knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spoken Input</td>
<td>.19 (.15)</td>
<td>.18 (.16)</td>
</tr>
<tr>
<td>Typed Input</td>
<td>.14 (.10)</td>
<td>.08 (.06)</td>
</tr>
</tbody>
</table>

Although some research suggests that the efficacy of tutorial dialogues may not be influenced by the modality of communication, our experimental findings indicate that interaction modality does matter on measures of metacognitive statements. The results also showed that students who displayed a higher proportion of metacognitive statements tended to have lower posttest scores. This finding is not surprising in one respect. Students with lower subject matter knowledge will presumably notice that they lack knowledge and will express this in tutoring. On the other hand, the result is incompatible with claims that it takes a lot of knowledge to know what one knows and what one does not know, as documented by Miyake and Norman [7]. In the context of these AutoTutor sessions, the low knowledge students tended to express “I don’t understand” extremely often (more than “I get it”) either because they detected their knowledge deficits accurately or because they were gaming the system.

References