Impact of Rejection Sensitivity on Socio-cognitive Conflict Learning in Intelligent Tutoring System Environments

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Abstract Socio-cognitive conflict is not only an inevitable cognitive and affective state in group learning experience, but also creates opportunities for better learning. When learners experience socio-cognitive conflict, they inspect the gaps in their knowledge. But not all learners benefit from this experience. Students vary greatly in their dispositions to react to social rejection (rejection sensitivity, RS) with implications for knowledge acquisition in group learning. How learners face and engage in conflict, therefore, may be dependent on learners’ RS. In this paper, we examine the extent to which Low Rejection Sensitivity (LRS) and High Rejection Sensitivity (HRS) influence socio-cognitive conflict learning gains. In a 4×2 mixed-design with contradictory information as a within-subjects factor (True-False, False-True, False-False, True-True) and RS as the between-subjects factor (Low, High), we analyzed perceived socio-cognitive conflict and knowledge acquisition in a multi-agent intelligent tutoring system (ITS) environment, where 78 participants engaged in dialogues on research methods concepts with animated two peer agents. The results show that high as compared to low (HRS vs. LRS) learners display a significantly more socio-cognitive conflict perception but less knowledge acquisition in contradictory information conditions. Our findings suggest that RS biases the knowledge acquisition in socio-cognitive conflict learning environments, which indicates that socio-cognitive conflict strategy cannot simply be generalized across different learners in ITS environments, and ITS learning environments need to be designed with respect to learners’ dispositions.

Keywords: Socio-cognitive Conflict, Rejection Sensitivity, Intelligent Tutoring Systems

1 Introduction

Intelligent tutoring systems (ITSs) are designed to increase learning through adaptive, individualized instruction and scaffolding [1]. ITSs can adaptively help the student by generating well-selected tutoring moves based on tracking what the learner knows. Adaptive guides can range from rich media content to various ways of interaction with
learners, such as conversation [2, 3]. Although the one-way media content presentation is a traditionally popular guide, in which a lot of information is delivered in a short time, the two-way conversation between the learner and machine to talk about what is in the text is somewhat more attractive than one-way media content presentation. Whom do the learners converse with? Specifically, it is the pedagogical agent, which has been developed to serve as a substitute for humans ranging in expertise from novice peers to experienced peer to subject matter experts with pedagogical strategies. The majority of tutoring systems are more concerned with the tutor agent because the human tutor is known to be effective for learning gains [2, 3]. The unpopular peer agent, however, has its own unique features, which may provide correct or incorrect information, encourage or motivate the human learner, and collaborate or compete with the learner [4]. The zone of proximal development (ZPD) in Vygotsky’s theory confirms the benefits of cooperative learning with peers [5]. Peer learning offers more proactive learning opportunities to think, question, and share knowledge than independent learning, which helps learners to adopt more effective learning strategies. The experiment described in this research is done in such a multi-agent ITS environment. Human students first watch a multimedia presentation about the learning content for shallow understanding and then argue with two peer agents in conversational trialogues for deeper understanding.

Researchers have investigated why tutoring is so effective in ITSs [6, 7]. A number of tutoring strategies used in the systems may be one of the reasons for its effectiveness, which are ignored or hardly used in the traditional learning environments, such as socio-cognitive conflict [8]. The importance of socio-cognitive conflict in learning has a long history in psychology that spans the cognitive, social, and developmental sciences [9-12]. Many researchers have built on the Piagetian approach of socio-cognitive conflict [13]. Their research shows that critically reviewing each others’ contributions for elaborating and improving shared knowledge can be highly beneficial for collaborative learning [14]. Does it always work? The answer from previous research results is “No” [13, 15]. Like other tutoring strategies, the socio-cognitive conflict strategy is suited for certain students to learn given tasks under the right situation. We, therefore, focus on the feature of target students, discussing how personality traits affect the socio-cognitive conflict learning performance.

Students depend on others for knowledge acquisition in the group. Yet, efforts to connect with others holds the potential for rejection. Because the prospect and reality of rejection are aversive, it can powerfully shape our social behavior [16-18]. People vary greatly, however, in the extent to which they identify cues of a social threat as personally threatening and in how they respond to them [17, 19]. This variability can be described in individual differences in rejection sensitivity (RS), which Downey and Feldman characterized in social-cognitive terms as the disposition to anxiously expect, readily perceive, and strongly react to social rejection [19]. There is considerable
evidence linking rejection sensitivity with a number of distinct relationship difficulties, including reactive hostility, over accommodation to the needs of others, and avoidance of situations that entail a risk of rejection or criticism. Here we examined whether RS might influence two kinds of socio-cognitive conflict processes involved in learning. First, we hypothesized that RS might influence conflict perception processes, such that High Rejection Sensitivity (HRS) individuals perceive more socio-cognitive conflict. Second, we hypothesized that RS might influence learning processes, such that HRS individuals less effectively gain from the discussion.

2 Methods

2.1 Participants and Design

Seventy-eight volunteers (45 females and 33 males, mean age = 21.2 yrs) were recruited from a general university in China (see table 1). Participants were recruited both through advertisements on campus and through contacting pre-screened individuals with high and low scores (75th and 25th percentiles, respectively) relative to the normative sample for the Rejection Sensitivity Questionnaire (RSQ) [19]. Although RS is measured continuously, to simplify the analyses we treated it as a dichotomy. People scoring at or above 75th percentiles were defined as HRS and could be viewed as tending to anxiously expect rejection. People scoring at or below 25th percentiles were defined as Low Rejection Sensitivity (LRS) and could be viewed as tending to calmly expect acceptance.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>p</th>
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<tr>
<td>Low RS</td>
<td>39</td>
<td>5.33</td>
<td>1.53</td>
<td>13.75</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>High RS</td>
<td>39</td>
<td>13.51</td>
<td>3.39</td>
<td></td>
<td></td>
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</tbody>
</table>

The experiment had a mixed-design with contradictory information as a within-subjects factor (True-False, False-True, False-False, True-True) and rejection sensitivity as the between-subjects factor (Low, High). Participants completed two learning sessions in each of the four conditions with a different critical thinking topic in each session (8 in all). Order of conditions and topics and assignment of topics to conditions was counterbalanced across participants with a Graeco-Latin Square.
2.2 Materials

Contradictory Information Manipulation. Discrepancies between the opinions presented by the agents represented the contradictory information manipulation, which varied in agent agreement and information correctness. There were two conditions in which the two agents agreed on the quality of the research study. In the True-True condition, both agents presented correct information (control condition), while in the False-False condition both agents presented incorrect information. In the two remaining conditions, the two agents disagreed on the quality of the research study. In the True-False condition, one peer agent presented correct information whereas the other agent disagreed by presenting incorrect information. In contrast, it was one peer agent who provided the incorrect information and the other agent who disagreed with correct information in the False-True condition. For example, in one True-False condition triologue one peer agent asserted that the study was flawed (helped to come up with the right answer) whereas another peer agent disagreed and asserted that the study was flawless, then one agent asked the participant whether he or she believed that the study contained a flaw. While in one False-True condition triologue one peer agent asserted that the study was flawless (ended up with the wrong answer) whereas another peer agent disagreed and asserted that the study was flawed, then one agent asked the participant whether he or she believed that the study contained a flaw. It should be noted that all misleading information was corrected over the course of the trialogues and participants were fully debriefed at the end of the experiment.

Knowledge Test. Research methods knowledge was tested three times. The pretest was tested before multimedia learning, the goal of which was to examine participants’ prior knowledge. The mid-test was tested after multimedia learning, the goal of which was to examine for intellectual control degree in multimedia learning. The posttest was tested after trialogue, the goal of which was to examine for intellectual control degree in trialogue. Each test had 24 multiple-choice questions, three questions per concept (e.g., random assignment, experimenter bias, control groups). Three types of test items were adopted: definition, function, and example. There was three alternate test versions and assignment was counterbalanced across participants for pretest, mid-test, and posttest.

2.2.3 Perceived socio-cognitive conflict

The perceived socio-cognitive conflict was measured by nine items of a translation and elaboration of the Intragroup Conflict Scale (ICS) [20], including the relationship conflict subscale (five items) and the task conflict subscale (four items). The items were tailored to reflect the group argumentation context and were slightly modified to enhance the diversity of item phrasing. For example, “How frequently are there conflicts about ideas in your work unit?” was rendered as, “How frequently are there conflicts [emphasis added] about ideas in your group argumentation?” Responses were
provided on a 5-point Likert-type scale ranging from 1 = “none” to 5 = “a great deal”. Coefficient alphas for the scale were 0.78.

2.2.4 Rejection Sensitivity

The Rejection Sensitivity Questionnaire (RSQ) was adopted to assess anxious expectations of social rejection by measuring responses to 18 hypothetical interpersonal interactions in which rejection is a possibility (e.g., “You ask your friend to do you a big favor”) [19]. For each hypothetical interaction, the respondent indicated his or her degree of concern or anxiety about the outcome, as well as the perceived likelihood that the interactant (or interactants) would respond with rejection. RS scores were calculated by first weighting the expected likelihood of rejection for each situation by the degree of anxiety and then averaging these weighted scores across all situations. Coefficient alphas for the scale were 0.83.

2.3 Procedure

Participants had finished the Rejection Sensitivity Questionnaire (RSQ) before the formal experiment. The pre-screened individuals with high and low RS scores (75th and 25th percentiles, respectively) relative to the normative sample were recruited. Participants were seated in front of a 14-inch notebook computer with headphones, individually testing over a three-hour session during a single day. The experiment occurred over five phases. These phases were: (1) Prior knowledge test (pretest), to check and control over participants’ prior knowledge; (2) Multimedia learning: In order to improve participants’ related knowledge to identify the contradictory information in the fourth phase; (3) Knowledge test of learning (mid-test): To examine and control over what participants gain in multimedia learning, and highlight the effect of contradictory information, which is manipulated in the next phase; (4) Argumentation trialogues: It is the most important phase in the experiment, because the independent variable, contradictory information, is manipulated in it; (5) Knowledge test of trialogues (posttest): To check what participants gained in argumentation trialogues.

Prior to the first trialogue, the participant chose one portrait for himself or herself during argumentation, and then entered the argumentation interface. Two peer agents first introduced themselves and then invited the human participant to introduce himself or herself. After mutual self-introduction, the perceived socio-cognitive conflict was first tested by ICS (pretest), which worked as a baseline during the comparison. Next, the participant began the first of eight trialogues. In each trialogue, the participant discussed the case study for one of the research methods concepts with peer agents. The trialogue interface is shown in Figure 1 consisting of (A) two peer agents’ headshots at
the top of the screen, (B) the optional headshot from the participant at the bottom of the screen, (C) a description of the case study in the middle of the screen, (D) a text transcript of the dialogue history on the left of the screen, and (E) a text box for the presenter beside the headshot. The agents delivered the content of their utterances via synthesized speech and texts, while the participant typed his or her responses.

![Screenshot of learning interface](image)

**Fig. 1.** Screenshot of learning interface

The trialogue for each case study involved four multi-turn trials. Prior to the first trial, the participant was asked to offer his or her initial response to the case study question, and then the following activities occurred in each trial: (1) one peer agent provided an opinion on an aspect of the study; (2) the other peer agent either concurred with that opinion or disagreed by providing an alternate opinion; (3) the participant provided his or her opinion, and indicated how certain he or she was of the opinion, along with a peer confusion judgment; and (4) the participant was asked to explain his or her opinion (third and fourth trials only). The trialogue would only proceed to the next trial if the participant had responded with texts. The system only restricted whether to respond, but did not limit the content of participant’s response. Hence although this cycle was repeated in each trial, with each trial becoming increasingly more specific about the research study, the trialogue did not appropriately scaffold participants to the direction of problem-solving. The ICS would be tested again after the four multi-turn trials (posttest), which represented the change of perceived socio-cognitive conflict in different contradictory information conditions. All contradictory and false information was corrected after the fourth trial.
3 Results

3.1 RQ1: Effects of contradictory information and rejection sensitivity on perceived socio-cognitive conflict.

The effect of contradictory information on the perceived socio-cognitive conflict was shown to be successful. First, a repeated measures ANCOVA analysis was performed, with contradictory information as an independent variable, RS (RSQ scores) as a covariant and perceived socio-cognitive conflict as dependent measures (see table 2). The perceived socio-cognitive conflict was computed as (posttest - pretest). The result showed that the interaction between contradictory condition and rejection sensitivity was significant, $F(3, 228)=5.2, p=.002, \eta_p^2=.06$. An ANCOVA successfully removes any contribution of the covariate to the mean square error, however, it does not provide a valid test as to whether the difference between the four conditions is significant because the mean square for the within-subject main effect is contaminated by the presence of covariant variance, whereas the mean square error is not. Hence a standard ANOVA in repeated measures design was employed secondly, with contradictory information as the independent variable and perceived socio-cognitive conflict as dependent measures. The results revealed that the main effect of contradictory information on the perceived socio-cognitive conflict was extremely significant, $F(3, 231)=333.22, p<.001, \eta_p^2=.81$.

Besides rejection sensitivity, are the perceived socio-cognitive conflict and knowledge acquisition influenced by other individual variables, such sex, and age? Due to some doubt as to whether the population means covariate is the same across all groups, we conducted both an ANCOVA and a two-way ANOVA in mixed between-subjects and within-subject design [21]. The ANCOVA was used for testing the main effect of the covariate and the within x covariate interaction. Then the Two-way ANOVA was used to test all other remaining effects. The results of the ANCOVA analysis indicated that the main effect of the sex covariate ($F(1, 74)=0.13, p=.723, \eta_p^2=.002$) and age covariate ($F(1, 74)=3.08, p=.084, \eta_p^2=.04$) respectively on perceived socio-cognitive conflict were not significant. The interaction between contradictory condition and the sex covariate ($F(3, 222)=0.93, p=.428, \eta_p^2=.01$) as well as the interaction between contradictory condition and the age covariate ($F(3, 222)=1.74, p=.16, \eta_p^2=.02$) were also not significant. Then a 4(contradictory information) x 2(rejection sensitivity) two-way ANOVA was performed, with perceived socio-cognitive conflict as dependent measures. The results showed that the main effect of contradictory information ($F(3, 228)=358.31, p<.001, \eta_p^2=.83$) and rejection sensitivity ($F(1, 76)=35.6, p<.001, \eta_p^2=.32$) respectively on perceived socio-cognitive conflict were extremely significant. The interaction between contradictory condition and rejection sensitivity was extremely significant, $F(3, 228)=6.8, p<.001, \eta_p^2=.08$. The simple effect analysis suggested that in the LRS group, the perceived socio-cognitive
conflict in the true-false condition was higher than in the false-true, false-false and true-true conditions (MTT>MTF>MFF, p<.05); in the HRS group, the perceived socio-cognitive conflict declined more sharply (MTF>MFF>MFT>MTT, p<.05) (see fig. 2).

Table 2. Means and standard deviations of perceived socio-cognitive conflict and knowledge acquisition

<table>
<thead>
<tr>
<th></th>
<th>RS</th>
<th>True-False</th>
<th>False-True</th>
<th>False-False</th>
<th>True-True</th>
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<tr>
<td>Perceived Socio-Cognitive Conflict</td>
<td>LRS</td>
<td>3.12±.61</td>
<td>2.91±.62</td>
<td>1.45±.52</td>
<td>1.34±.33</td>
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<tr>
<td></td>
<td>HRS</td>
<td>3.9±.59</td>
<td>3.64±.75</td>
<td>1.73±.57</td>
<td>1.54±.53</td>
</tr>
<tr>
<td>Knowledge Acquisition</td>
<td>LRS</td>
<td>.35±.11</td>
<td>.34±.17</td>
<td>.19±.15</td>
<td>.21±.13</td>
</tr>
<tr>
<td></td>
<td>HRS</td>
<td>.07±.04</td>
<td>.06±.05</td>
<td>.06±.05</td>
<td>.24±.13</td>
</tr>
</tbody>
</table>

3.2 RQ2: Effects of contradictory information and rejection sensitivity on knowledge acquisition.

An ANCOVA in repeated measures design was performed first, with contradictory information as an independent variable, RS (RSQ scores) as a covariant and knowledge acquisition as dependent measures (see table 2). Proportional knowledge acquisition was computed as (posttest - mid-test)/(1 - mid-test). Mid-test and posttest scores were computed as the proportion of questions answered correctly. The result showed that the interaction between contradictory condition and rejection sensitivity was significant, $F(3, 228)=17.2, p<.001, \eta^2_p=.19$. A standard ANOVA in repeated measures design was employed secondly, with contradictory information as the independent variable and knowledge acquisition as dependent measures. The results revealed that the main effect of contradictory information on knowledge acquisition was significant, $F(3, 231)=7.94, p<.001, \eta^2_p=.1$.

A mixed between-subjects and within-subject ANCOVA was performed first. The results indicated that the main effect of the sex covariate ($F(1, 74)=0.11, p=.742, \eta^2_p=.001$) and the age covariate ($F(1, 74)=0.97, p=.328, \eta^2_p=.01$) respectively on knowledge acquisition were not significant. The interaction between contradictory condition and the sex covariate ($F(3, 222)=0.61, p=.607, \eta^2_p=.008$) as well as the interaction between contradictory condition and the age covariate ($F(3, 222)=0.08, p=.972, \eta^2_p=.001$) were also not significant. Then a 4(contradictory information) x 2(rejection sensitivity) two-way ANOVA was performed, with knowledge acquisition
as the dependent measure. The results showed that the main effect of contradictory condition was significant, $F(3, 228)=11.08$, $p<.001$, $\eta^2_p=.13$; and the main effect of rejection sensitivity was also significant, $F(1, 76)=138.47$, $p<.001$, $\eta^2_p=.65$. An interaction effect of contradictory information and rejection sensitivity was found, $F(3, 228)=31.42$, $p<.001$, $\eta^2_p=.29$. The simple effect analysis suggested that in the LRS group, the knowledge acquisition in the true-false and the false-true conditions were higher than in the false-false and the true-true conditions ($M_{TF}>M_{FT}>M_{TT}>M_{FF}$); in the HRS group, however, the knowledge acquisition in the true-true condition was higher than in the true-false, false-true and false-false conditions ($M_{TT}>M_{TF}$, $M_{TT}>M_{FT}$, $M_{TT}>M_{FF}$) (see fig. 2).

![Fig. 2. The interaction between contradictory condition and rejection sensitivity](image)

### 4 Discussion

The results indicated that the HRS students perceived more socio-cognitive conflict than the LRS group. LRS students, however, benefited more from the conflict-oriented online learning environment. These results might be explained by the differences in the internal perception of contradictory information that is being shared in the respective LRS and HRS groups. HRS individuals showed larger arousal responses across all types of contradictory information. This might indicate a general anxious apprehension in a situation characterized by an ambiguous threat, which depleted the psychological resources and weakened their knowledge acquisition.

Compared to their LRS peers, HRS students benefited more from the non-conflict group learning environment. For LRS, socio-cognitive conflict creates opportunities for better learning. When LRS learners experience the socio-cognitive conflict, they inspect the gaps in their knowledge. However, when HRS students are in this situation, the socio-cognitive conflict is the learning burden instead of learning opportunities.
HRS students are not only aware of the holes in their knowledge, but also prepare physiologically for the worst to happen, and become anxious even before anything aversive has happened. The group learning environment without contradictory information, therefore, facilitates knowledge acquisition in HRS learners.

Fewer knowledge acquisitions in HRS students, however, does not imply that HRS students need to entirely reject the group learning situation, where conflict scenes are hard to avoid. A persistent question in ITSs is which strategy is suited for certain students to learn given tasks under the right situation. Since we have had some success in identifying the trait of learners in socio-cognitive conflict learning, the next step may be to implement interventions that will help HRS students to regulate anxiety and make use of learning opportunities from conflict. Further research will be required to find and compare the effective interventions that aim to promote learning for HRS students on socio-cognitive conflict learning in ITSs environments.

Work has been ongoing to develop ITSs to support tailored, guided learning experiences. Not only for individuals but also for teams. As missions become more complex, success requires teamwork. Teams are usually made up of individuals who differ in competency, content comprehension, and disposition. Individuals working in the team not only gain knowledge differently but also contribute in various ways. For example, HRS individuals benefit less from a conflict teamwork environment, and also bring a little contribution to other members’ gain and team performance. Hence compared to HRS individuals, HRS team members’ interventions are more complicated but more necessary. The complexity lies in the heterogeneous and various team structure and the complex interactions. The necessity is mainly embodied in the triple impact from HRS, including himself/herself, other members and the whole team. Additional research is needed to find/develop effective interventions for HRS team members and empirically evaluate/validate these interventions.

5 References