

Comprehension Monitoring and Regulation in Distance Collaboration

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Abstract

Comprehension monitoring and regulation in a distance learning situation were examined in comparison to individual learning through an error-detection paradigm. The collaborative learning condition produced significantly better learning and monitoring. These results were interpreted as the effect of regulative interaction in the collaboration. Then, the specific interactions of 3 good and 3 poor pairs were contrasted to examine their interaction pattern in terms of monitoring and regulation. The results showed that the good pairs had a higher level of monitoring and regulative interaction. Also when the good and poor groups successfully monitored comprehension failure, the poor groups implemented less effective regulation strategies.

To understand text, learners need to integrate successively encountered information from that text into a coherent and well-integrated (mental) representation (Kintsch, 1998). According to Kintsch this comprehension process proceeds in a piecemeal way, sequentially developing a bigger and more coherent representation. This process tends to be prone to errors such as representation of incorrect information and/or misrepresentation of correct information due to omissions, inconsistencies, and/or anomalous and unclear text. When these comprehension failures occur, learners should be able to use metacognitive monitoring to detect the failures and regulation strategies to repair them and thus construct a more coherent understanding of the text in order not to end with a lack of understanding or misunderstanding.

However, despite the significance of monitoring and regulation strategies to text understanding, learners tend to fail to detect their own misunderstandings (Markman, 1979), ignore incorrect information (Otero & Kintsch, 1992), and overestimate their own understandings (Glenberg, Wilkinson, & Epstein, 1982) and capabilities (Presseley & Ghatala, 1990). Learners are too often satisfied with their *faulty* understanding to challenge given tasks and hence fail to trigger regulation processes. Accordingly, various efforts such as metacognitive strategy training, setting up explicit comprehension goals, or self-generating feedback have been made to improve learners' comprehension.

Considering that effective learning often takes place in social settings, and that individual learners' comprehension could be affected by their peers' comprehension, it seems worthwhile to examine comprehension monitoring and regulation in collaborative learning situations. More

specifically, comprehension monitoring and regulation seem especially critical in distance collaboration situations where a lot of learning takes place from text. Therefore, the goals of this research are to examine whether distance collaboration improves individuals' comprehension monitoring and regulation abilities, as well as the conditions that make distance collaboration produce effective or ineffective text comprehension.

Monitoring and Regulation in Collaboration

Monitoring and regulation have been considered critical in effective face-to-face collaboration because they help learners construct a more coherent understanding. First, externalizing thinking and understanding through communication might help collaborators better monitor and regulate their performance (Miyake, 1997) because it causes thinking and understanding to become objects that can be sharable and manipulable between collaborators (Miyake, 1986). While learners working alone are often subject to self-confirmation bias, learners can benefit from working with peers thanks to a 'checking mechanism' in collaboration (Miyake, 1986) that advances comprehension monitoring and regulation. Second, the division of cognitive processes in collaboration (Dillenbourg, Baker, Blaye, & O'Malley, 1995) may play a part in improving monitoring and regulation in collaboration. For example, one peer might take the role of leader, while another peer might take the role of monitor (e.g. Miyake, 1986). In the process of collaboration, many errors made are detected and corrected by partners (Miyake, 1986; Resnick & Salmon, 1993). Also, Karabenick (1996) recently showed that learners may have better comprehension monitoring after receiving questions from colearners. Third, comprehension monitoring and regulation could be easily implemented when peers have conflicting perspectives. As Piaget's socio-cognitive conflict theory suggests, collaborating individuals with different understandings of the same task may advance their understanding in the process of resolving their differences. Fourth, regulating comprehension problems seems fundamental to collaboration processes because the regulation process in collaboration may be activated automatically (Schegloff, 1991), and incorrect elements of their representation might then be fixed through communicative interactions such as engaged discussion (Kruger, 1992), elaboration or arguments (van Boxtel, van

der Linden, & Kanselaar, 2000), or other repairs (Lumpe & Staver, 1995).

Because collaborating learners may have higher chances of monitoring (detecting that there might be something wrong) and of regulation (knowing what could be correct knowledge), it might be straightforwardly expected that collaborating learners will have better comprehension than isolated learners. However, when distance between learners is involved in learning, the above inference seems complicated because people working together at a distance report various kinds of difficulties that seem to deteriorate collaboration. First, the lack of nonverbal communication cues in distance communications may torture clear communications (Armstrong & Cole, in press) that help to manipulate thinking. Second, distance learners have difficulty in grounding communications and spend a long time doing so (Kiesler, Siegel, McGuire, 1984). Third, some studies report that cognitive conflicts are not only well detected (Armstrong & Cole, in press), but also rather emotionally charged with no easy method of cognitive resolution. Finally, anonymous individuals who are placed in group distance learning situations tend to be less supportive of each other because of low perceptions of group cohesion and conformity.

Therefore, one could propose the following model of effective distance collaboration. When comprehension failures occur, they should be detected. If not, the failures might end up with non- or mis-comprehension. Once the failures are detected, they should be repaired. If not, the failures also might lead to non- or mis-comprehension. To test the model, we hypothesized that if interactions between individuals working at a distance (e-Pairs) are sufficiently effective, they will be better than the individuals working alone (Singles) in learning scores because of better comprehension monitoring and regulation and that good e-Pairs will be better than poor e-Pairs in comprehension monitoring and regulation.

Method

Comprehension monitoring and repairing during distance collaboration was compared to monitoring and repairing during individual learning. Unlike typical face-to-face collaboration studies that emphasize ecological validity, we wanted better experimental control and a wider range of data.

Participants. Sixty-nine undergraduates (Male = 27, Female = 42) taking introductory psychology courses volunteered in this study. All the participants received course credits for participation. The first language of all the subjects was English. They all reported that they had experience using chatting interfaces on the internet and were familiar with these interfaces. Randomly, thirty-seven of them were assigned to an individual learning condition (Singles: male=15, female=22) and the other 32 to the collaborative learning condition (e-Pairs: male=12,

female=20). All e-Pairs participants were randomly paired with a same sex partner. One pair was removed from the data analysis because of a problem with the interface.

Materials. Two expository texts about theories of knowledge representation were used. One text concerned symbolism and the other connectionism. The text content was selected because undergraduate students were not familiar with these theories of representation, and this allowed us to minimize the pre-knowledge effect and maximize the purity of comprehension monitoring and regulation strategies. Each text consisted of 15 sentences and had two versions: Consistent and inconsistent. Following Markman (1979)'s *error-detection paradigm*, inconsistent versions had contradictory or inconsistent information at the 5th, 10th and 15th sentences. For example, the first five sentences used in the symbolism text were (1) *One of the major theories about representation is called symbolic representation.* (2) *The symbolic representation view is that the human mind represents information as a language-like or symbolic form.* (3) *Because most of us think and all of us write linguistically, we tend to couch our ideas in symbols like a natural language form.* (4) *We can understand thought, belief, problem solving in a language-like symbolic form.* (5c) *Thus, in this view, symbols (roughly, words) are used to represent information in the human mind.* (5i) *Thus, in this view, symbols (roughly, words) are not used to represent information in the human mind.* Here the 5c was a consistent sentence, while 5i was an inconsistent sentence. Thus, when subjects came to read the fifth sentence, either (5c) or (5i) was displayed to them. Detecting the first inconsistent sentence located at the 5th position was manipulated to be the easiest, that of the second at 10th position the middle, and that of the last at the 15th position the most difficult in terms of the amount of correct representation needed to detect the inconsistency.

Interface. A computer interface (see Figure 1) was used to manage the experiment automatically, to collect data, and to provide an environment in which the participants could work. The interface for the main experiment session consisted of five units: (1) a new sentence display unit, (2) a history window, (3) a monitoring detection task unit, (4) a comprehension self-rating slider, and (5) an IRC (internet relay chatting) as a distance communication channel. The new sentence display unit was used for displaying each new sentence. When each new sentence appeared, the previous sentence moved up to be located at the bottom in the history window which accumulated all the previous sentences. Thus, the participants could focus on comprehension instead of memorizing sentences. The distance communication channel was an internet relay chatting interface where each pair communicated without any verbal and nonverbal interaction. The individual learning condition was identical except for not having the distance communication channel.



Figure 1: Computer interface

Comprehension monitoring task. There were two monitoring tasks: Detection and comprehension self-rating. The detection task was to decide whether or not each sentence was consistent with previous sentences. The self-rating of comprehension was measured with a rating scale labeled with 0%, 25%, 50%, 75%, and 100%, indicating the approximate percentage of the meaning that the subject believed he/she understood. However, self-rating measures appeared unreliable and were thus removed from the results.

Comprehension regulation interaction coding scheme. Each episode (the period between the end of one sentence and the start of the next new sentence), was evaluated in terms of the level of monitoring and regulation quality exhibited. The conversation levels were coded using the following hierarchical scheme: 0: off-task – coded when an episode consisted of task-unrelated things; 1: Checking answers – coded when an episode consisted only of asking for and providing each other's answers; 2: Rephrasing – coded when an episode consisted of providing answers and rephrasing the given sentence as their rationale; 3: Explanation – coded when an episode included integrating, relating, or generating information to explain answers; 4: Elaboration – coded when subjects proceeded to elaborate or clarify each other explanation, and 5: Negotiation – coded when an episode was resolved with an agreed cognitive solution. This scheme was hierarchical in that the higher, the better in comprehension as a continuum from low level monitoring (Checking answers) to high level regulative behavior (Negotiation). When multiple levels in an episode appeared together, the highest one was selected to represent the quality of interaction of the episode. Two coders independently coded two randomly selected groups for the analysis and achieved a 0.84 inter-coder reliability.

Procedure. Each participant was randomly assigned to either the Singles condition or the e-Pairs condition. The participants went through an instruction session, a pretest session where they answered 20 multiple choice questions about the main texts, a warm-up session that had two short texts to familiarize them with the interface, a 2nd instruction session that was exactly same as the 1st instruction, a main task session, and a posttest session. In the instructional

sessions, they read that they would study, with or without a partner, two draft texts that might or might not have inconsistent information. They were also instructed that they should explain the meaning of each sentence – to themselves in the Singles or with their peer in the e-Pairs – and that they would get bonus credits based on their performance. Both the pre- and post-test comprehension questions, and their alternatives about the main tasks, were completely randomized. In the main task session, all the participants in the e-Pairs were randomly paired with a same-sex partner with whom they had no interaction before the main task session. The order of presentation of the two texts was randomized and the selection of either version was counterbalanced. Thus, the participants studied two texts but only one of them was an inconsistent version. In each episode identified as each sentence level interaction, whenever a new sentence appeared, the participants individually read the sentence, performed the comprehension monitoring tasks (the detection and self-rating task) with no means of communication. Then they studied the sentence by explaining the meaning of the sentence either alone in the Singles or together with a peer through the distance interaction channel in the Pairs. When they decided to finish studying, they hit a button to request another sentence, at which point the communication channel was automatically disabled. These sentence level activities repeated until the end of the two tasks. Note that the e-Pairs were not asked to reach an agreement, did not have an interaction before the main task session, and only their first names were shown on the communication channel interface.

Results

1-1. e-Pairs will be better than Singles in learning

A one-way ANOVA showed no significant difference in the pretest scores between the Singles and e-Pairs. Another one-way ANOVA was done with the learning defined as the difference between the post- and pre-test scores. The e-Pairs ($M = 4.47$, $SD = 1.73$) were significantly better than the Singles ($M = 2.62$, $SD = 1.88$) ($F(1,65) = 5.13$, $p = .03$). Finally, the effect size as *Cohen's d* was 1.02. These results provided a rationale to conduct further analyses.

1-2. e-Pairs will be better than Singles in monitoring

The detection task performance as comprehension monitoring was examined (see Figure 2). In the consistent versions, the e-Pairs ($M = .92$, $SD = .06$) and Singles ($M = .88$, $SD = .04$) were not significantly different on any sentence. However, in the inconsistent versions, the e-Pairs were significantly better for the first inconsistent sentences, the easiest one (5th sentence: for e-Pairs $M = .75$, $SD = .18$; for Singles $M = .18$, $SD = .01$) at text 1: $F(1,32) = 18.03$, $p = .00$ and at text 2: $F(1,33) = 5.05$, $p = .02$, not for the second (10th) and the third (15th) inconsistent sentence.

2-1. Good e-Pairs will be better in monitoring

To examine what mechanisms drive effective distance collaboration, three good ($M = 13.3$, $SD = 2.1$) and three poor e-Pairs ($M = 4.0$, $SD = 7.0$) were selected, $t(4) = 5.74$, $p = .00$). This selection was made after removing e-pairs where peers had large knowledge differences, to avoid looking at extreme cases. No significant differences between the good and poor Pairs were found in the pretest scores (Good: $M=11.0$, $SD=2.0$; Poor: $M=13.0$, $SD=5.6$), the pretest difference between members in each pair (Good: $M=1.0$, $SD=.0$; Poor: $M=1.0$, $SD=1.0$), the mean number of turns per episode (Good: $M=6.7$, $SD=.33$; Poor: $M=6.4$, $SD=5.0$), the total time spent per group (Good: $M = 52.7$ min, $SD=15.0$; Poor: $M=47.2$, $SD=14.3$), and time per episode (Good: $M=1.76$ min, $SD=.5$; Poor: $M=1.6$, $SD=.5$). These non-significant indices formed the baseline against which to examine differences in the level of monitoring and regulation quality in collaboration.

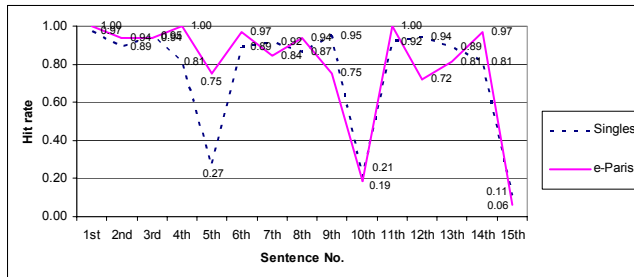


Figure 2. Comprehension monitoring task performance

Then, the hypothesis that high e-Pairs will be better in comprehension monitoring was tested. There were no significant differences at all three inconsistent sentences, although the pattern looks similar to that of the comparison between the e-Pairs and Singles.



Figure 3. Quality of regulative interaction in general

2-2. Good e-Pairs will have higher quality of monitoring and regulative interaction than poor e-Pairs

Another difference was found in the level of monitoring and regulation quality in their interaction. The good e-Pairs ($M = 2.77$, $SD = .97$) had a significantly higher level of regulative interactions than the poor e-Pairs ($M = 1.64$, $SD =$

1.0), $F(1,178) = 58.40$, $p = .00$ (see Figure 3). In general, the good e-Pairs interaction quality was around explanation level, whereas the poor e-Pairs interaction quality was between just checking answer and rephrasing (refer to coding scheme in the method section).

2-3. Given successful monitoring, good e-Pairs will be better than poor e-Pairs in regulative interaction.

Before answering the question, we examined when e-Pairs had longer conversations, which means they tried to do something more like repairing. Based on each individual decision on the detection task before starting each interaction period, each episode was categorized into one of three categories: both members' answers or perspectives were 'same and correct', 'same and incorrect', or different. Then comparisons were made between good e-Pairs and poor e-Pairs. According to a two-way ANOVA ($F(2,174) = 8.2$, $p = .00$) and its *Scheffe*, the only significant difference was on the category dimension, especially between the level *different* and the others (see Table 1).

Table 1: The mean number (SD) of turns in episode

Categories	Good	Poor	Mean
Same & Correct	6.3 (3.1)	5.7 (4.8)	6.0 (4.0)
Same & Incorrect	5.0 (2.5)	6.8 (4.2)	6.0 (3.3)
Different	9.8 (3.0)	8.8 (4.9)	9.2 (4.3)
Mean	6.7 (3.3)	6.4 (5.0)	6.5 (4.1)

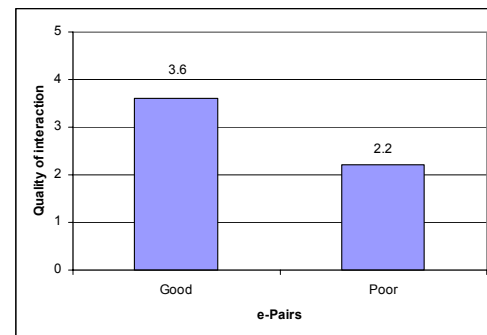


Figure 4: Quality of interaction given successful monitoring

Then we examined the hypothesis that good e-Pairs will have higher quality of interaction (see Figure 4). Regulative interaction qualities between the good and the poor e-Pairs were compared when they all had successful monitoring. Given the total 24 episodes (good: $n = 10$; poor: $n = 14$) where peers in an e-Pair had different perspectives that signaled there might be something *wrong*, their interaction qualities were examined. Interestingly, the poor e-Pairs ($M = 2.21$, $SD = 1.31$) showed a significantly lower level of regulative behavior than the good e-Pairs ($M = 3.60$, $SD = .52$), $F(1,23) = 9.95$, $p = .00$. The interaction quality of the good e-Pairs was between the explanation and elaboration

level, while that of the poor e-Pairs was around rephrasing. For example, the following episode from a good e-pair shows that when peers had different opinions they tried to resolve the difference.

1: Lao	i put incorrect b/c i had no clue what that was about
2: Lao	sorry:(
3: Cat	haha
4: Cat	that's alright
5: Lao	i just thought that the info sounded like conflicting symbols
6: Cat	it's just saying that by adding another symbol to a sentence you can make it a fact
7: Cat	the sentence is kinda weird
8: Lao	oh ok
9: Lao	yeah it is
10: Cat	maybe the next sentence will be about displacement
11: Lao	ok

However, another episode from a poor e-pair shows that after they checked their answers they did not try to resolve their comprehension failure.

1: Cu	hmm
2: Ja	i wasn't sure about this one
3: Cu	me either
4: Cu	I chose incorrect
5: Ja	oh, i chose correct. i don't know why though...
6: Cu	me either
7: Ja	oh well

Discussion

Comprehension processes are error-prone because they are constructive and approximate. Learners need to be error sensitive to attain error-proof comprehension. In this study, we examined the role of collaboration in improving comprehension monitoring and regulation in a distance communication situation, a matter that had not been investigated before. With a relatively well-controlled collaboration experiment, we first showed that distance collaboration is more beneficial to learning than working alone. In addition, performance in detecting contradictory information is also somewhat better in collaboration. Therefore, the better learning that occurred in the e-Pairs may be attributed to the process of collaboration.

Furthermore, to examine the role of collaboration in comprehension monitoring and regulation in detail, 3 good e-Pairs and 3 poor e-Pairs were examined. The good e-Pairs were not significantly better than the poor e-Pairs in comprehension monitoring (error detection). However, the regulative interaction quality of good e-Pairs' interactions was generally higher than that of poor e-Pairs. In general,

the good e-Pairs interaction quality was around the explanation level, whereas the poor e-Pairs interaction quality was between just checking answer and rephrasing.

Another interesting finding was from the comparison when both the good e-Pairs and the poor e-Pairs had successful monitoring. The poor pairs' regulative interactions were not highly activated even though their comprehension problems were monitored explicitly, while the good groups tended to indulge in higher level of regulative interaction.

Therefore, the results can be interpreted as supporting the claim that participants in distance collaboration benefit from collaborative interaction by improving their detection of comprehension failures, and implementing repair processes through regulative interaction. Also, the results support the research model that states that when comprehension failures or cognitive conflicts happen they should be detected and repaired to achieve correct comprehension or learning.

Thus, the model explains why some research on cognitive conflict finds increased learning while other research does not. As the model states, cognitive conflicts do not necessarily result in learning unless the conflicts are detected and resolved. In this experiment, no case was found to reach a cognitive resolution coded as negotiation. Instead, a lot of cases ended up with social negotiation. Here social negotiation means that conversants agree to blur their conflicts without reaching a clear resolution, as seen in the example conversation from the good e-Pair. Interestingly, there was also no instance of flaming, which is frequently reported in distance collaboration studies.

The so-called 'checking mechanism' (Miyake, 1986) may be a key for suppressing self-confirmation bias that may be dominant in solo learning. Self-confirmation bias is a tendency to stick to an already held explanation rather than developing alternative explanations. This tendency, when learning alone, tends to block learners from changing their representation by suppressing (Otero & Kintsch, 1992) and/or ignoring (Chinn & Brewer, 1993) inconsistent information that does not match with their representations. However, the confirmation bias in a group may be smaller, because groups are better than individuals at rejecting presuppositions (Gorman, Gorman, Latta & Cunningham, 1984), so long as they entertain hypotheses and alternative ideas, and consider justifications (Okada & Simon, 1997).

The results of this research are consistent with other research in the collaboration community. For example, Brown and Campione (1986) argued that "understanding is more likely to occur when a student is required to explain, elaborate, or defend his or her position to others; the burden of explanation is often the push needed to make him or her evaluate, integrate, and elaborate knowledge in new ways" (p. 1060). Also, Forman and Cazden (1994) identified *parallel*, *associative*, and *cooperative* interaction patterns, of which *cooperative* is the highest level – characterized as constantly monitoring, guiding and correcting each other's

work. Additionally, Barron (2000) argued that after contrasting a high-achievement group with a low-achievement group, greater monitoring for coordination between members would result in higher results. Therefore, collaboration might be an ideal way to improve individuals' monitoring and regulation abilities.

Finally, some aspects of this study should be noted that may limit generalizations of the results. One is that this experiment was highly controlled compared to other face-to-face collaboration research. We tried to separate the collaboration period from individuals' comprehension monitoring decision periods, to examine the effect of collaboration on individual learners' comprehension. Also, we tried to remove socially confounding variables. For example, the participants in each pair did not interact before the main tasks. Although this may appear to limit the *ecological* validity of this study in terms of face-to-face collaboration, it seems acceptable in terms of *e-ecological validity* since distance collaboration is often between anonymous individuals. Also it may provide a cleaner demonstration of the cognitive effects of collaboration on learning.

Acknowledgments

This study was supported by the NetLearn project funded by a Technology Innovation Challenge Grant from the U.S. Department of Education to New York City Community School District No. 2 and the University of Pittsburgh and by Microsoft Corporation. We thank Randi Engle, Heisawn Jeong, Lelyn Saner, Mark McGregor, Patrick Jermann, Amy Soller, and Brad Morris for their sincere help.

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