

# Constructing new knowledge in collaboration: instructional support for improving information pooling and processing in groups

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Groups can build valuable new knowledge by drawing inferences from their members' complementary knowledge. Unfortunately, groups tend to focus on information known to all members from the start ("shared") and neglect members' unique ("unshared") knowledge. The present study investigated whether a similar bias could also be found at the level of inferences drawn from shared and unshared information. In an experiment, 27 student dyads solved a murder mystery task over a videoconferencing system. A control condition was compared to two instructed conditions which were informed about typical task difficulties, and either received external guidance from a collaboration script (script condition), or planned their own collaboration (planning condition). Dialog analyses revealed the expected biases towards shared information in both the pooling of text information and the drawing of inferences. Instructional support helped dyads to produce more correct solutions, but did not improve the drawing of inferences.

Groups of learners and problem solvers can profit greatly from pooling and integrating their members' complementary knowledge. In particular, new knowledge can be built at the group level by drawing inferences from the information contributed by individuals. This collaborative pooling and integration of information enables the co-construction of new shared knowledge (Roschelle & Teasley, 1995) and the generation of more advanced problem solutions (e.g. Rummel & Spada, 2005). Thus, it is an important aspect of successful collaboration (Meier, Spada, & Rummel, 2007). Unfortunately, groups tend to focus on information that is known to all members from the start ("shared") and neglect members' unique ("unshared") knowledge. For this reason, groups typically fail to detect the best solution in "hidden profile" situations, where the best alternative can only be found if all available shared and unshared information is pooled (see Wittenbaum, Hollingshead, & Botero, 2004 for an overview). Experimental research on the effects of information sharedness on group discussion, however, has so far focused on the mere pooling of information and neglected higher levels of information processing, i.e. the collaborative construction of new knowledge. The present study therefore 1) investigated whether biases towards shared information can also be found at the level of inferences, and 2) explored two kinds of instructional support for overcoming such biases.


















## The task: solving a murder mystery

Dyads of university students collaborated on a murder mystery case over a desktop-videoconferencing system. Each student first read a set of "interrogation protocols" individually, which had to be returned after 30 minutes. The dyad was then given 50 minutes to discuss which out of four suspects had most likely committed the murder, and to justify their decision. To succeed, students had to draw 12 inferences from both shared and unshared pieces of information, yielding the motive, the alibi, and one further piece of evidence for each of the four suspects. The task was a "hidden profile" in that the unconnected, individual pieces of information pointed towards the wrong suspect, while the inferences pointed towards the murderer. All participants were informed that their sets of information differed to some extent, that they had to return all materials after reading them, and that they were supposed to find motives, alibis, and further evidence for the four suspects. In order to investigate the effect of information sharedness on information processing, three types of inferences were analyzed (Table 1):

- "*collaborative inferences*" from unshared information distributed between dyad members
- "*individual inferences*" from unshared information located with the same dyad member ("undistributed"), and
- "*common inferences*" from shared information.

The text information in the "interrogation protocols" was distributed between participants in such a way that each dyad could draw four collaborative, four individual, and four common inferences. Three different text versions of the murder mystery story were realized in order to not confound the sharedness of information items and inferences with the implications of their specific content. All data were aggregated over these text versions.

Table 1: Visualization of collaborative, individual, and common inferences (adapted from Härder & Spada, 2004)

Information	Person A	Person B	Type of inference
unshared, distributed			collaborative   $\Rightarrow$ 
unshared, undistributed	 		individual   $\Rightarrow$ 
shared	 	 	common   $\Rightarrow$ 

In line with the existing literature (Wittenbaum et al., 2004), our hypothesis was that more shared than unshared text information would be pooled. In addition, group members holding an interdependent pair of unshared, undistributed information should find this information more relevant (and probably easier to remember) than isolated pieces of unshared, distributed information (Fraudin, 2004). Our hypothesis concerning the three types of inferences was that common inferences should be the easiest type to draw, because they can be drawn individually by each member as well as collaboratively. Collaborative inferences, on the other hand, should be the hardest type to draw, because they can only be drawn collaboratively during discussion.

## Videoconferencing setting

During collaboration, dyad members sat in adjacent rooms and collaborated via a desktop-videoconferencing system (VCON running with ViGO). This setting established controlled conditions in which all utterances and actions could be recorded. Dyads were provided with a shared text editor (Groove Office) which both students could access and edit at the same time. A first shared document contained a questionnaire in which students judged how likely each of the suspects had committed the murder, and wrote down their final decision. A second shared document served to collect information and collaboratively write down a justification for the joint solution. Both documents were available during the whole length of the discussion. Each student also received paper and pencil for individual note-taking. All dyads underwent a short technical tutorial prior to collaboration.

## Instructional support

Three experimental conditions were realized: two instructed conditions, and an uninstructed *control condition*. Individuals in both instructed conditions were informed about typical task difficulties in advance of their collaboration on the murder mystery task: the existence of unshared information, the need to recall all information from memory during discussion, and the need to draw inferences in order to find a good solution. Dyads in the *script condition* were then provided with external guidance from a collaboration script (running on a second computer monitor) which prescribed four phases of work: Students were to first pool the available information thoroughly in their shared text editor, and then engage in a phase of individual recall in order to complete the information pool. In a third phase, students were told to search for interconnections between pieces of information, and to write down inferences regarding motives, alibis, and further evidence for all suspects. Finally, the script instructed students to summarize their information and make a decision. Structuring collaboration by means of collaboration scripts has proved an effective means of fostering the generation of new knowledge (e.g. Kollar, Fischer, & Hesse, 2006). Collaboration scripts, however, also bear the danger of reducing motivation, in particular if they run counter to participants' own strategies for effective collaboration and problem-solving (Dillenbourg, 2002). Therefore, the means of support employed in the second instructed condition, informed planning, aimed at facilitating self-regulation by prompting students to construct their own script, presumably more in line with their "internal collaboration scripts" (Kollar et al., 2006). Prior to the murder mystery task, dyads in this *planning condition* were given 10 minutes to discuss how they wanted to structure their problem-solving process. They were encouraged to write down their plan in an additional shared text editor that stayed available for them during problem-solving.

## Design

Instructional support (control/script/planning) was realized as a between-subjects factor, and sharedness of information (shared/unshared undistributed/unshared distributed) as within-subjects factor. Fifty-four female students from various departments (except psychology) with an average age of  $M=23.17$  ( $SD=3.32$ ) years took part in the experiment. Dyads were randomly assigned to one of the three conditions ( $n = 9$  dyads per condition). Dyads' collaboration was videotaped and later coded for relevant pieces of text information and inferences in students' discussion. The correctness of the solution served as an outcome measure.

## Results and discussion

Analysis of students' dialogs revealed the expected effects of information sharedness. An ANOVA with information sharedness (unshared distributed/unshared undistributed/shared) as within-subjects factor, experimental condition as between-subjects factor, and pooled information as the dependent variable confirmed our hypotheses: Across all conditions, 71% of unshared distributed, 84% of unshared undistributed, and 93% of shared information was pooled ( $F=11.44$ ,  $p<.001$ ; partial  $\eta^2=.32$ ). An ANOVA with the number of drawn inferences as the dependent variable also revealed a significant effect of information sharedness ( $F=7.56$ ;  $p=.001$ ; partial  $\eta^2=.24$ ): Across all conditions, 49% of the collaborative inferences, 65% of the individual inferences, and 79% of the common inferences were drawn (compare Table 1). Thus, collaborative inferences emerged as the most difficult, as expected. Interestingly, the number of collaborative inferences drawn during discussion also showed the highest correlation with the probability rating students gave for the correct suspect in their solution ( $r=.42$ ;  $p=.03$ ). Thus, the integration of unshared, distributed information into new shared knowledge was indeed very important for finding a good solution. These effects go well beyond the existing literature on the effects of information sharedness in "hidden profile"-like situations on group information processing (e.g. Wittenbaum et al., 2004). For the field of CSCL, the findings may suggest that complementary knowledge is not only a great resource for learning, but also a significant challenge for successful collaboration that calls for support. However, more research is needed in order to find effective support measures. The instructional support realized in the present study, contrary to expectations, did not improve the drawing of inferences significantly. Nevertheless, it did lead to a higher number of correct solutions of the murder mystery case: All dyads in the two instructed conditions, but only 6 dyads in the control condition solved the case correctly ( $\chi^2=6.75$ ;  $p=.03$ ). This difference was probably mediated by a stronger focus on inferences in the uptakes during discussion in the instructed conditions. However, this effect did not reach the .05-level of significance ( $F=3.09$ ;  $p=.06$ ; partial  $\eta^2=.21$ ). We assume that a more difficult task would have been necessary in order to detect differences between experimental conditions.

To better understand the processes involved in the collaborative drawing of inferences, a descriptive analysis of the patterns in which inferences were actually drawn during discussion was performed, that will inform further approaches towards supporting the collaborative drawing of inferences from distributed information. A follow-up study is planned to explore more specific support measures, both in the form of instruction and in the form of technical tools embedded in the collaboration environment, and evaluate their effects with the help of more difficult task materials.

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