Resource Interdependence, Student Interactions and Performance in Cooperative Learning

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Two studies were carried out during university workshops, and analyzed the effects of resource interdependence on student-student interactions, and the impact of these interactions on performance. Students worked cooperatively, either on complementary information (positive resource interdependence) or on identical information (resource independence). In Study 1, analysis of videotaped interactions revealed that working on complementary information produced more positive interactions; however this was not sufficient to prevent students who had no direct access to the information from being disadvantaged, because of informational dependence. In Study 2, with simpler texts allowing better information transmission, performance was favored when students worked on complementary information. Moreover, working on identical information not only enhanced confrontations of point of views, it also elicited competence threat. Further analysis revealed that competence threat mediated resource interdependence effect on performance. Discussion provides insights into the conditions in which different cooperative methods can benefit learning.

Cooperation has been studied in various, sometimes very different, formats, resulting in rather divergent lines of research (Johnson & Johnson, 2002; Slavin, 1995). Despite these differences, cooperative learning has been consistently shown to be beneficial both for groups and for dyads (Johnson & Johnson, 2002; O'Donnell & Dansereau, 1995; Slavin, 1995). Under what conditions and in what way is cooperative learning effective? Two lines of research have been informative with regard to this question. The first directly investigates the effect of different dimensions of cooperative methods (Johnson & Johnson, 1990; Slavin, 1983). Among these dimensions the present study focused on interdependence of means, and more specifically upon resource interdependence. This investigation has been carried out in the natural setting of university workshops. Resource interdependence refers to the method used

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in a task to share the resources necessary to achieve specific goals (Johnson & Johnson, 1989). Resource independence involves the use of identical resources, whereas positive resource interdependence entails the use of complementary resources with each member receiving only one part of the necessary resource (Johnson, Johnson, Ortiz, & Stanne, 1991; Johnson, Johnson, & Stanne, 1989; Ortiz, Johnson, & Johnson, 1996).

A second approach to investigating the variables mediating the benefits of cooperative methods focuses on interaction processes. Specifically, the relations between interaction processes in learning groups and students' outcomes can shed light on the conditions under which cooperative learning is effective (Battistich, Solomon, & Delucchi, 1993). Relatively little research has investigated interaction processes in cooperative learning groups (Dansereau, 1988; Johnson, Johnson, Roy, & Zaidman, 1985; Webb, 1985, 1991). The quality of student interactions, however, does appear to be an important mediating variable (Cohen, 1994; Gettinger, 1992).

These two lines of research can be combined by investigating the impact of resource interdependence on student interactions, and the impact of their different interaction patterns on performance. Hence, in the present work we examine the effect of resource interdependence on interaction processes and performance.

It is worth noting that the above goal—investigating the mechanisms that are responsible for the effects of cooperative learning—appears to be frequently and consistently mentioned as important in the literature (Battistich et al., 1993; Cohen, 1994; Fantuzzo & Ginsburg-Block, 1998; Johnson, Maruyama, Johnson, Nelson & Skon, 1981). The present article is intended as a contribution to the pursuit of this goal.

Resource Interdependence, Interaction Processes and Performance

A variety of theoretical propositions and experimental results support two quite different predictions regarding the effects on achievement of resource interdependence in cooperative learning. One favors the superiority of resource independence (working on identical information); the other favors the superiority of positive resource interdependence (working on complementary information).

Identical Information, Interactions and Performance

Identical information and confrontation. At first, it might be anticipated that working on identical information (namely information that both partners have read before discussion) could be beneficial. Indeed, partners may understand this information in different ways, which in turn could lead to a confrontation of points of view between them.

Confrontation of points of view between partners has proved to be beneficial for learning (Doise, Mugny, & Pérez, 1998; Gilly, 1989). Positive effects of socio-cognitive conflict—that is, confrontation of different responses to the

same task—have been demonstrated on Piagetian tasks with children (Doise & Mugny, 1984, 1997; Emler & Glachan, 1991) and on school tasks with students (Perret-Clermont & Nicolet, 2001). It has also been shown that controversy—that is, confrontation of incompatible positions between people— can lead to cognitive and interpersonal gains (Johnson & Johnson, 1995; Johnson, Johnson, & Tjosvold, 2000).

Identical information and competence threat. However, working on identical information can also reinforce students' comparison of competencies. Rosen-holtz and Wilson (1980) have suggested that classroom structure affects the likelihood of social comparison for both students and teachers (see also Marshall & Weinstein, 1984). From this research, it can be expected that the focus on social comparison of competencies will be greater when partners work on identical information than when they work on complementary information.

Several authors argued that such a comparison of competences could be detrimental for learning (Darnon, Buchs, & Butera, 2002; Lambiotte et al., 1987). Research conducted on social influence in aptitude tasks (Pérez & Mugny, 1996; Quiamzade & Mugny, 2001) provides some support for the hypothesis that when comparison is oriented toward competence, reasoning as well as learning can be undermined (Butera & Mugny, 1995, 2001; Mugny, Tafani, Falomir, & Layat, 2000; Quiamzade, Tomei, & Butera, 2000). In this line of research, it has been demonstrated that competence threat prompts competition that accounts for its detrimental effect. Other results indicate that as competence threat is removed participants process more deeply the information the source provides (Mugny, Butera, & Falomir, 2001).

Taken together these results point to the hypothesis that working on identical information can promote potentially beneficial confrontations of points of view between partners; but it can also give rise to social comparison of competences and this can reduce the benefits of these confrontations.

Complementary Information, Interactions and Performance

There are several pointers to the hypothesis that working on complementary information may also be beneficial (Johnson & Johnson, 1989; Johnson et al., 1989; Lambiotte et al., 1987, 1988; Ortiz et al., 1996).

Complementary information: students' informational dependence and students' involvement. When working on complementary information, individual students access only one part of the information. Therefore, students are dependent on their partner to access the rest of the information. It might be expected that learning can be reduced in the case of poor information transmission. But, at the same time, complementarity between partners legitimates reliance on the partner and would enhance cooperation (Gruber, 2000). Findings reported in the social influence literature indicate that decentering, or presenting knowledge as a coordination of complementary points of view, can enhance learning

(Butera & Buchs, in press; Butera, Mugny, & Buchs, 2001; Butera, Mugny, Legrenzi, & Pérez, 1996). Moreover, Cohen and Cohen (1991) suggested that such reciprocal dependence involves recognition of the need to exchange information, and thus enhances the level of interaction between partners.

An important benefit of working on complementary information is the involvement generated by this learning situation (Lambiotte et al., 1987, 1988). First, given that they access certain information only via their partners, listeners have no way of guessing information and are likely to be more motivated to ask more thoughtful questions (Lambiotte et al., 1987). Second, when students share complementary information, summarizers will be more involved in providing explanations and in caring about their partner's learning, because they anticipate being in the complementary role (they will themselves later be listeners). Summarizing information (Spurlin, Dansereau, Larson, & Brooks, 1984) and giving explanations (Johnson et al., 1985; Webb, 1985, 1991) have been shown to be positively related to achievement. Moreover, summarizers' care for their partner could protect listeners from the detrimental effect of receiving no response (Webb, 1985, 1991).

Effects of Resource Interdependence on Interactions between Students

The great variety of results in the literature can support contrasting predictions regarding the effects of resource interdependence on interaction processes. On the one hand, working on identical information can create confrontations of points of view and give rise to the kind of socio-cognitive conflict supposedly beneficial to cognitive elaboration and learning. At the same time, however, working on identical information can also reinforce competence evaluation and competence threat, which can reduce the benefits of confrontations. Sharing complementary information can, in comparison, reduce the stress on competence evaluation, promote decentering, and thereby favor learning. Moreover, working on complementary information can promote more involvement on the part of both partners (giving explanations, asking questions, providing answers), which could lead to better performance. However, when students are working on complementary information, they are dependent on their partner for access to information.

Overview and Preliminary Results

The aim of the studies presented in this article is to examine the effect of resource interdependence on student interactions and performances, by contrasting two different cooperative methods: working on complementary versus identical information. An earlier study, reported by Buchs and Butera (2001), was designed to test the two alternative hypotheses regarding the effect of interdependence on performance: the superiority of working on identical information versus the superiority of working on complementary information. In this study, performance was measured by a multiple choice test (MCT) on

the content of the texts. Results provided more support for the hypothesized superiority of working on identical information. It appeared that performance was better overall when students discussed identical information than when they shared complementary information. However, the interaction between resource interdependence and roles played during discussion (summarizer versus listener) indicated that only listeners who had not read the text before discussion showed a significant disadvantage, (that is, listeners working on complementary information). In other words, working on complementary information puts the listeners in a highly dependent position: Their performance can be impaired if, in the interaction with the summarizer, the information is not transmitted in an effective way (Buchs & Butera, 2001).

The studies reported here investigate the effect of resource interdependence on interaction processes, and the link between student interactions and performance.

Study 1

In the study presented by Buchs and Butera (2001), all the interactions were videotaped, but these materials were not analyzed at the time. In this study, we analyzed these videotapes, with the aim of testing the effect of resource interdependence on students' actual interactions. Working on complementary information should favor a positive climate and should enhance partner involvement. However, learning could be impaired in case of poor information transmission because of the informational dependence typical of this condition. In contrast, working on identical information should favor confrontation between partners. Here, however, competence threat could damage the relationship between partners. These theoretical hypotheses lead to several specific predictions.

H1: Summarizers working on complementary information will provide more explanations and listeners will ask more questions than summarizers and listeners working on identical information.

H2: Students working on identical information will be less positive about their interaction and more confrontational than those working on complementary information.

H3: Listeners working on complementary information will be more dependent on their partners than students working on identical information. Therefore, listeners' performance will be negatively related to summarizers' individual activities (non-interactive behaviors) when working on complementary information.

Study 1: Method

Participants

A total of 64 second-year psychology students at Grenoble University (France) participated in this study, which took place during regular social

psychology workshops. Students were randomly assigned to one of the two experimental conditions (identical information $n = 32$ versus complementary information $n = 32$). Experimental dyads were constituted by same-sex students who did not know each other, but with no other strategic matching criteria. Over the 32 dyads, three were male (two in the complementary information condition and one in the identical information condition).

Due to various technical problems, six videotapes were not available, but bias should not have been introduced since they are missing in both experimental conditions; 58 videotapes were finally included in the analysis (28 in the complementary information condition and 30 in the identical information condition).

Procedure

Students were asked to work cooperatively over the course of three two-hour sessions, separated by a three-week interval. In order to videotape students' interactions, workshops were organized so that students were meeting six at a time under the teacher's supervision. From those six participants, three dyads were formed and each dyad was located in a small room in which a camera was in place. Students were informed that, for each workshop session, they would work cooperatively on two social psychology texts, not taught as part of their social psychology course but related to the content of their course. Students were requested to read the texts and share their ideas with the aim of mastering the content of the texts and facilitating their partner's understanding. This introduced goal interdependence for all dyads. Then resource interdependence was introduced (see the independent variables section).

Two roles were defined for the learning session: summarizer and listener (see the roles section). The aim behind these roles was to favor partner participation and to improve the quality of interaction during discussion (Cohen, 1994; Dansereau, 1988; O'Donnell, Dansereau, Hall, & Rocklin, 1987).

For each text, 20 minutes were devoted to silent reading, followed by 10 minutes of discussion based on the assigned roles. At this point, students completed an individual MCT on the two social psychology texts. It is worth noting that the MCTs do not account for their social psychology grade; however, the subject matter of the texts studied during the experiment was supposed to be known for the final social psychology exam.

Materials

For each of the three sessions, students worked on two social psychology texts (6 texts in total) extracted from a book related to the course content, but different from those used for the course (see Buchs & Butera, 2001).

Independent Variables

Resource interdependence. In the identical information condition, both students silently read the first text for 20 minutes. One of the students played the summarizer role in the 10-minute discussion following the reading while the other student played the listener. Then, both students silently read the second text (20 minutes). The student who played listener for the first text became the summarizer for the second text, and vice versa. In the complementary information condition, in the first stage, one of the partners read the first text (20 minutes), and played the summarizer in the 10-minute discussion. In the second stage, the other student—who had previously played the listener—read the second text (20 minutes) and played the part of summarizer. In this condition, each student had complementary information, since the MCT contained questions on both texts. Each student played the summarizer role for one text and learned the other text from his or her partner. In order to sustain a high level of attention on the part of the listener, this student was asked to read a newspaper article. Students were informed that this newspaper article would not be discussed afterwards; its purpose was to maintain the listener's attention during the reading period. In both conditions, students were informed that they would individually answer an MCT on the two texts. Therefore, reinforcement was independent.

Roles. The two roles were defined as follows (Lambiotte et al., 1987). The summarizer role consisted of explaining as clearly as possible and in a detailed way the information contained in the text. Listeners had to ask questions and request clarifications and also identify errors or lack of information while listening to the summarizer. Students were informed that, within the dyad, each individual would have responsibility for summarizing one of the two texts, and that roles would be reversed for the second text. Order of roles for each text was counterbalanced.

Dependent Variables

Interactions. The two 10-minute interactions were fully videotaped at each session. These videotapes were coded with regard to different behaviors. Two coders were trained to identify these behaviors. Inter-judge agreement on the coding of 12 records was good enough to retain just one judge (split half alpha = 0.88). Some behaviors were coded in terms of time devoted to that behavior (total time over each of the 10-minute interactions, in seconds), others on the basis of their frequency (number of occurrences during each of the 10-minute interactions). Behaviors were coded for each partner in such a way that one student's behavior could be related to the partner's behavior and performance. For each category of behavior, three measures were available: behaviors expressed when in the summarizer role, behaviors expressed when in

the listener role, and overall behaviors (that is, mean across listener and summarizer positions).

Partner involvement. Time devoted to giving explanations was coded. A number of question-related activities were also coded: number of questions asked, number of responses to questions, and number of no responses (that is, when a question received no response).

Affective reactions. Expressed difficulties were coded for expressions of difficulties in comprehension ("I don't understand", "I'm lost"), or doubts about own abilities ("I'm not sure", "Maybe I'm wrong"). Negative reactions were coded when the partner was criticized ("You don't explain it right", "What you say is meaningless"), or when one partner displayed negative behaviors like looking elsewhere, looking frequently at his/her watch, or not listening. Behaviors such as encouraging the partner ("Yes, you are right", "Go on") and expressing understanding ("Yes, I understand") were coded in the positive reactions category.

Confrontation activities. The time spent in confrontations of points of view, namely when partners disagree and defend their respective positions, was measured.

Individual activities. The time students took for themselves (reading for themselves or taking notes) was also measured.

Performance. Performance was assessed through a MCT at the end of each session. These MCTs included 10 questions per text—a total of 20 questions for each session. One point was allocated for a good answer, zero for no answer and -0.25 for mistakes (to discourage students from answering at random). These criteria are used in official evaluations, and were explained to students before the MCT. Three scores were computed for each session: a mark from -5 to 20 for overall performance, a mark between -2.5 and 10 for questions based on the text participants had summarized and a mark between -2.5 and 10 for questions on the text for which participants had played the listener role.

Study 1: Results

Because of the naturalistic context of the study, it was not possible to counter-balance the order of the six texts; it was then impossible to distinguish between the effect of sessions and the effect of texts. Thus, for each measure, analyses were conducted on the mean across the three sessions. The effect of resource interdependence was examined using non-parametric tests (Mann Whitney) because for some variables there was very little variance. In order to simplify the presentation, only results directly related to the hypotheses are reported.

Consistent with Hypothesis 1, summarizers working on complementary

information with their partners did indeed spend more time giving explanations (M = 397.90) than when working on identical information (M = 316.70, $Z = 3.15$, $p < 001$). Moreover, summarizers working on complementary information also provided their partners with more responses (M = 2.85) than those working on identical information (M = 1.84, $Z = 2.62$, $p < 0.01$). The number of non-responses was very small when sharing complementary information (M = 0.06) and lower than in the identical information condition (M = 0.22, $Z = 2.16$, $p < 0.04$). Finally, listeners working on complementary information asked more questions (M = 2.96) than those working on identical information (M = 1.98, $Z = 2.34$, $p < 0.02$).

These results indicated that working on complementary information seems to favor summarizers' involvement (more time allocated to give explanations, more responses given and less non-responses when help was solicited), as well as listeners' involvement (more questions).

As for Hypothesis 2, it appeared that the number of positive reactions was higher when students worked on complementary (M = 16.26) than on identical information (M = 12.87, $Z = 2.18$, $p < 0.03$). Moreover, number of negative reactions was higher when students discussed identical information (M = 0.14) than when they shared complementary information (M = 0.03, $Z = 2.56$, $p < 0.02$). Similarly, expressed difficulties about competencies were higher in the identical condition (M = 1.48) than in the complementary condition (M = 0.73, $Z = 2.77$, $p < 0.01$). Results also indicate that sharing identical information promoted confrontations and encouraged students to argue for longer. Indeed, time devoted by students to confrontations about points of view was higher when discussing identical information (M = 5.35) than when sharing complementary information (M = 0.3, $Z = 5.43$, $p < 0.01$).

In order to test Hypothesis 3, a regression analysis was conducted with time devoted by summarizers to individual activities (this variable was statistically centred), resource interdependence (coded -1 for identical information and $+1$ for complementary information), and the interaction between these two variables as predictors; listeners' MCT performance was the dependent variable. The three predictors explained more than 29% of the listeners' MCT performance ($R^2 > 0.29$). This analysis indicated that listeners' MCT performance was poorer when they worked on complementary information ($\beta = -0.55$, $p < 0.01$). Time devoted to individual activities did not predict listeners' MCT performance ($\beta = 0.07$, ns). However, the interaction between the two predictors was significant ($\beta = -0.30$, $p < 0.03$).

As displayed in Figure 1, the relation between time devoted by summarizers to individual activities and listeners' MCT performance was negative when students worked on complementary information, and positive when students worked on identical information. Consistent with this result, it appears that the number of ideas transmitted by summarizers is positively and significantly linked to listeners' MCT performance in the complementary information condition [$r (28) = 0.42$, $p < 0.05$], but not in the identical information condition [$r (30) = 0.09$, ns].
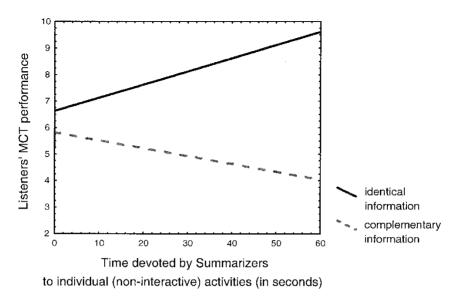
Figure 1. Relations between summarizers' individual activities and listeners' MCT perform-
ance in the two resource interdependence conditions (Study 1)

Study 1: Discussion

Overall, working on complementary information favored both summarizers'
(more time allocated to give explanations, more responses given) and listeners'
involvement (more questions asked). Additionally, positive reactions were
higher when students worked on complementary information than when they
worked on identical information. Conversely, discussing identical information
generated more viewpoint confrontations and more arguments (more time
allocated to active argumentation). But this condition also produced more
negative reactions towards partners and higher numbers of expressed
difficulties. Thus, it seems that the relationship between partners was impaired
when they worked on identical information. This impairment could be due to
competence threat in this condition. Nevertheless, the present analyses of
videotaped student interactions do not allow any conclusions to be made about
competence threat. This matter will be directly addressed in Study 2.

The results concerning individual activities support the view that informa-
tional dependence is a crucial element when working on complementary
information. Indeed, although summarizers' individual activities were posi-
tively related to listeners' performance when students worked on identical
information, this relation was negative when students worked on complemen-
tary information. The fact that summarizers focus on individual activities
rather than on their partner when they are working on complementary infor-
mation seems to be detrimental to the listeners. As mentioned by Cohen and
Cohen (1991) "[groups] productivity will depend on their level of interaction
only among groups with reciprocally interdependent structure" (p. 211).

Moreover the relation between the number of ideas transmitted by summarizers and listeners' performance emphasizes that the quality of transmission is also important.

In sum, the present study showed that sharing complementary information leads to positive interaction processes that are potentially beneficial for learning. However, these positive processes were not sufficient to overcome the disadvantage of listeners who could only access information via their partners. Indeed, the results reported by Buchs and Butera (2001) and mentioned in the preliminary results showed that listeners sharing complementary information (that is, students who access the content of the texts only via their partners) had the worst performance of all conditions. This underlines informational dependence on the partner under conditions of complementary information.

If informational dependence on the partner is crucial when working on complementary information as indicated by the above results on individual activities and number of ideas expressed, it follows that poor-quality presentations by summarizers can hinder listeners' performance. This might explain why, despite the high quality of the relationship between partners working on complementary information, listeners' performance is lower. If this is true, using easier texts should allow listeners in the complementary information condition to benefit from the positive interactions that take place in this setting, and overcome the handicap of not directly reading the text. Study 2 was conducted using simpler texts, in order to improve the quality of summarizers' explanations.

The main aim of Study 2 was to investigate more precisely, through self reports, the impact of resource interdependence on competence threat, and the potential detrimental effect of competence threat on performance. Indeed, it was not possible in Study 1 to infer competence threat from student interactions. Negative reactions and expressed difficulties can indicate a negative relationship between partners, but cannot be interpreted undoubtedly as a sign of competition or competence threat. Therefore, the second study aimed to assess directly the relevance of competence threat for predicting performance.

Study 2

The second study was designed to test four specific hypotheses.

> H1: Working on complementary information will result in more involvement and efforts in information transmission, whereas working on identical information will enhance confrontation and competence threat.

> H2: Summaries of simpler texts should be more informative; consequently listeners accessing information only via their partner (complementary information) should not be disadvantaged, as occurred in the first study. Moreover, thanks to positive involvement and reduced competence stake when working on complementary information, performance will be favored in that condition. We expected that, in contrast, the competence evalu-

ation likely to occur when working on identical information will threaten self-competence, and performance would in consequence suffer.

H3:   Competence threat will be a mediating variable between resource interdependence and performance. More specifically, competence threat will be responsible for the detrimental effect on performance of working on identical information (as compared to complementary information).

H4:   Partner competence may be perceived as a threat and may therefore undermine performance when working on identical information, whereas it may be helpful and therefore enhance performance when working on complementary information, where quality of communication is important.

Study 2: Method

Participants

Participants were 36 second-year psychology students at Grenoble University. All were female. As with the first study, this experiment took place during regular social psychology small groups courses. Groups were organized so that students worked in dyads for three two-hour sessions; 20 students worked under conditions of complementary information and 16 under conditions of identical information. For delayed assessment of performance, 18 were present from the complementary information condition and 12 from the identical information condition.

Procedure

The procedure was the same as for the first study. Students worked in cooperative dyads for three sessions. Questionnaires were proposed before MCT evaluation. Two weeks separated each session.

Materials

Students worked on six social psychology texts related to the topic of the course, but not used in the course. The teacher formatted the six texts in such a way that they could be read independently in less than 20 minutes [from $M = 7.25$ minutes to 8.14 minutes, $F\,(5, 40) = 0.28$, $p > 0.10$, without taking notes].

Pilot. A pilot study, with 149 psychology students, was conducted to evaluate the perceived difficulty of the texts used in Study 1 (six texts) and Study 2 (six texts); the hypothesis was that texts in Study 2 would be considered easier than those in Study 1. Twenty minutes were devoted to individual reading of each text. Each student read a pair of texts used in one of the three sessions in Study 1 or planned for use in Study 2. Students then assessed the difficulty of the text and the extent to which they felt they had mastered it. Each text was read by 23 to 26 students.

Perceived difficulty level was assessed via 10 questions (for example, "I find this text difficult to understand", "I find the main idea clear", "The experiments seem to be clear"). After recoding the items so that a higher score indicates the texts were found to be easy (1 = difficult, 7 = easy), alphas for perception of difficulty across the texts were in the range 0.75–0.94. As each student read two texts, a measure of perceived difficulty of the texts was computed for each student.

Four further questions were designed to assess feelings of mastery (for example, "I think that I have understood the text well", "I think that I can remember the ideas contained in the text well"). Students recorded their agreement with these four items on a seven-point scale ranging from 1 (totally disagree) to 7 (totally agree). Alphas for the texts ranged from 0 .81 to 0.93, which allowed us to compute a mastery score.

A MANOVA with study (1 versus 2) as the independent variable was performed on the difficulty and mastery scores ($n = 128$ due to missing responses). This analysis revealed a main effect of study, significant for both measures [$R Rao$ (2, 125) = 37.76, $p < 0.01$]. Students perceived the Study 2 texts as easier (M = 5.56) than the Study 1 texts (M = 4.39); moreover, perceived mastery was higher for Study 2 (M = 4.81) than for Study 1 texts (M = 3.92).

Thus the texts we intended to use in Study 2 were perceived as simpler and easier to master than those used in Study 1. The Study 2 texts should therefore allow summarizers to provide higher quality explanations.

Independent Variables

Resource interdependence and roles were manipulated as in Study 1.

Dependent Variables

Immediate performance. Immediate performance was assessed through a MCT as in Study one. These MCTs included 10 questions per text (20 questions for each session). Due to the negative score for mistakes (-0.25), performance could range from -5 to $+20$ overall and from -2.5 to $+10$ when roles were separated.

Delayed performance. Before they started a fourth—non experimental—session, students were presented with a delayed MCT containing different questions from those for the immediate performance. Four questions for each text were introduced in this MCT with the same evaluation criteria as in the immediate MCT (performance from -1 to $+4$ when roles were separated). This delayed MCT took place four weeks after the last session of dyadic work. Students had not been led to anticipate this test.

Students' involvement. Students' involvement was assessed in each session by questionnaire, completed before the MCT. Eight questions were designed to measure involvement in cooperative learning. Four questions concerned the amount of time (1 = little time, 7 = much time) dyads devoted to asking questions and seeking clarifications, providing clarifications, checking that both partners had understood the information and suggesting strategies for recalling information. Four other questions asked about the frequency (1 = very infrequent, 7 = very frequent) with which they tried to summarize information as clearly as possible, thought about how to reconcile different points of view, integrated what was discussed with prior knowledge, and thought about concrete examples (α for the eight items = 0.83).

Four further questions concerned efforts to explain information. Students were asked to evaluate the efforts made to explain the information (one item), and the willingness to be clear (one item), both for themselves [correlation between the two items: r (36) = 0.87, $p < 0.01$] and for their partner [r (35) = 0.77, $p < 0.01$] on a seven-point scale (1 = not very good, 7 = very good).

Confrontation of points of view. Level of confrontation within dyads was assessed by asking how much time (1 = little time, 7 = much time) dyads devoted to confrontation regarding different points of view, to defend and argue ideas, to try to impose points of view, and to try to understand alternative points of view (α for the four items = 0.79). The aim of these questions was to assess the level of confrontation, independently of the manner of its resolution.

Competence threat. Four questions were designed to investigate competence threat, by asking how frequently students checked that what their partners said was correct, evaluated their partners' competence, tried to present themselves as more competent than their partners, and wondered how to appear competent (α for the four items = 0.84).

Partner's competence. Partner's competence was assessed by two questions: perceived competence to understand information and perceived competence to summarize information [r (36) = 0.74, $p < 0.001$].

Study 2: Results

H1: Effects of Resource Interdependence on Student Interactions

A one-way ANOVA with resource interdependence as the independent variable was performed on the involvement score. This analysis indicated that student involvement was similar overall in the two conditions [M = 4.21 for complementary information versus M = 4.28 for identical information, F (1, 31) = 0.08, $p > 0.10$, $\eta^2 = 0.01$].

A 2 (resource interdependence) $\times$ 2 (targets: participants and partner,

Table 1. Perceived efforts expended explaining information as a function of resource interdependence, for both the participant and her partner (Study 2)

| | Identical information | | | Complementary information | | |
	M	SD	n	M	SD	n
Partner's efforts	5.28	0.65	16	5.66	0.57	19
Participant's efforts	4.50	0.91	16	5.42	0.45	19

Scale ranges from 1 (not very good) to 7 (very good). Difference in Ns due to missing values.

within-participants) ANOVA was performed on the scores for perceived efforts to explain information. Means and standard deviations are presented in Table 1.

This analysis revealed that efforts were judged to be greater when information was complementary (M = 5.54) than when information was identical [M = 4.89, F (1, 33) = 12.54, $p < 0.01$, $\eta^2 = 0.28$]. Students judged their partner's efforts as greater (M = 5.47) than their own efforts [M = 4.96, F (1, 33) = 16.11, $p < 0.01$, $\eta^2 = 0.33$]. Moreover, the interaction effect [F (1, 33) = 4.61, $p < 0.05$, $\eta^2 = 0.12$] indicated that, when information was identical, students judged that they made less effort (M = 4.5) than their partner (M = 5.28, $p < 0.05$), whereas when information was complementary, efforts by the two partners were judged to be similar (respectively M = 5.42 versus M = 5.66).

To summarize, although the involvement measure did not yield significant effects, it appeared that students perceived more efforts when they worked on complementary than on identical information, especially when evaluating their own efforts.

It was predicted that discussing identical information would enhance confrontations as well as competence threat (social evaluation of competence and protection of self-competence). Means and standard deviations are shown in Table 2.

Consistent with the prediction, mean level of confrontations was higher for identical information (M = 3.23) than for complementary information [M = 2.38, F (1, 32) = 10.14, $p < 0.01$, $\eta^2 = 0.31$]. Moreover, mean evaluation of competence threat was higher when students worked on identical infor-

Table 2. Effect of resource interdependence on level of confrontation and competence threat (Study 2)

| | Identical information | | | Complementary information | | |
	M	SD	n	M	SD	n
Confrontation of points of view	3.23	0.64	16	2.38	0.89	18
Competence threat	3.03	1.03	15	2.05	0.88	19

Scale ranges from 1 (weak) to 7 (strong). Difference in ns due to missing values.

mation (M = 3.03) than when they worked on complementary information [M = 2.05, F (1, 32) = 8.97, $p < 0.01$, $\eta^2 = 0.28$].

Therefore, the hypothesis that discussing identical information could bring about confrontation as well as competence threat received support from this second study.

H2: Effects of Resource Interdependence on Performance

The first 2 (resource interdependence) × 2 (roles) MANOVA on the two standardized performances (immediate and delayed MCT) showed a marginal main effect of resource interdependence [R *Rao* (2, 27) = 3.31, $p < 0.06$]. Roles did not affect performance, neither as a main effect [R *Rao* (2, 27) = 0.73, $p = 0.49$], nor in interaction with resource interdependence [R *Rao* (2, 27) = 1.00, $p = 0.38$].

Table 3 displays unstandardized performances (easier to read), on which univariate analyses were conducted. Student performance on the immediate MCT was similar under both conditions [complementary information M = 5.26, identical information M = 5.27, F (1, 34) = 0.01, ns, $\eta^2 = 0.01$]. Furthermore, listeners (M = 5.21) and summarizers (M = 5.32) performed equally well [F (1, 34) = 0.21, ns, $\eta^2 = 0.01$] under both conditions [interaction: F (1, 34) = 0.35, ns, $\eta^2 = 0.01$].

As for delayed MCT, students performed better after having worked on complementary information (M = 2.59) as compared to identical information [M = 2.14, F (1, 28) = 4.69, $p < 0.05$, $\eta^2 = 0.14$]. Roles did not yield significant effects [M = 2.28 for listeners, M = 2.45 for summarizers, F (1, 28) = 1.28, $p > 0.10$, $\eta^2 = 0.04$] and neither did the interaction [F (1, 28) = 0.07, ns, $\eta^2 = 0.01$].

Thus, consistent with the hypothesis, listeners in the positive resource interdependence condition performed as well as listeners in the independence condition. Moreover, as predicted, performance was better when students worked on complementary information than when they worked on identical information, although the effect was significant only for delayed performance.

H3: Competence Threat as a Mediating Variable

Competence threat was examined as a variable mediating the effect of resource interdependence on delayed performance, that is, the measure on which the performance of those who had worked on identical information was poorer. Following Baron and Kenny (1986; see also Knight & Bohlmeyer, 1990), four steps were taken to assess mediating effects. The first two steps confirmed the effect of the independent variable (resource interdependence) on both delayed performance ($\beta = -0.37$, $p < 0.05$, $\eta^2 = 0.14$), and on the mediator variable (competence threat, $\beta = 0.46$, $p < 0.01$, $\eta^2 = 0.22$). Third, competence threat was used to predict delayed MCT performance. This analysis revealed that competence threat was detrimental to performance on the delayed MCT

Table 3. Immediate and delayed MCT unstandardized performance as a function of resource interdependence conditions and roles played during discussion (Study 2)

	Immediate MCT						Delayed MCT					
	Identical info.			Complementary info.			Identical info.			Complementary info.		
	M	SD	*n*	M	SD	*n*	M	SD	*n*	M	SD	*n*
Summarizers	5.26	1.16	16	5.38	1.12	20	2.24	0.71	12	2.65	0.77	18
Listeners	5.29	0.88	16	5.14	0.76	20	2.04	0.63	12	2.53	0.57	18

Difference in *n*s due to missing values.

($\beta = -0.45$, $p < 0.05$, $\eta^2 = 0.20$). The last step consisted of entering both the independent variable (resource interdependence) and the mediator variable (competence threat) at the same time as predictors for delayed MCT performance. This last analysis showed that resource interdependence was no longer significant ($\beta = -0.13$, $p = 0.52$), whereas the competence threat variable was still marginally significant ($\beta = -0.37$, $p < 0.09$). Thus, it can be suggested that competence threat did mediate some of the effect of resource interdependence effects in this study.

In order to rule out other mediating hypotheses, mediation analyses were conducted with the other interaction variables (confrontations, subject's efforts, partner's efforts and involvement). For none of these variables could all four steps be completed. Therefore it seems that, in Study 2, competence threat is responsible for the poorer performance in the delayed MCT when students work on identical information.

H4: Partner's Perceived Competence

It was hypothesized that, although partner competence will be perceived as a threat to students' own competence, damaging performance when working on identical information, when working on complementary information partner competence will be helpful and enhance performance. To test this hypothesis, a regression analysis was performed on both performance scores, with resource interdependence (coded -1, $+1$), partner's perceived competence (measured on a seven-point scale and statistically centred for the analysis), and the interaction between the two as independent variables. These three factors explain little of the variance in immediate performance ($R^2 < 0.03$), but explained 30% of delayed performance. The analysis of delayed performance showed a significant effect of resource interdependence ($\beta = -0.37$, $p < 0.04$) and a significant interaction between resource interdependence and partner competence ($\beta = -0.39$, $p < 0.03$). This interaction is illustrated in Figure 2. As predicted, perceived partner competence is negatively related to students' performance when working on identical information, but positively related to performance when working on complementary information.

Study 2: Discussion

The results of Study 2 showed that students who had worked on complementary information reported more efforts to explain information. In line with the first study, students who had worked on identical information reported more confrontations regarding points of view. Nevertheless, in this condition students also reported more competence threat.

As regards performance, working on simpler texts allowed students who accessed information only via their partner to overcome this disadvantage. Overall, performance was better in the complementary information condition. Mediation analysis suggested that competence threat was responsible for the
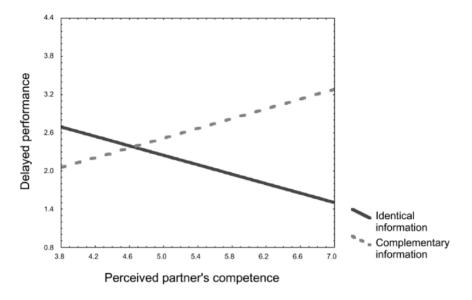
Figure 2. Relations between partner's competence and students' delayed performance in the two interdependence conditions (Study 2)

detrimental effect on performance of dyads working on identical information (as compared to complementary information).

Thus, it appeared that students working on identical information were oriented toward competence evaluation and competition. In this case, partner competence was indeed a threat to students' own performance. Competence threat, we propose, damaged performance by interfering with the effective processing of information. In contrast, the positive resource interdependence entailed in working on complementary information favored positive interactions and cooperation. Reciprocal informational dependence underlines the necessity for cooperation. In this case, partner competence makes a valuable contribution to effective information transmission, which in turn enhances performance.

General Discussion

The aim of the two studies presented in this paper was to study the impact of resource interdependence by contrasting two cooperative methods: working on complementary versus identical information.

In the first study, it appeared that sharing complementary information had a positive effect on interaction processes and is thus potentially beneficial for learning. However, these positive interaction processes were not strong enough to overcome the disadvantage of listeners able to access information only via their partners. Overall, listeners sharing complementary information performed

more poorly than summarizers, or than listeners sharing identical information (Buchs & Butera, 2001).

It was hypothesized that, because of the complexity of the texts used, poor quality explanations from summarizers' explanations did not allow listeners to master information in the interdependence condition. Therefore, even though sharing complementary information favored interaction processes, the quality of summarizers' explanations probably did not allow listeners to understand and master the information. To test this idea the second study was conducted using simpler texts with the aim of improving the quality of summarizers' explanations.

Results of the second study, even with its relatively small sample, support this hypothesis. One the one hand, simpler texts resulted in no differences in immediate performance between the two resource interdependence conditions. Students sharing complementary information performed as well as those discussing identical information. In particular—and this is important—listeners were no longer disadvantaged. As regards delayed performance, students who had shared complementary information had delayed performances superior to those who had discussed identical information. Thus, in Study two, students who discussed complementary information were no longer disadvantaged as regards immediate performance, and performed even better on the delayed test than those who had worked on identical information.

Thanks to self-report measures, the second study also allowed us to investigate the impact of resource interdependence on competence threat, and its potential for a detrimental effect on performance. This study demonstrated that discussing identical information enhanced the perceived level of confrontation regarding points of view, but at the same time increased competence threat. This competence threat could prevent students benefiting from the confrontation of points of view. The second study indeed suggested that competence threat mediates the detrimental effect of discussing identical information.

Taken together, these two studies point to the operation of two different dynamics in the two resource interdependence conditions. When students work on identical information, competence threat seems to be a crucial element, whereas when working on complementary information, informational dependence on the partner seems to be crucial for learning. Thus, these studies add two supplementary elements to the investigation of the conditions that make cooperative learning effective.

However it should also be pointed out that the present results have been obtained from a population composed of university students and within the setting of university workshop. Moreover, it should be noted that our sample was mainly composed of women and only included same-sex dyads. These factors will have to be investigated in future research.

These studies have implications for higher education. It seems that students are used to studying in a competitive system, and that working on identical information does not favor cooperation, even in the context of a cooperative

assignment. It appears that students persist in being competitive. The two studies suggest that competence threat (namely the evaluation of relative competences and protection of own competence) can inhibit the effectiveness of a cooperative environment. In contrast, working on complementary information seems to enhance cooperation. It supports more positive interactions between partners, and informational dependence is a crucial element here. Listeners seem to be dependent on the quality of their partner's input. Even when partners are willing to be clear and helpful, if the quality of their input is weak, their listeners will be disadvantaged. Therefore, working on complementary information cannot readily be adapted to difficult materials (that are too long or too complicated to communicate). Nevertheless, for simpler texts, working on complementary information can be a good means of reinforcing students' efforts and of promoting cooperation.

The two studies presented suggest that teachers should take into account these two dynamics to decide how to structure peer learning (see also Buchs, Butera, Mugny, & Darnon, 2004). One suggestion is to try to reduce competence threat when students work on identical information. For example, this could be done by introducing a positive interdependence of reward, by reducing focus on comparative evaluation, or by enhancing self-referenced evaluation. The latter would ensure that students can correctly summarize the materials when they work on complementary information. This could be done by matching the level of text difficulty to the level of student competence, or by requiring careful note-taking during reading in order to facilitate summary. Thus, understanding the mechanisms accounting for the effects of resource interdependence can allow teachers to build more appropriate learning situations.

Acknowledgements

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