PRINCIPLES OF REGULATING INTERACTION IN TEAMS PRACTICING FACE-TO-FACE COMMUNICATION VERSUS TEAMS PRACTICING COMPUTER-MEDIATED COMMUNICATION

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This study investigates how the regulation of interaction on the performative level (types and functions of interactions) and the referential level (relations of concepts) varies depending on the modality of communication: face-to-face, synchronous, and asynchronous text-based computer-mediated communication. In the experimental setting, six groups consisting of four experts cooperated per one of the three modalities in planning a marketing campaign for solar energy systems. The communication transcripts were analyzed on the performative level by SYMLOG. On the referential level, a network analysis was established to examine how relevant concepts were introduced in the discussion. The group output was measured with regard to group work, satisfaction, and performance. The results show that all communication modalities differ on the performative and on the referential level. No differences between the modalities were found regarding group work and satisfaction of the members. Group performance was judged better in face-to-face than in computer-mediated groups.

Keywords: *computer-mediated communication; group interaction; teams; interpersonal communication*

SMALL GROUP RESEARCH, Vol. 36 No. 4, August 2005 499-536
DOI: 10.1177/1046496405277182

INCREASING IMPORTANCE OF COMPUTER-MEDIATED COMMUNICATION

Computer-mediated communication (CMC) is becoming more and more important in organizations with locally distributed teams in exchanging knowledge or completing a task (Boston Consulting Group, 2002). Numerous examples can be found in education, science, economy, and public administration (see special issue of the journal *Unterrichtswissenschaft* [1997, Vol. 1]; Armstrong & Cole, 1996; Hollingshead, 2001; Orlikowski & Yates, 1994):

- virtual courses at universities
- interdisciplinary research teams or project groups with members from different nations
- virtual teams within organizations, for example, the "virtual team network" at British Petroleum (see Hollingshead, 2001; Harvard Business Review, 1997)

There are two different types of text-based CMC: synchronous (CMCs) and asynchronous (CMCa). By comparing both types with face-to-face (FTF) communication, it can be observed that FTF and CMCs are effectively more analogous—both being characterized by the synchronicity in the participation of the actors—than FTF and CMCa. Therefore, reactions to messages of other group members should occur more quickly in FTF and CMCs than in CMCa.

What distinguishes CMC (synchronous and asynchronous) from FTF is the existence of the written or typed word in CMC. Another difference is that, in CMC, participants can be spatially separated (missing colocation). Because the physical presence is missing in CMC, nonverbal and paraverbal cues cannot be transferred. This inadequacy may inhibit understanding, as immediate

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AUTHORS' NOTE: *This research was supported by the Deutsche Forschungsgemeinschaft (German National Science Foundation; Grant Wi 555/5-1, Wi 555/6-1). Boris Jöhren, Markus Paul, and Christoph Esser were coworkers in this research project. We also express our appreciation to Anne Fürstenberg, Tanja Gerum, Pia Reichel, and Heike Schwarz for their assistance with coding.* *Please direct all correspondence concerning this article to Ulrike Becker-Beck, Institut für Psychologie, Johann Wolfgang Goethe-Universität Frankfurt am Main, Kettenhofweg 128, Postfach 11 19 32, D-60054 Frankfurt am Main, Germany; e-mail: becker-beck@psych.uni-frankfurt.de.*

TABLE 1: Comparison of Communication Modalities: FTF, Synchronous CMC, and Asynchronous CMC

	Synchronicity	*Social Colocation*	*Message Presence*	*Format*	*Permanence of Storage*
FTF	yes	yes	high	oral	nonpermanent
CMC synchronous	yes	no	low	written	permanent
CMC asynchronous	no	no	low	written	permanent

NOTE: FTF = face-to-face; CMC = computer-mediated communication.

back-channel signals or reactions are lacking; however, it may also prevent the formation of status hierarchies with unequal participation rates (Sproull & Kiesler, 1986). The requirement to produce typewritten messages in CMC involves, in comparison, a much greater effort than the verbal interaction possible in FTF. Therefore, Reid, Malinek, Stott, and Evans (1996) assumed in their hypothesis of a messaging threshold that the threshold for sending messages that are not immediately relevant for the task is higher in text-based CMC than in FTF. Table 1 summarizes the differences between the three communication modalities.

In view of the considerable differences between the three communication modalities, it is important, from an applied perspective, to know if computer-mediated work groups are as effective as FTF work groups. It is of fundamental importance to investigate the principles of regulating FTF versus CMC in teams with distributed knowledge. The current study concentrates on the performative level (types and functions of interactions) and the referential level (semantic relations of concepts) of communication (Wintermantel & Becker-Beck, 2000). Methods of interaction analysis (System for the Multiple Level Observation of Groups [SYMLOG], sequential analysis) are used to examine the performative level, while the referential level is examined through network analysis. The goal of the current project is twofold. First, we sought to elaborate on a theory of the regulation of interpersonal interaction. Second, we intended to give suggestions on how to design the technical and organizational environment for CMC working groups most appropriately to ensure the best results in problem solving or task fulfillment.

THEORETICAL BACKGROUND AND PREVIOUS EMPIRICAL FINDINGS

PRINCIPLES OF REGULATING INTERACTION

The principles are discussed on two levels: the performative level and the referential level. Most of the reported findings are derived from research on FTF communication.

Performative Level

The systematic description of interaction processes in small groups is essentially influenced by the interaction process analysis (IPA; Bales, 1950) and, furthermore, by the System for the Multiple Level Observation of Groups (SYMLOG, Bales & Cohen, 1982). In 1953, Bales conducted a first analysis of interaction patterns in groups with problem solving and decision tasks. The reactions he observed are compatible with the so-called equilibrium hypotheses, according to which, in FTF groups, an equilibrium must be maintained between the instrumental-adaptive activities contributing to the goal of accomplishment and the integrative-expressive activities contributing to the goal of satisfaction. It could, for instance, be observed that group members react to task-oriented answers in a social-emotional positive manner (they agree) rather than responding with another task-oriented act. To maintain an equilibrium in the group, it is important to reinforce that group members interact in a task-oriented manner: The alternation of task-oriented and social-emotional acts contributes not only to the instrumental-adaptive group aim but also to the social-emotional group aim. Consequently, Bales' equilibrium hypothesis is an essential principle of the regulation of interaction.

Further principles of the regulation of interaction were formulated in the framework of interpersonal theory (Leary, 1957; Orford, 1986; Strong et al. 1988). It is supposed that acts characterized by the love-hate dimension tend to elicit similar reciprocal responses, whereas acts characterized by the dominance-

submission dimension tend to elicit complementary responses (for a more differentiated discussion, see Becker-Beck, 1997).

Interaction patterns in FTF problem-solving and decision-making groups were investigated by applying methods of sequential analysis (Becker-Beck, 1989, 1994, 1997; Becker-Beck & Fisch, 1987). Group interaction was coded act by act, applying SYMLOG. A structure analysis of interaction behavior (van Hooff, 1982) revealed that the 26 SYMLOG categories can be grouped into six functionally similar clusters of interaction behavior: accomplishment, complementary accomplishment, reinforcement, tension release, conflict, and withdrawal (Becker-Beck, 1994, 1997). How these behavioral clusters are embedded in the stream of behavior was investigated through sequential analysis. As a result, clusters of self-reinforcing behaviors were found, in which one act prompted a further similar act. These behavioral modes were conflict, complementary accomplishment, withdrawal, and tension release. At the same time, self-inhibiting behavioral modes such as accomplishment and reinforcement were found, in which the occurrence of an act inhibited the occurrence of a further similar act in the next step. These two behavioral clusters support each other: accomplishment elicits reinforcement and reinforcement elicits accomplishment. The interaction sequence "accomplishment $\rightarrow$ reinforcement" (e.g., utterance of a proposal, followed by a signal of understanding or agreement) is a manifestation of equilibrium processes in the sense of Bales (1953). In addition, it is important for the process of grounding in the sense of Clark and Brennan (1991), which is discussed in the next section.

Referential Level

The referential level deals with processes by which a group implements a common cognitive representation. In communication, the members must utter their knowledge in a way that fits the situation and the assumed knowledge of their partners. We are especially interested in the representation of critical facts the group members have to deal with and how the group members arrive at a shared mental model for problem solving.

As noted by Clark (1996; see also Krauss & Chiu, 1998), reaching a shared knowledge base is crucial for communication. During the process of grounding, interlocutors try to arrive at a common consensus by gathering evidence that their communication partner has understood what has been said. In doing so, both parties intend to make sure that they have a related concept of meaning. According to Clark, this is achieved in two main phases:

- Presentation: Production and presentation of an utterance
- Acceptance: Signal that the utterance has been understood

Meaning, therefore, emerges from the implicitly shared product of both interlocutors. Feedback, in this case, not only advances better understanding but also is primarily an intrinsic part of communication. If interlocutors do not have the same basis for understanding (i.e., experts in different disciplines), coordination in communication becomes more difficult. According to the principle of least collaborative effort (Clark, 1996; Clark & Brennan, 1991), interlocutors articulate statements in a way that the collective effort—meaning the combined process starting from the initiation of a contribution to the mutual acceptance of such a contribution—is being kept to a minimum.

Different communication media vary in their costs for grounding. Agreement, for example, can be expressed time-efficiently and unambiguously by saying "okay" in a FTF or phone conversation, whereas this might become difficult in CMCa. Communication media differ on the following essential dimensions for the process of grounding: copresence, visibility, audibility, cotemporality, simultaneity, sequentiality, durability of messages, and possibility of revision. Clark and Brennan (1991) supposed that interlocutors ground their messages with minimal effort in accordance to the possibilities of the medium.

Speech production and its situational dependence. Among the highly relevant aspects of communication is the addressee. To verbalize his own intention, the sender must create a specific model of his partner (Herrmann, 1992); the addressee, and with the help of

perceived and anticipated cues, tries to gauge the situation. Based on this evaluation, the sender will decide on the appropriate information that is to be extracted and afterwards verbalized. The relevance of the information depends also on situational constraints: In a task-oriented situation, for example, the partner's familiarity and experience with the specific task is of utmost importance.

In FTF communication, evaluating the partner's knowledge and aptitude is much easier than in CMC environments. For one thing, expression is much more detailed in FTF, and people can check whether they are being understood, as they frequently obtain feedback from their conversation partner on how well the given information has been received (Kraus & Fussell, 1990; Wintermantel, 1991a). In CMC, this kind of feedback is missing. As Traxler and Gernsbacher (1992) demonstrated with regard to written communication, missing feedback obstructs the interlocutor's conception of the partner model. In CMC, different strategies must therefore be implemented "to stay up to date."

Further important situational features in communication were investigated by Wintermantel (1991b). In an analysis of dialogical instructions for technical procedures, Wintermantel found that the most essential factors in speech production were the communicational aim, the communicational situation, including the topic, and the interlocutors' knowledge base. It was shown that, in FTF communication, speakers adjust their utterances to the listeners, according to any feedback or questions they receive (Wintermantel & Siegerstetter, 1988). However, direct feedback by the listener is not necessarily required in the process. The content and mode of the instruction given by the speaker is also influenced by the proficiency the speaker assumes his or her listener to have. Three stages could be identified during the process of giving instructions: comprehension of the communicative task, generation of verbalized knowledge, and encoding (Wintermantel & Laier, 1994).

Feedback and perspective taking. Feedback not only is highly relevant for the coordination and progress of a conversation but also enables communicating partners to take on each other's perspective (see Clark & Brennan, 1991; Kraut & Lewis, 1984).

According to Krauss, Fussell, and Chen (1995), effective perspective taking in communication involves two sorts of processes: during the intrapersonal process, a model of the conversation partner is built on readily available intrinsic information and prior beliefs on how "people like this" generally are. The interpersonal process, on the other hand, draws on the feedback made available during the communicative situation (see also Wilkes-Gibbs & Clark, 1992). The modality of communication is supposed to have influence on both sorts of processes.

Team-mental-models. Team-mental-models (Klimoski & Mohammed, 1994) represent the result of communication processes in groups. They are also called *shared cognitions*, *shared mental models*, or *group cognitions*. To date, it is still unclear which principles control the communication processes that lead to shared mental models and how the modality of communication influences these processes.

THEORETICAL APPROACHES TO DIFFERENCES BETWEEN FTF AND CMC

To formulate a hypothesis concerning the fine-tuning of interaction and the expected interaction patterns, we refer to diverse theories on CMC. For the sake of comprehensibility, the following theories have been grouped in (a) models that focus on the medium and (b) models that focus on the individual.

Models Focusing on the Medium

Among the earliest theories on CMC (see Döring, 1997, 1999) are the "Cues-filtered-out-theories" (Culnan & Markus, 1987), which assume that CMC is less personal and more task oriented than FTF communication because it has a limited communication channel that filters out social cues. CMC also has a lower degree of "social presence" (Short, Williams, & Christie, 1976) than FTF because nonverbal or paraverbal cues and status characteristics cannot be transmitted. Further theories that focus on the reduced

social cues in CMC are the absence/lack-of-social-context-cues approach by Kiesler, Siegel, and McGuire (1984), the cuelessness model by Rutter (1987), and the cues-filtered-out approach by Culnan and Markus (1987).

MODELS FOCUSING ON THE INDIVIDUAL

More recent approaches focus on processes in the individual using CMC. Walther's social information–processing perspective (Walther, 1992, 1994, 1996; Walther, Anderson, & Park, 1994; Walther & Burgoon, 1992) leads to predictions contradictory to those of the cues-filtered-out theories. It asserts that

> communicators using any medium experience the similar needs for uncertainty reduction and affinity, and to meet these needs CMC users will adapt their linguistic and textual behaviors to the solicitation and presentation of socially revealing, relational behavior. The critical difference between FTF and CMC from this perspective is not a question of *rate*, not capability. . . . due to cue limitations of CMC, the medium cannot convey all the task-related as well as social information in as little time as multichannel FTF communication. However, users adapt in the stream of language and textual behaviors messages that might otherwise be nonverbal. The exchange of social information in CMC may be slower than FTF but it is potentially just as potent over time. (Walther et al., 1994, p. 465)

The social information–processing perspective is supported by different empirical findings (see Walther, 1992). By means of a meta-analysis, Walther et al. (1994) showed that time restriction is a crucial determinant for lacking social orientation in CMC. In CMC groups where communication was not temporally restricted, group members were able to express social orientation, even with the cue limitations of CMC. This finding supports the assumption that members of CMC groups still find ways to interweave components relevant to interpersonal relations into the communication, in spite of the obvious cue limitations in CMC and even though this process requires an ample amount of time. In his formulation of a hyperpersonal perspective, Walther (1996; Walther, Slovacek, & Tidwell, 2001) even asserted that in the course of long-time CMC

interactions, members tend to idealize their partners and reach a higher level of interpersonal affinity than in direct communication.

The approach of Reid et al. (1996) partly integrates the assumptions of cues-filtered-out theories and the social information–processing perspective. In their hypothesis of a messaging threshold, they assumed that, in CMC, the decision to send a message depends on the urgency and relevance of the message in relation to the costs associated with its transmission. Given that the costs for sending a message are higher in CMC than in FTF, the number of time-critical social-emotional messages transmitted in task-oriented settings should be comparatively lower in CMC groups than in FTF groups. Reid et al. (1996) compared the interaction process in a task-oriented setting in FTF groups and CMCs groups in which group identity was salient. Results showed that, in CMCs, brief statements with short-lived regulatory or affective functions simply were not relevant enough to justify the effort required to relay the message. Accordingly, there was a shortfall of time-critical social-emotional acts (tension release, agreement, all negative reactions) in CMCs, whereas the number of social-emotional acts that show the members' solidarity to their group are, therefore, important for group identity increased, as predicted by the SIDE model (social identity and deindividuation model) by Spears and Lea (1992, 1994). Just like the time-critical social-emotional acts, task-oriented acts, such as requesting directions or information, were also reduced. Further results showed that CMC teams had lower interaction rates, took longer to complete their work, but produced outcomes of similar quality to FTF teams.

Although Reid et al. (1996) found that the lack of short-lived regulatory acts, such as agreement and disagreement, had no negative effects on group outcome, Hron, Hesse, Reinhard, and Picard (1997) found that, in collaborative learning, such utterances had a positive influence on problem solving and knowledge acquisition.

To sum up, the effects of communication modalities (FTF vs. CMC) depend on further conditions, the most important ones being the following: time (duration and frequency of group interaction), task, intra- or intergroup context, and group members' degree of

acquaintance. These conditions determine which categories of communicative acts (e.g., task-oriented or social-emotional acts) have high or low relevance. The threshold for conveying communicative acts that appear to have little relevance in a specific group situation is definitively higher in CMC because the costs for sending a message are higher than in FTF. These act categories, as well as interaction patterns that include such act categories as communicative acts, will therefore have a lower frequency of occurrence. The relevance of the different act categories depends on the individual and common goals of the group members.

EMPIRICAL FINDINGS ON CMC

In the available studies, CMC and FTF groups have been investigated with regard to differences in performance and the interaction process (see literature surveys by Hollingshead, 2001; Hollingshead & McGrath, 1995; McGrath & Hollingshead, 1994). In general, it can be said that there is no systematic differentiation in theory building between CMCs and CMCa. The empirical findings sometimes involve CMCa, while concerning themselves with CMCs at other times, for the most part without any direct comparison.

Group Process

Participation. The reduction of social cues in CMC implies that status characteristics (Berger, Fisek, Norman, & Zelditch, 1977) such as age or sex, which are obvious in FTF, are hidden in CMC and thus cannot immediately influence interaction processes, especially participation rates. This is one explanation for the frequently found effect that participation rates are more equalized in CMC than in FTF (e.g., Hiltz, Johnson, & Turoff, 1986). In other studies, the participation equalization effect was not observed (see Hollingshead, 2001). Hollingshead (1996a, 1996b) found that, when status characteristics were salient in CMC, members with low status participated less and communicated less information.

Turn taking and coherence. Text-based CMC is less coherent than FTF communication in the sense that turn taking and topic maintenance are impaired. Herring (1999) showed that CMCs, as well as CMCa, are characterized by a lack of cross-turn coherence: disrupted adjacency, overlapping exchanges, and topic decay. A study by Levin, Kim, and Riel (1990) found that in a computer-mediated teacher-student interaction only 54% of the messages were referred to. The fact that CMC is popular in spite of lacking coherence may be, according to Herring, because users are able to adapt to the medium and draw on its advantages, such as heightened interactivity and the possibility of playing language games. Other approaches try to compensate the shortcomings of CMC with arrangements that regulate turn taking (Hancock & Dunham, 2001; McKinlay, Procter, Masting, Woodburn, & Arnott, 1994) or structure interaction (e.g., explicit references; Pfister, Muehlpfordt, & Mueller, 2003).

Interaction styles and interaction patterns. One of the first studies on differences in interaction styles between FTF and CMC was conducted by Hiltz et al. (1986). In a 2×2 design, they investigated group interaction processes and their outcomes in two modalities of communication (FTF vs. CMCs) with two different tasks (discussion of a relationship problem vs. ranking important objects in a situation of danger). The group process was coded in IPA. Because of a lower degree of so-called social presence in the CMC condition, it was expected that there should be more equal participation and fewer social-emotional acts. In accordance with this hypothesis, in FTF groups, more tension release, agreement, and disagreement could be observed. In CMC groups, there was more task-oriented interaction, such as asking for an opinion, giving an opinion, or making a proposal. Still, questions concerning information or clarification were asked more frequently during FTF communication. In addition, members of FTF groups were able to reach a consensus more often. Although the two communication modalities may differ from one another, the quality of the outcome

does not vary. Instead, it has a positive correlation to the frequency with which solidarity is shown and proposals are made, while having a negative correlation to the frequency with which tension is being released and orientation is given.

Adrianson and Hjelmquist (1999) investigated communication and problem solving in groups that interacted FTF or in a CMCa environment via e-mail (anonymous or with name indication). Social interactions in CMC are characterized by the fact that many ideas and proposals are uttered that are not followed by questions or other comments. The FTF interaction contained more answers and other types of reactions to utterances by other group members. Altogether, CMC contains much speaker-generated information but few reactions to it. FTF communication is characterized by more responsiveness.

The hypothesis that more uninhibited behavior ("flaming" Siegel, Dubrovsky, Kiesler, & McGuire, 1986) would occur in CMC because of greater social distance and less salient communication norms could neither be confirmed in the reported studies, nor in other recent studies (e.g., Coleman, Paternite, & Sherman, 1999).

Information exchange. Generally, less information is being exchanged in CMC than in FTF (Hollingshead, 1996a, 1996b; Straus & McGrath, 1994). Hollingshead (2001), therefore, spoke of information suppression. Procedures to improve information exchange sometimes only affect FTF communication: Hollingshead (1996b) studied the exchange of shared and unshared information in a so-called hidden profile task where group members were to make an investment decision. The result of this examination showed an effect already known from prior studies (e.g., Stasser & Titus, 1985): Shared information was exchanged more often than unshared information. When group members received the instruction to rank the three best alternatives, rather than simply choosing the best, information was exchanged more completely in FTF groups than in CMC groups.

Group Performance

Reflections on how the different communication media influence group performance are based on the media richness theory (Daft & Lengel, 1986). According to this theory, different media, for example, FTF communication and written communication, differ in the richness of the information they can transfer. The decisive criterion for choosing a medium is the message's degree of ambiguity. For messages or tasks with a high degree of ambiguity, a rich medium should be used and for unambiguous messages, a lean one should be used.

McGrath and Hollingshead (1994) enlarged the media richness theory in their task-media-fit hypothesis. The authors assumed that for particular types of tasks (see the task circumplex by McGrath, 1984), the information requirement should fit the richness of the communication environment. The task types—generating, intellective, judgment, negotiation—reflect an increasing information requirement. They should be completed in an appropriately rich communication environment. Computer, audio, video, and FTF systems are characterized by the increase of the richness of the information.

From the hypothesis of matching task and communication environment, it could, for example, be derived that brainstorming—a task of the generating type—should be more effectively performed via CMC than via FTF communication. Meanwhile, there are some supporting findings for this (Diehl & Ziegler, 2000; Jonas & Linneweh, 2000; Valacich, Dennis, & Connolly, 1994).

Mennecke, Valacich, and Wheeler (2000) examined the predictions of the task-media-fit hypothesis concerning two task types: (a) problem-solving tasks with a possible correct answer (intellective) and (b) negotiation tasks with conflicts of interests (negotiation). Problem-solving tasks require an exchange of facts. They should be easier to manage with the help of audio and video systems than with computer systems (not rich enough), whereas the latter ones should still be superior to FTF systems (too rich). Negotiation tasks, on the other hand, require that participants reach

shared preferences and agree based on their personal values. These tasks should be coped with best in FTF communication. Dyads worked on each of the two tasks; four synchronous communication media were realized: FTF, videophone, audiophone, and CMC. The results for the negotiation task confirm the prediction and better results were achieved in FTF and video conditions than in audio and CMC conditions. Predictions could not be confirmed, however, for the problem-solving task. As expected, audio and video conditions did produce better results than CMC conditions but contrary to what could be expected, FTF conditions were superior to CMC conditions and under no circumstances worse than audio and video conditions. The authors concluded that the task-media-fit hypothesis is not comprehensive enough as it only concerns itself with task requirements and not with the whole group process.

To date, the most comprehensive study comparing the outcomes of groups working in a computer-mediated environment or face-to-face was conducted by Baltes, Dickson, Sherman, Bauer, and LaGanke (2002). The authors carried out a meta-analysis of 27 studies that compared the quality of group decisions in the two communication modalities. The CMC was mostly synchronous (chat); it was asynchronous in only two cases. Results suggest that, compared to FTF communication, CMC leads to a decline in group effectiveness, an incline in the time required to complete tasks, and a decline in member satisfaction. This result can be specified with regard to the moderator variables anonymity in the group process, time limitations in the decision-reaching process, group size, and task type. It was shown, for example, that CMC groups in which the members were anonymous performed equally well as FTF groups. However, these CMC groups needed more time and were less satisfied. In contrast, satisfaction in nonanonymous CMC groups was just as high as in FTF groups; however, their members performed less effectively. Because neither inefficiency nor dissatisfaction are desirable in group work, the authors cautioned organizations about adopting CMC as a medium for group decision making in an unbri-

dled rush. Furthermore, they pointed out a research deficit: the forms of CMC mostly applied in organizations, namely CMCa (e-mail) and video conferencing, are scarcely represented in empirical studies.

Conclusions

The quality of the outcome of group work under FTF and CMC conditions depends on the task type. CMC groups only performed better at generating tasks that require little richness of their communication environment (e.g., brainstorming). The completion of tasks with higher adaptive requirements was often lower in CMC; only specific conditions (e.g., anonymity) produced equal outcomes in FTF and CMC.

The following are the—for the current study most important—differences in the interaction processes in FTF and CMC groups:

- Fewer utterances with short-lived regulatory or affective functions in synchronous CMC. These are social-emotional acts such as tension release, agreement, negative reactions in general, but also questions seeking clarification.
- More task-oriented acts such as asking for an opinion, giving an opinion, or making a proposal in CMC (Hiltz et al., 1986; Reid et al., 1996).
- More speaker-generated information and fewer reactions in asynchronous CMC (Adrianson & Hjelmquist, 1999).
- More social orientation in CMC without time restriction, as compared to CMC with time restriction.

The available studies on the interaction process consider only the frequency of occurrence of the different interaction categories. There is a lack of studies on interaction patterns, that is, the way group members react to messages of other group members. The aspect of content or the referential level, that is, language and the establishment of common ground, are also neglected. Concerning theory building, there is no systematic differentiation between synchronous and asynchronous CMC.

ARGUMENT AND HYPOTHESES

The current study sought to investigate how the regulation of interaction on the performative and the referential level varies depending on the modality of communication (FTF, text-based CMCs, and CMCa).

With regard to the performative level, we arrived at the following hypotheses:

Concerning the frequency of occurrence of the interaction categories, it is expected that, in the context of the actual experiment, group interaction in the CMC condition will be more task oriented (higher frequencies in the accomplishment categories) than in the FTF condition. The reason being that the threshold for positive and negative utterances is heightened (lower frequencies of tension release, reinforcement, conflict). We did not formulate different expectancies for synchronous and asynchronous CMC; the analysis of possible differences will be exploratory.

Based on the assumption of a messaging threshold, we expect that interaction sequences that, in FTF communication, are in the service of the equilibrium between the instrumental-adaptive and the expressive-integrative group goal (Bales, 1953), will be relatively seldom in CMC (accomplishment → reinforcement, sequences of tension release, or conflict).

With regard to the referential level, we arrived at the following hypotheses:

Because of the uncertain partner model in CMC, we expect that the more global or central concepts of the semantic network will be used.

Because there is no possibility of direct feedback in CMC, we assume that the movements in the semantic network will be shorter resulting in shorter distances between the concepts.

DESIGN AND METHODS

The variables assessed in the current study are embedded in the well-known input-process-output model as shown in Figure 1.

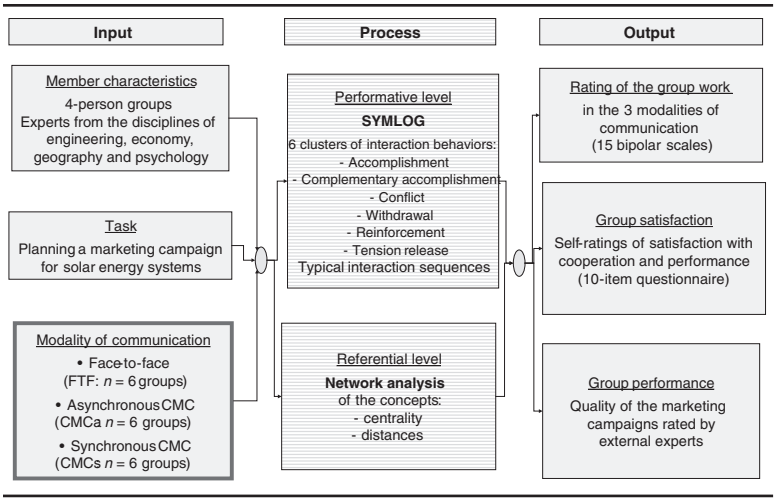

Figure 1: Design, Variables, and Methods of the Study Embedded in the Input-Process-Output Model

NOTE: FTF = face-to-face; CMCs = synchronous computer-mediated communication; CMCa = asynchronous computer-mediated communication.

INPUT

The interactions of 18 interdisciplinary teams, each consisting of experts from four disciplines (engineering, economy, geography, psychology), were subject of the current study.

Participants were 72 students (41 men and 31 women) of different universities in Germany. They were told that they would join in a discussion with three partners, either via CMC (synchronous or asynchronous) or FTF. Participants did not know each other and had never met before. They received €30 for participating in the experiment.

The groups were given the task to plan a marketing campaign for solar energy systems for private houses. As a basis for discussion, the four student experts received texts containing information from their respective disciplines (engineering, economy, geography, psychology).

The groups interacted in one of three communication modalities: (a) FTF ($n = 6$), (b) via a text-based asynchronous computer conference realized by the Internet conference system Webboard

2.0 (Peck & Sherf, 1997); (CMCa, $n = 6$), or (c) via chat (CMCs, $n = 6$). The chat was established on locally connected computers to ensure that just the participants could join the discussion. A simple structured program was implemented in which participants could only read and write. The FTF groups were given 2 hours for interaction, the CMCs groups 3 hours, and the CMCa groups were given 14 days for their conference.

PROCESS

For the analysis of the performative level, the discussions were coded act-by-act by SYMLOG (Bales & Cohen, 1982). The form or type of the behavioral acts is categorized within a 26-category system that is based on a three-dimensional space model for social behavior. The bipolar dimensions are: dominant (U) versus submissive (D), friendly (P) versus unfriendly (N), and instrumentally controlled (F) versus emotionally expressive (B). For further analyses, the categories were classified into six clusters of functionally similar behaviors (for details, see Becker-Beck, 1994 and the Performative Level section above). These are the task-oriented clusters: accomplishment and complementary accomplishment (questions and answers), the social-emotional positive categories reinforcement and tension release, and the social-emotional negative categories conflict and withdrawal. FTF and computer-mediated interactions were subdivided in thought units, which were categorized. The computer-mediated interactions were all coded in their entirety; however, because of the tremendous costs of coding, FTF interactions were only coded in part: 15 minutes from each one third of the interaction. The coders had been trained in SYMLOG during a period of 3 months. To determine the interobserver agreement, part of the material was coded by two observers. The interobserver agreement was calculated by Cohen's kappa for the six superordinate categories in the different modalities: FTF: .65 (good), CMCa: .57 (fair), CMCs: .53 (fair). The methods of categorical data analysis and sequential analysis are used to analyze syntagmatic and sequential characteristics of the discussion.

The analysis of the referential levels concentrates on the organization of meaning in the utterances. For this reason, propositions were extracted from the discussion and, by means of network analysis (Pappi, 1987), it was examined how relevant concepts were introduced into discussion to build a shared mental model. A criterion network was constructed based on the texts given to the experts at the beginning of the experiment. The following indices were calculated for concepts brought up during the discussion:

- indices of centrality (Bavelas and adjacency index): strategic position of a concept in a network
- indices of distance: distance of a concept from the preceding concept and from the central concepts solar energy system and marketing campaign.

OUTPUT

Three output measures were used: Group work was rated by group members on 15 bipolar scales. Self-ratings of satisfaction with cooperation and performance were assessed by using a 10-item questionnaire. Group performance, that is, the quality of the marketing campaigns, was rated by external experts (marketing students) with regard to form and content, using a scale from 1 (*very good*) to 6 (*very bad*). Fifteen experts rated all 18 marketing campaigns, which were presented in random order.

RESULTS

PERFORMATIVE LEVEL

Syntagmatic Aspects: The Relative Frequency of the Six Interaction Categories in the Three Modalities of Communication

To examine differences between the three communication modalities, one-way ANOVAs were conducted for each superordinate behavior category. Afterwards, hypotheses about differ-

ences between FTF and CMC were assessed by contrast tests. Furthermore, exploratory post-hoc comparisons (Tukey HSD) were conducted. Figure 2 shows the mean percentage of the six interaction categories in the three communication modalities.

The one-way ANOVAs reveal significant differences between the communication modalities in all interaction categories except for withdrawal (see Table 2). The results can be specified by planned and post-hoc comparisons.

As expected, the task-oriented category complementary accomplishment is more prevalent in CMCa than in FTF. For the category accomplishment, the difference between FTF and CMCa is nearly significant in a one-tailed contrast test (p = .06). The social-emotional positive category reinforcement is more prevalent in FTF than in CMCa. There is no difference between FTF and CMCa with regard to conflict and tension release.

The interaction style in CMCs is very different from CMCa: CMCs is less task oriented (significantly lower percentages in accomplishment and complementary accomplishment) and more social-emotional (significantly higher percentages in conflict, reinforcement, and tension release). In CMCs, there are even more social-emotional acts than in the FTF condition (categories conflict and tension release).

Sequential Aspects: Reactive Interaction Patterns

The fine-tuning of interaction on the performative level manifests itself in the way in which group members respond to utterances of other group members. When one member makes a proposal or offers an analysis, does another member agree or disagree, or is there a further task-oriented message? Are there sequences of conflict or tension release? These questions can be answered by analyzing reactive interaction patterns with the sequential analysis method (for details, see Becker-Beck, 1997, 2001).

According to Bales (1953), one can distinguish between proactive and reactive patterns in the analysis of interaction patterns. Proactive patterns concern the sequences within a longer

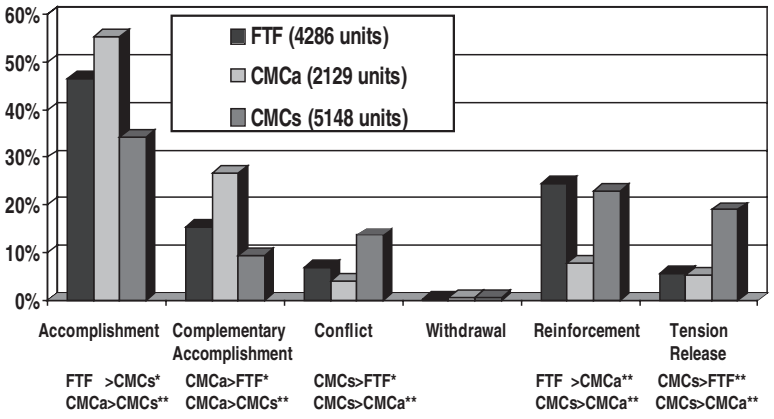

Figure 2: Mean Percentage of the Six Interaction Categories in the Three Communication Modalities

NOTE: FTF = face-to-face; CMCs = synchronous computer-mediated communication; CMCa = asynchronous computer-mediated communication. Significant post-hoc comparisons (Tukey HSD) after ANOVA: $*p < .05$. $**p < .01$.

message of one sender. Reactive patterns concern sequences which include turn taking. In the following, we consider reactive interaction patterns.

The procedure for detecting reactive interaction patterns in an FTF discussion group is as follows: A transition frequency matrix is established, indicating how often Group Member B responds with a specific category of behavior, after Group Member A has shown a certain type of behavior first. For example, when Person A has initiated an act of conflict, how often does B respond with an act of accomplishment? The sequential analysis method (e.g., Bakeman & Gottman, 1986; Becker-Beck, 1997; Becker-Beck & Fisch, 1987; Gottman & Roy, 1990; Sackett, 1979) made it possible to determine which interactive sequences occur significantly more or less often than expected. To identify nonrandom interaction sequences, z scores were computed (Allison & Liker, 1982; Bakeman & Gottman, 1986), which consist of the difference between an observed and an expected transition frequency divided by the standard error of this term. Significant positive z scores indi-

TABLE 2: The Results of the Six One-Way ANOVAs

Interaction category	df	F	*Significance*	η
Accomplishment	2, 15	12.507	.001	.791
Complementary accomplishment	2, 15	10.75	.001	.765
Conflict	2, 15	10.707	.001	.767
Withdrawal	2, 15	1.001	.391	.343
Reinforcement	2, 15	16.946	.000	.833
Tension release	2, 15	22.184	.000	.864

cate excitatory dependency; for example, conflict behavior of Person A is followed significantly often by conflict behavior of B. Significant negative *z* scores indicate inhibitory dependency; for example, after Person C has shown an act of accomplishment, it is very rare that Person D reacts with conflict behavior. Because not all cells of the transition frequency matrix contained a sufficient number of observations for interpreting *z* scores, exact probabilities for single transition frequencies were determined in addition by cumulative binomial distribution (Lisch, 1979). All sequential analyses were carried out by SASKIA, a system developed by Becker-Beck (1997) for the sequential analysis of SYMLOG-coded interactions.

In the case of CMCs and CMCa, the sequential structure of interaction is lost to a certain degree. Therefore, a somewhat different procedure was used to identify reactive sequences. FTF communication is characterized by relatively short messages that often imply a direct reference to the immediately preceding message. By contrast, CMCa often contains long and complex messages that can be subdivided in many units. Thus, successive units in CMCa belong less often to different senders than in FTF communication. The CMCs resembles FTF in that it also contains rather short messages. However, these often do not refer to the messages immediately preceding in the chat protocol but rather to an earlier message. Because of the written presence of all messages in both forms of CMC, it is very easy to refer not only to immediately preceding but also to earlier messages. To analyze reactive patterns, we determined interaction units that contain a direct reference to a preced-

ing utterance of another group member, according to the following criteria: naming a specific preceding sender, commenting on a preceding argument, continuing a sentence, questioning a preceding utterance, and answering a question. The utterances referred to may precede the corresponding message immediately or not immediately. The transition frequency matrix represents how often an interaction category shown by one person is referred to by a specific interaction category by another person. A further analysis of characteristic interaction patterns is done by the same methods as applied in the FTF condition.

To assess the interobserver agreement in the identification of reactive sequences, a CMC with 339 acts was coded by two independent observers who came up with similar findings: a kappa of .75 was calculated, a value that, according to Fleiss (1981), can be considered good.

Because of short messages and frequent turn taking, the mean percentage of reactive sequences relative to the whole interaction is rather high in FTF communication (81.1%); in CMCa, it comes up to only 13.2%, in CMCs to 51.6%. The FTF communication and the CMCs are characterized by a higher reactivity than the CMCa. Not only the intensity with which people react to one another but also the way in which they do should differ between the communication modalities.

Based on the messaging threshold hypothesis, we expected that interaction sequences that support an equilibrium between the task-oriented and the social-emotion goal of the group are less prevalent in the CMC than in the FTF condition (accomplishent → reinforcement, sequences of tension release, or conflict). To test this hypothesis, the reactive tendencies in the FTF and CMC groups were compared based on the *z* scores for the different types of act sequences. For each type of act sequence, a one-way ANOVA was conducted with the communication modalities as independent variables and the *z* scores as dependent variables. Afterwards, specific hypotheses were examined in contrast tests and further differences were explored in post-hoc tests (see Table 3).

Figure 3 shows the six behavioral categories and significantly frequent sequences of categories in each communication modality (Mean z score > +1.65).

At first, we compared the interaction sequences in the FTF and the CMCa condition. The hypothesis that interaction sequences that support an equilibrium between the task-oriented and the social-emotion goal of the group will be less prevalent in the CMC than in the FTF condition is confirmed by the following results: Sequences of conflict are significantly more prevalent in FTF. Furthermore, a facilitating effect of reinforcement for acts of accomplishment was only present in the FTF condition. A not explicitly expected difference between FTF and CMC is that, in FTF communication, sequences of complementary accomplishment acts (e.g., question-answer sequences) are more prevalent than in CMCa (this is symbolized in Figure 3 by arrows of different thickness).

All communication modalities are characterized by the tendency to react to accomplishment with reinforcement and to reciprocate acts of tension release. The reactive patterns characteristic for CMCs are similar to those of FTF communication with regard to conflict sequences and reinforcement → accomplishment. The tendency to react to acts of complementary accomplishment with further similar acts is still more pronounced in CMCs than in FTF communication.

REFERENTIAL LEVEL

An assessment of the referential level was done based on the indices from network analysis. The measures of centrality and distance were calculated at the level of single groups, aggregating the respective indices for the uttered concepts. The measures of centrality and distance were entered as dependent variables in one-way ANOVAS with the communication modalities as independent variables. The results are represented in Table 4.

Results do not confirm the hypothesis that more global or central concepts of the semantic network should be used because of the uncertain partner model in CMC. On the contrary, the analysis of

TABLE 3: Differences in the Distinctness of Reactive Patterns in the FTF and CMC Conditions

	Following Act					
Preceding Act and/or Communication Modality	*Conflict*	*Complementary Accomplishment*	*Withdrawal*	*Accomplishment*	*Reinforcement*	*Tension Release*
Conflict U, UN, UNF, UNB, N, NF, NB, DNB	FTF < CMCa**[b] (one-tailed) CMCs < CMCa*[b]					
CMCa	.028	–.325	.378	.343	–.327	.128
FTF	2.995	–.242	–.388	–1.037	–.348	–.052
CMCs	2.81	–1.378	.11	–.49	–.533	–.598
Complementary accomplishment UP, D, DF, DPF		FTF > CMCa*[a] CMCs > FTF > CMCa*[a]			CMCs < FTF*[a] CMCs < CMCa*[a]	
CMCa	.208	1.787	–.15	–.35	–1.202	–.507
FTF	–.923	4.495	–.492	–1.683	–.008	–1.233
CMCs	–.873	7.468	.378	.128	–2.138	–1.852
Withdrawal NF, DN, DB						
CMCa	0	0	0	0	0	0
FTF	–.018	–.512	1.153	.248	–.555	.667
CMCs	.06	.195	–.01	.138	–.043	–.235

Accomplishment UPF, UF, F						
CMCa	–.05	–1.818	–.098	.81	1.782	–.625
FTF	–.32	–2.493	–.148	–.462	3.508	–2.197
CMCs	–.467	–1.862	–.17	–.038	3.032	–1.26
Reinforcement P, DP, PF				FTF > CMCa*[b] (one-tailed) CMCs > CMCa*[b]		
CMCa	–.132	1.053	–.057	–.138	.052	–.523
FTF	–.772	–.01	.057	3.202	–2.638	.1
CMCs	–.637	–1.178	.063	2.753	–1.005	–.432
Tension release UB, UPB, B, PB, DPB				CMCs < CMCa*[a]		FTF > CMCa*[b] (one-tailed)
CMCa	–.175	–.417	–.068	–.65	–.713	2.097
FTF	–.05	–.638	.638	–1.667	–.78	4.982
CMCs	–.7	–1.292	–.235	–2.843	–.568	4.928

NOTE: U = dominant; UN = dominant-unfriendly; UNF = dominant-unfriendly-instrumentally controlled; UNB = dominant-unfriendly-emotionally expressive; N = unfriendly; NF = unfriendly-instrumentally controlled; NB = unfriendly-emotionally expressive; DNB = submissive-unfriendly-emotionally expressive; UP = dominant-friendly; D = submissive; DF = submissive-instrumentally controlled; DPF = submissive-friendly-instrumentally controlled; DNF = submissive-unfriendly-instrumentally controlled; DN = submissive-unfriendly; DB = submissive-emotionally expressive; UPF = dominant-friendly-instrumentally controlled; UF = dominant-instrumentally controlled; F = instrumentally controlled; P = friendly; DP = submissive-friendly; PF = friendly-instrumentally controlled; UB = dominant-emotionally expressive; UPB = dominant-friendly-emotionally expressive; B = emotionally expressive; PB = friendly-emotionally expressive; DPB = submissive-friendly-emotionally expressive.

a. Mean *z* scores and the results of the Tukey HSD post-hoc test.

b. Mean *z* scores and the results of the contrast test.

*$p < .05$. **$p < .01$

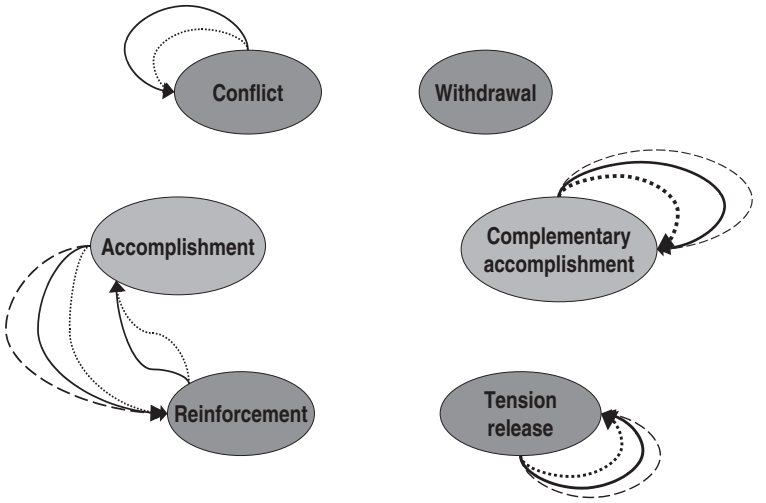

Figure 3: Significant Reactive Interaction Sequences in the Three Communication Modalities (FTF, CMCs, CMCa)

NOTE: FTF = face-to-face (continuous lines); CMCs = synchronous computer-mediated communication (dotted lines); CMCa = asynchronous computer-mediated communication (broken lines).

the Bavelas indices revealed that the uttered concepts were more specific in the CMCs condition than in the FTF condition.

The assumption that movements in the semantic network should be shorter because of a lack of direct feedback in CMC could not be confirmed either. Instead, the mean distance between an uttered concept and the one preceding it was greater in the CMC conditions than in the FTF condition. As already mentioned, CMC is characterized by a partial dissolution of the sequential structure. One reason for the greater distance between two concepts could be that they stem partly from messages that do not directly refer to one another. Therefore, the distances between those successive concepts that stem from messages with direct reference to one another (reactive sequences in the above-defined sense) were further analyzed. It was shown that under this condition, the mean distances between successive concepts did not differ from one communication modality to another.

TABLE 4: Means of Parameters of Network Analysis: Results of One-Way ANOVAS and Post-Hoc Tests

	Measures of Centrality		*Measures of Distance*			
	Bavelas Index (Lower Values = More Central Concepts)	*Adjacency (Higher Values = More Central Concepts)*	*Distance to Preceding Concept With Explicit Reference*	*Distance to Preceding Concept*	*Distance to the Central Concept: Marketing Campaign*	*Distance to the Central Concept: Solar Energy System*
Means in each modality						
CMCa	.00174	.0339	2.46	2.81	2.26	2.10
FTF	.00173	.0310	2.22	2.57	2.37	1.94
CMCs	.00181	.0303	2.30	2.97	2.38	2.18
ANOVA						
F	3.997	.892	.494	9.699	1.574	1.805
df	2, 15	2, 15	2, 15	2, 15	2, 15	2, 15
Significance	.041	.430	.620	.002	.240	.198
Tukey HSD	FTF < CMCs, $p = .045$; CMCa < CMCs, $p = .109$			FTF < CMCs, $p = .001$; FTF < CMCa, $p = .05$.		

NOTE: CMCa = asynchronous computer-mediated communication; FTF = face-to-face; CMCs = synchronous computer-mediated communication.

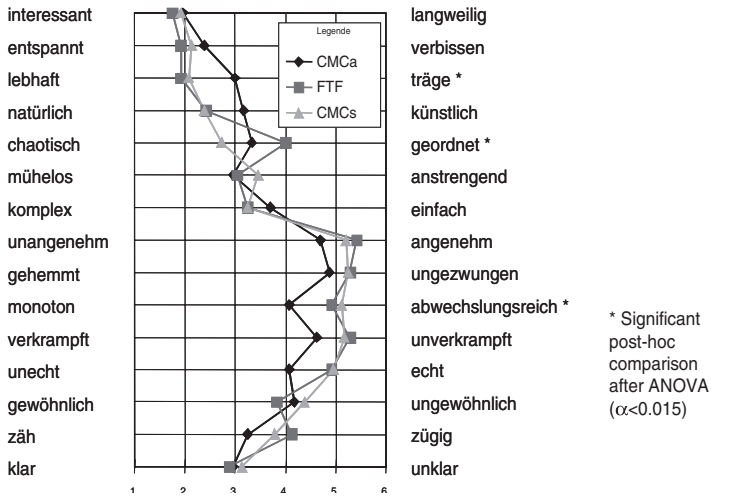

Figure 4: Ratings of Group Work of the Three Communication Modalities
NOTE: In the figure, the German notations are put down. For a better understanding, the translation (top down): interesting-boring; relaxed-tense; lively-lazy; natural-artificial; chaotic-ordered; easy-exhausting; complex-simple; pleasant-unpleasant; inhibited-at ease; monotone-diversified; inhibited-informal; false-authentic; normal-abnormal; tough-speedy; clear-unclear.

OUTPUT

Group satisfaction did not differ among the three communication modalities and was rather high ($M = 4.0$; minimum: 1; maximum: 6).

The ratings of group work were rather similar too, with three exceptions: FTF communication was rated as being more lively than CMCa and more orderly than CMCs; CMCs was seen as more diversified than CMCa (see Figure 4).

Although self-reports hardly reveal any differences between communication modalities, significant differences can be observed in the ratings of the quality of the group product. Fifteen expert ratings of 18 marketing campaigns were entered as dependent variable in a hierarchical ANOVA with marketing campaigns nested under communication modality. The rated quality of the group products differed significantly from one another, $F(2, 252) = 15.88$,

$p < .001$. The marketing campaigns produced by the FTF groups received the highest ratings ($M = 3.0$), followed by those of the CMCa groups ($M = 3.3$), while CMCs groups ranked last ($M = 3.8$).

Are qualitative differences in the group product related to process variables on the performative and the referential level? Are there significant predictors for the group performance? To answer these questions, we conducted a stepwise regression analysis. Only two reactive patterns turned out to be significant predictors: The higher the tendency to reciprocate acts of tension release and the less inhibiting the effect of accomplishment on complementary accomplishment, the poorer the rating of the group product ($R^2 = .583$).

DISCUSSION

The results of the analysis of the performative level show that the regulation of interaction differs not only between FTF and CMC groups but, at the same time, significant differences exist between the two CMC modalities.

A comparison between the FTF and CMCa condition shows, in accordance with the assumption of a messaging threshold (Reid et al., 1996), a higher percentage of categories of accomplishment in CMCa groups and a relatively lower percentage of signals of reinforcement and agreement. Concerning the reactive interaction patterns, sequences of negative social-emotional acts (sequences of conflict) are less prevalent in CMCa, as are sequences of reinforcement → accomplishment. In CMCa, the equilibrium between the instrumental-adaptive goal of performance and the social-emotional goal of satisfaction seems, therefore, to have shifted toward the instrumental aspect. In addition, the exchange of ideas takes place with less fine-tuning in CMCa; this is indicated by the rare occurrence of question → answer and reinforcement → accomplishment sequences.

CMCs was characterized by interaction sequences very similar to those in the FTF condition. With regard to how frequently the diverse interaction categories appear in CMCs, as opposed to

CMCa, clearly, differences can be observed: In CMCs, a lower percentage of categories of accomplishment and a higher percentage of social-emotional categories is apparent; concerning conflict and tension release, their level is even higher in CMCs than in FTF interaction.

On the referential level, CMCs differs from FTF interaction in terms of the usage of less central, more specific constructs—a result that contradicts our hypothesis.

How can the differences between CMCa and CMCs concerning the regulation of interaction be explained? The simultaneous participation of all group members in CMCs seems to stimulate interaction patterns similar to those that actors are used to showing in FTF interaction. In spite of the higher costs of sending messages, participants produce many short-lived messages with regulatory or affective functions. These different conclusions, when compared to the findings of Reid et al. (1996), may be because of the more generous time allowance of 3-hours interaction time given in this experiment. Because the CMCa condition is characterized by a lack of synchronicity, it will not give rise to familiar interaction patterns; hence, the expected differences between the FTF and the CMCa condition became apparent. It can thus be hypothesized that the cost of sending a message is a less critical factor than synchronicity.

Concerning group output, there was no difference between the communication modalities, as far as the group members' satisfaction is concerned. CMC is well received so that, from this point of view, it could unquestionably be implemented in work groups. A difference between FTF interaction and the two forms of CMC appears concerning the quality of the group product as rated by external experts. Here, FTF groups did better than CMC groups. The interpretation of this result is complicated by the fact that none of the process variables in which the FTF and the CMC condition differ are a significant predictor for the group performance. For the implementation of CMC in real work groups, it is important that group work be effective. Therefore, further research is necessary to examine if the quality of CMC group performance can be enhanced by moderation of the group process or by making partner models

more explicit so that information can be exchanged more specifically.

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