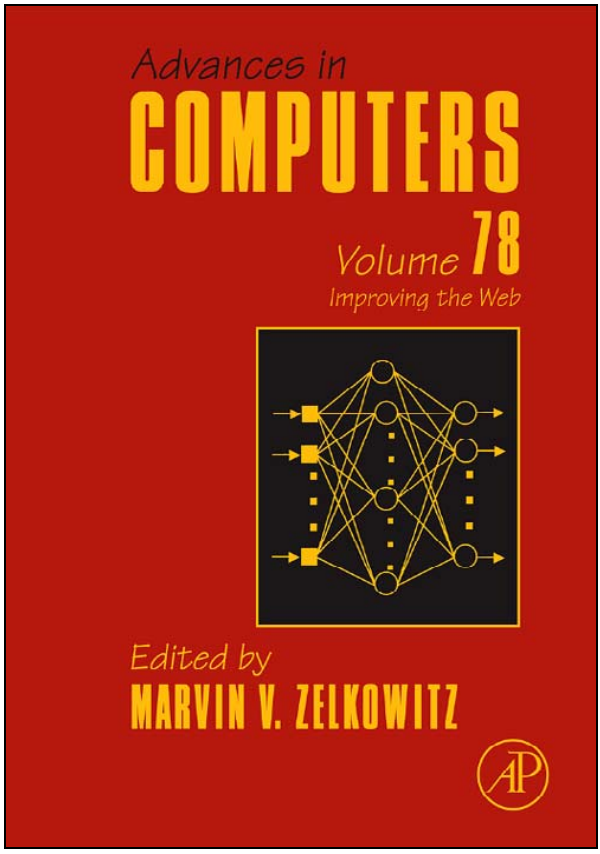

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Communication Media Selection for Remote Interaction of *Ad Hoc* Groups

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Abstract

Nowadays work is becoming predominantly distributed, bringing significant challenges to effective communication of geographically dispersed groups. In fact, multisite work presents considerable loss of opportunities for rich interaction and a very substantial reduction in frequency of both formal and informal communication between coworkers. While communicating face-to-face (F2F) by speech is easy for individuals, conducting a long-running, productive conversation through the digital medium is difficult, especially as the group size increases. The difficulty of computer-mediated communication (CMC) and collaboration stands in stark contrast to our natural ability to easily communicate and collaborate with one another in the physical world. As such, there is a need to further our understanding of the effectiveness of the many available synchronous and asynchronous communication media (e.g., e-mail, videoconferencing, or specialized collaboration tools) to support activities of distributed teams. However, not only media properties (e.g., synchronicity) affect the performance of groups collaborating from a distance but also the characteristics of groups (e.g., size, history) and tasks (e.g., idea generation, decision making) play a key role. In this chapter, we first present a survey on the group-, task-, and media-related theories that are relevant for the selection of the most appropriate synchronous communication media to better support distributed *ad hoc* groups, that is, short-term groups with neither a history of previous collaborations nor expectation of future ones. Then, we consistently combine all the reviewed theories to create two general models that, respectively, can help researchers to manage the context of experiments on remote group collaboration, and distributed groups themselves to evaluate, compare, and select the most appropriate fits between the task at a hand and the media available.

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1. Introduction

Nowadays, no one works completely independently. Almost everyone is part of at least one group, typically several groups at any point in time. Figure 1 shows a typical cooperative work framework [1]. Groups of two or more participants (P) communicate together, share information, generate and organize ideas, build consensus, make decisions, and so on. Being engaged in some common work, participants interact with tools and products (i.e., artifacts of work, A). The main purpose of communication is to establish a common *understanding* of the work shared between participants. The development of the understanding happens both indirectly and directly. The arrows that link participants to the artifacts denote *indirect communication*. It happens

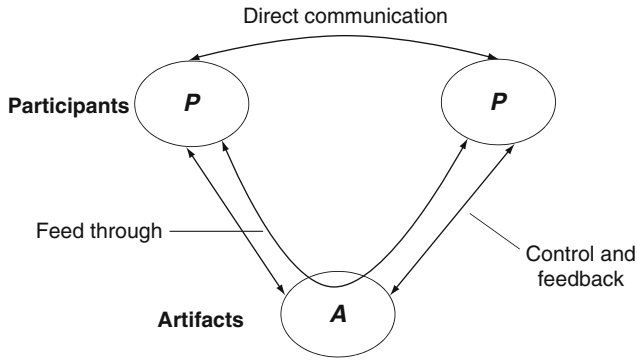

FIG. 1. Cooperative work framework: Communication as the basis of collaboration (adapted from Ref. [1]).

through the manipulation of shared tools and work objects (e.g., a document, a piece of code). *Feedback* represents the information gained by the participant who directly controls a shared artifact. Further, the changes applied to an artifact convey information also to the other participants (*feed through*). *Direct communication* is denoted by the arrow between the participants and happens by speech or over communication media, such as telephone, fax, and e-mail.

While communicating face-to-face (F2F) by speech is easy for individuals, conducting a long-running, productive conversation through the digital medium is difficult, especially as the group size increases. The difficulty of computer-mediated communication (CMC) and collaboration stands in stark contrast to our natural ability to easily communicate and collaborate with one another in the physical world [2]. As such, there is a need to further our understanding of the effectiveness of the many available synchronous and asynchronous communication media (e.g., e-mail, videoconferencing, or specialized collaboration tools) to support activities in distributed teams. However, not only media properties, such as synchronicity, affect the performance of groups collaborating from a distance. In fact, also *who does what* matters, that is, the characteristics of groups (e.g., size, history) and tasks (e.g., idea generation, decision making) play an important role.

Mainly because of economic factors, nowadays work is becoming predominantly distributed, bringing significant challenges to effective communication of geographically dispersed groups. In fact, multisite work presents considerable loss of opportunities for rich interaction and a very substantial reduction in frequency of both formal and informal communication between coworkers [3]. Following the trend to business globalization, also software development has increasingly become distributed, with little or no possibility for developers to meet. Among the software

development activities, requirements engineering is one of the most communication-intensive and then, its effectiveness is greatly constrained by the geographical distance between stakeholders [4, 5].

The definition of requirements is a highly collaborative, interactive, and interdisciplinary process, involving heterogeneous teams of stakeholders [6, 7]. It provides another example of a dynamic collaboration that can be accomplished by a virtual, *ad hoc* group, where some members (e.g., representatives from the customer organization) join the developer group when they can add a value (e.g., to take part in the elicitation of the requirements, in a prototype demo session), and disengage at the end of the task. These groups create temporary networks of independent companies and collaborate as virtual organizations, using information technology to share skills and costs. Thus, such teams are *ad hoc* in the sense that they tend to be highly dynamic in creation, participation, and release, other than typically being geographically dispersed and cross-organizational. Other common scenarios of *ad hoc* group collaborations are provided by the partner consortium formed by representatives from different organizations in various sectors (e.g., academic institutions, industry), who have to coauthor a funding proposal for applying to the Framework Programme of the European Commission. Also in the field of software development, several processes, such as document inspections and reviews in general, can be carried out by *ad hoc* groups. The first contribution of this chapter is the proposal of a new definition of *ad hoc* group, which builds on the previous ones given in the existing literature on group research and is compliant with the emerging scenario of short-term distributed collaborations.

Due to their temporary nature, *ad hoc* teams need tools with infrastructure and administration costs kept at minimum. Instead, multipoint audio–video communication poses significant practical barriers to deployment (e.g., expense, infrastructure, support). As such, short-term groups like *ad hoc* teams often fall back to textual communication only. However, rich media theories on CMC, namely *Social Presence* [8], *Media Richness* [9–11], and *Common Ground* [12], have hypothesized group effectiveness to decrease when media other than F2F are used to accomplish equivocal tasks that require relational cues to be exchanged. They have reported about the inadequacy of text-based communication, as compared to rich media, like F2F and video. Lean media, such as e-mail and instant messaging, lack the ability of conveying nonverbal cues that contributes to the level of social presence (e.g., gaze, tone of voice, facial expressions), which in turns fosters individuals' motivation and mutual understanding. Nevertheless, these theories have also been criticized for considering the task to execute as an atomic activity. In addition, both Social Presence and Media Richness theories have generally been supported when tested on traditional media, such as F2F communication and telephone, whereas inconsistent empirical findings have resulted when tested on e-mail and video.

These inconsistencies have encouraged a reconsideration of the descriptive and predictive general validity of such theories. Thus, more recent theories have asserted that the effectiveness of CMC depends also on factors other than media richness, such as the degree of synchronicity, task typology, and group temporal scope. *Media Synchronicity* theory [13–15] and *Cognitive-Based View* [16] have started to investigate on media effects, looking at the underlying communication processes that happen in group tasks. On the one hand, Cognitive-Based View represents a sort of ''Copernican revolution,'' which capsizes the existing perspective of CMC theories, looking at communication as a cognitive process: Not only must the sender's comfort with the communication medium be taken into account, but also the motivation of receivers and, above all, their ability to process the message properly. Furthermore, Cognitive-Based View argued that the use of rich media high in social presence should be used to assure attention for small amounts of information, whereas the use of lean media low in social presence causes a decreased motivation, but increases the ability to process large amounts of information during longer periods of time. On the other hand, Media Synchronicity theory distinguishes between the interplay of two different communication processes (the conveyance of additional information, and the convergence to shared views), which vary with the degree of synchronicity of the medium. Furthermore, since a task is not actually atomic, but rather constituted of several subactivities, Media Synchronicity theory suggests that the synchronicity level of media should be aligned with the degree of conveyance or convergence of each subactivity.

The concept of alignment between task and media characteristics is the very basis of the theories of *Time–Interaction–Performance* [17] and *Task/Technology Fit* [18, 19]. The frameworks proposed by these theories evaluate the appropriateness of task-medium matches, considering tasks no more as somewhat atomic activities, like in Media Richness and Social Presence theories, but rather as complex sets of subactivities and subprocesses, each having different characteristics. Likewise, also group and media characteristics have to be aligned for opportune collaborations to take place. The theories of Common Ground and *Channel Expansion* [20–22] argue that groups without a history of previous collaborations, like *ad hoc* groups, do not share any experience and thus, have not established a level of common ground (i.e., shared understanding) sufficient for communicating effectively over lean media. Conversely, members of long-term groups are expected to communicate more effectively over impoverished media, using their shared experiences to compensate for the media leanness.

Drawing upon these theories, we argue that, by understanding the paradoxical effects of rich media high in social presence, groups may be better able to select and use the most appropriate media to accomplish their goals. Hence, the second contribution of this chapter is presenting a critical review of the very many existing,

and often conflicting, theories on CMC, which have been combined in a comprehensive theoretical framework for predicting, evaluating, and comparing the goodness of Task-Technology Fits. The proposed framework also builds on McGrath's Task Circumplex [23], which is the most widely used reference model in group research for task analysis, comparison, and categorization.

Finally, the third and last contribution of this chapter is the definition of a high-level research model, adapted from Ref. [24] (see Fig. 2), which can be used to support empirical studies on distributed group research. The theoretical background outlined later in this chapter will show that providing evidence of group task effectiveness can be overly challenging: The effects of technologies are contingent on many factors that differ from situation to situation, according to the context of a group process—that is, *group composition*, *task typology*, and *communication medium*. Thus, also the outcome of a group task (e.g., efficiency, effectiveness, product quality) depends upon the interaction between the group process and these varying contextual factors. Therefore, results from empirical study with communication media must be qualified by the context—the group, the task, and the medium—to which they apply. Through the rest of this chapter, we will update such model to include the variables that define the contextual group-, task-, and media-related factors.

To summarize, the three main contributions of this chapter are:

(A) the definition of *ad hoc* groups, which builds on the previous definitions given in the existing literature on group research;
(B) the design of a high-level research model for remote group performance evaluation;
(C) the design of a comprehensive theoretical framework, built upon the Task Circumplex model and the very many existing theories on CMC, which can be used to predict, evaluate, and compare the goodness of Task-Technology Fits.

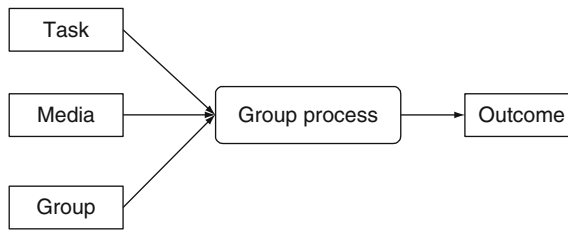

FIG. 2. The general research model adopted to represent the interaction of contextual factors with group process and their effect on the outcome (adapted from Ref. [24]).

The remainder of this chapter is structured as follows. Sections 2 and 3 deal with task-classification frameworks and *ad hoc* groups research, respectively. Section 4, instead, frames the complex background of CMC by reviewing the most prominent theories on media effect. In Section 5, we merge the contribution of the previous sections, thus creating two general frameworks relevant to group research on distributed collaboration. Finally, we conclude in Section 6.

2. Task-Classification Frameworks

When differences in group performance are studied, differences in group tasks must be taken into account with the due regard as well. A widely accepted, general definition of group task is the one given by Campbell, who defined it as ''the behavior requirements for accomplishing stated goals, via some process, using given information'' [25]. Such definition acknowledges that task characteristics define not only what is to be accomplished, but also how it is to be done. In fact, because required behaviors vary from task to task, it is argued that they can legitimately be viewed as characteristics of tasks themselves [26].

A number of task-classification schemes have been proposed in the literature, such as Hackman's *Task Framework* [26], Wood's *Model of Task Complexity* [27], and Mennecke's *Model of Task Processing in Groups* [28]. A list of historical task classification schemes can be found in Ref. [19]. The two tasks classification frameworks presented here focus on task complexity, the characteristic of task that has been studied the most because it relates to both process and outcomes of task performance, thus playing a key role in categorizing group tasks [19]. As such, the general research model is updated here to include the complexity of tasks factor as influencing the group interaction and outcome (see Fig. 3).

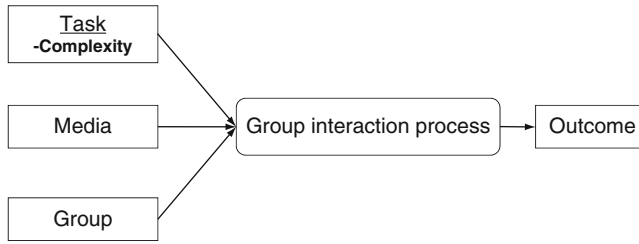

FIG. 3. The research model updated with the task complexity factor.

2.1 Task Circumplex

The most prominent theoretical framework formulated to provide a classification of group tasks is McGrath's Task Circumplex [23]. *Task Circumplex* classification scheme draws upon Hackman's *Task Framework* [26], which defined three types of tasks, namely tasks of idea production, tasks of discussion for group consensus, and tasks of problem solving. In addition, McGrath's classification is based on task as behavior requirements to the extent that each task is characterized not only by its own objective (i.e., *what* the group members are supposed to do to accomplish it), but also by its processes (i.e., *how* the task should be carried out). The Task Circumplex, shown in Fig. 4, categorizes all group tasks as belonging to one of four basic task processes, each of which has in turn two subtypes:

(I) Generate (ideas or plans);
(II) Choose (correct or preferred answers);
(III) Negotiate (conflicting viewpoints or conflicting interests);
(IV) Execute (in competition against other groups or in evaluation against standards of performance).

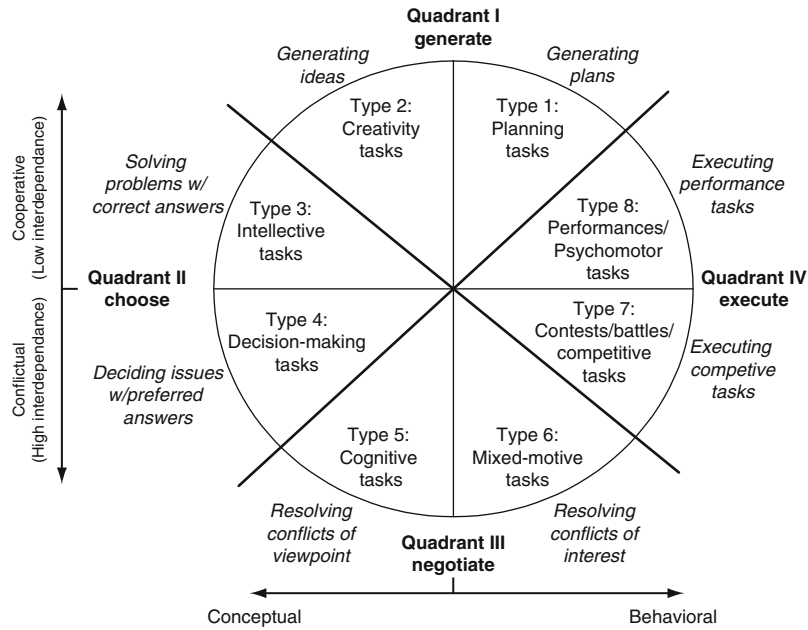

FIG. 4. The Task Circumplex [23].

The four process categories are related to one another and arranged in a circumplex along two dimensions, namely the degree to which processes involve cooperation (i.e., low member interdependence) versus conflict (i.e., high member interdependence), and the degree to which the processes involve conceptual versus behavioral activities. Furthermore, McGrath designed the four process categories to be collectively exhaustive, thus making the Circumplex useful for comparing similarities and differences of tasks used in group research.

As an example, we here use the Task Circumplex to categorize the activities of requirements elicitation (defined as the process of seeking, uncovering, acquiring, and elaborating requirements for computer-based systems [7]) and negotiation (defined as the process of reaching an agreement on requirements by resolving misunderstandings and conflicts due to the conflicting goals and priorities that stakeholders have [6]). According to the framework above, eliciting requirements is mostly a creativity task (Type 2), since it is about generating ideas, with a lower need for problem solving (Type 3) and decision making (Type 4). Conversely, the negotiation of software requirements involves tasks of Types 3–7, namely creativity, intellective, decision making, cognitive, mixed-motive, and competitive tasks [29]. Thus, comparing the two forms of requirements workshops, in Task Circumplex terminology, requirements negotiation is a more complex activity, in that it involves different tasks, both conceptual and behavioral, with medium to high degree of member interdependence. In contrast, elicitation is a simpler activity in that it is mostly a conceptual task of creativity, with low behavioral issues involved and low degree of member interdependence.

The Task Circumplex is not exempt from limitations and criticisms. While it gives a way to compare tasks, it does not provide with an objective means to measure the degree to which tasks in each wedge differ from tasks in both the same category or in different categories [28, 30]. Despite such criticism, the Task Circumplex has been the dominant task-classification scheme in the last two decades. It has been used not only as a task taxonomy, but also as the foundations to develop theories on communication media selection, discussed in Section 4, which encompass the intertwined relationships between tasks and technology, discussed in Section 5.2. Task Circumplex has been adopted by Group Support Systems (GSS) research (see Ref. [31]) for an exhaustive compendium on GSS-related research studies). GSS studies have largely dominated group studies for almost more than two decades, until the end of the 1990s. Christenesen and Fjermstad performed a meta-analysis of 67 GSS studies, conducted until 1997 [32]. They found that more than a half of GSS studies employed creative tasks and that more than one-quarter employed decision-making tasks. Furthermore, most of the laboratory studies reviewed used contrived tasks designed or manipulated for the research purpose. To improve the generalizability of results, Dennis et al. called for the use of tasks as

complex as ‘‘natural tasks,’’ requiring knowledge already within subjects’ knowledge domain [33]. However, since students were and are likely to continue as the most common source of experimental subjects, the usually contrived laboratory tasks were puzzles or games (e.g., lost at sea, the parking problem, the philanthropic foundation task [28]), which required limited or no specialized knowledge to be recalled [34]. These tasks represent a poor surrogate for the complexity of ‘‘wicked’’ natural tasks, and their employment potentially limited the external validity and generalizability of GSS laboratory experiments, and likely accounted for much of the contradictory findings between field and laboratory research [28, 35, 36]. The multifaceted properties and complexity of natural tasks can be achieved by using ‘‘realistic tasks,’’ that is, natural tasks replicated in controlled laboratory environments. The flipside of using realistic tasks in place of contrived tasks is the likely higher difficulty in evaluating group interaction processes and task performance. Effectiveness does not have a consistently held definition or interpretation in the group research literature [24]. Satisfaction with both the interaction process and the outcome is an important variable in group research, since it has been acknowledged to be indicative of both individual and group performance [37, 38].

2.2 Complex Tasks Typology

First Campbell [25] and then Zigurs and Buckland [19] identified four fundamental task attributes, from which a *typology of complex tasks* was derived. The first dimension is *outcome multiplicity*, which indicates that a task has more than one desired outcome. All tasks that involve more than one stakeholder with different expectation about the goal provide an example of tasks with outcome multiplicity (e.g., selecting a family home when every family member has different expectations on price, size, position, service proximity, and features alternatives).

The second dimension is *solution scheme multiplicity*, which indicates that more than a solution path exists to accomplish the task and reach the goal. Class scheduling is an example of task with solution scheme multiplicity.

The third dimension is *conflicting interdependence*, which may exist when conflicts are found between alternative task solution schemes or task outcomes. This may also happen when some pieces of information available are conflicting. Examples of tasks with conflicting interdependence are provided by quality versus quantity tasks [19].

The fourth and last dimension is the *solution scheme/outcome uncertainty*, which can be identified in all tasks where there is uncertainty about whether one solution scheme will lead to the desired outcome [19].

Finally, all the possible combination of the four dimension result in 16 distinct tasks categories, which have been narrowed down to 5, as shown in Table I.

TABLE I
AGGREGATED TASK CATEGORIES WITH PRIMARY ATTRIBUTES SHOWN IN BOLD (ADAPTED FROM REF. [19])

Dimension	Simple tasks	Problem tasks	Decision tasks	Judgment tasks	Fuzzy tasks
Outcome multiplicity	**No**	No	**Yes**	No	**Yes**
Solution scheme multiplicity	**No**	**Yes**	No	No	**Yes**
Conflicting interdependence	No	Yes or No	Yes or No	**Yes**	Yes or No
Solution scheme/outcome uncertainty	NA	Low to High	Low to High	Low to High	Low to High

Each of the five task categories is defined in terms of primary attributes, shown in bold in the table. Thus, Simple tasks are primarily characterized by the existence of a single outcome and solution scheme, the opposite of Fuzzy tasks. Problem tasks and Decision task are characterized, respectively, by solution scheme multiplicity and outcome multiplicity. Instead, conflicting interdependence dimension primarily identifies Judgment tasks. Finally, although not applicable in the case of Simple tasks, the dimension of solution scheme/outcome uncertainty does not primarily characterize any of the four remaining categories because it can be present in each of them, ranging from low to high, depending on the nature of the task itself (e.g., when the scope of the task is large or the outcomes hard to measure).

Campbell also observed that other than the four primary complexity attributes, there are also other characteristics that may be associated with task complexity, such as lack of structure, ambiguity, and difficulty. Hence, unlike McGrath's Task Circumplex, the complex tasks typology proposed by Cambpell is not designed to be collectively exhaustive. In addition, as pointed by Zigurs and Buckland, who refined the initial work by Campbell [25], it focuses on the kinds of tasks that are usually found in organizational decision-making groups [19]. As such, the Tasks Typology presented here results less useful than the Task Circumplex for general-purpose group tasks categorization and comparison.

3. Group Research

3.1 Teams with No Past and Future: *Ad Hoc* Groups

Besides task type, another contextual factor that influences group studies is temporal scope, that is, ''the extent to which groups have pasts together, and expect to have a future'' [17] (p. 149).

Work groups are today increasingly nimble and subject to frequent changes [39]. This underlying idea in *ad hoc* groups is that of a small entity, highly dynamic in creation, participation, and release, formed to accomplish the goal at hand (e.g., solve a specific problem), and then, disband as soon as the collaboration is over. Hence, *ad hoc* teams are also called *goal-oriented* teams [40]. These teams are sometimes associated with strike teams, which are small groups of people with a specialized purpose, such as responding to a critic situation, like a terrorist attack or a natural disaster, in a timely manner. In addition, *ad hoc* groups typically exhibit both loose affiliation and geographical dispersion, that is, they are virtual teams, composed recruiting members from independent departments in different organizations [41]. Virtual organizations of the future will be more and more comprised of flexible, *ad hoc* groups that individuals join when they can add value and disengage when they are no longer needed [42]. Today, a common scenario of *ad hoc* groups collaboration is provided by the partner consortium formed by representatives from different organizations in various sectors (e.g., academic institutions, industry), who have to coauthor a funding proposal for applying to the Framework Programme of the European Commission. Also in the field of software development several processes, such as document inspections and reviews in general, can be carried out by *ad hoc* groups [43]. The scenario of distributed requirements provides another example of a dynamic collaboration that can be accomplished by a virtual, *ad hoc* group, where some members (e.g., representatives from the customer organization) join the developer group, when they can add a value (e.g., to take part in the elicitation of the requirements, in a prototype demo session), and disengage at the end of the task.

The limited group size and temporal scope are the key characteristics of *ad hoc* groups. *Ad hoc* groups do not usually include more than 10 participants. However, every attempt to define the typical size is vain. Even research on small groups reports varying ranges, usually 3–5 participants for small-sized groups, and 6–12 for medium-sized groups [44]. However, in absence of a widely accepted definition of group size, these ranges can be considered reasonable, bearing in mind the research already undertaken. The study of small- and medium-sized groups is important because it has been shown that larger groups do not necessarily produce a proportionally higher number of ideas and thus, there is likely to be an optimal group size, beyond which any further increase in membership does not equate with an increase in contributions [44]. Temporal scope defines group history and future, that is, the shared experience that the group has developed in the past and the expectation of future collaboration, respectively. For *ad hoc* groups, temporal scope corresponds exactly with the time needed to carry out one collaboration. In other words, while traditional groups are conceived as *established*, that is, long-term, standing teams that work together for a long time across several independent projects, *ad hoc* groups

are instead teams brought together for a short time to carry out only the collaborative effort in attendance. The meaning of *ad hoc* groups today differs greatly from the earlier definitions provided by researchers over the years. *Ad hoc* groups, also called single-task groups initially, have been studied since the end of the 1950s [45–47] and over the last decades [33, 48–50]. According to the definition given by Mennecke et al. *ad hoc* groups are teams whose ''members have no experience working together with other members and little or no expectation that they would work together in the future.'' In contrast, they defined established groups as ''on-going groups, that is, groups where members have a significant history working together as a group and anticipate having a significant future together'' [30, 48]. Likewise, Dennis et al. defined *ad hoc* groups as single-task groups whose members have not worked together prior to the study and do not anticipate to continue working together after the study [33]. Although similar to the others, this definition is indicative of how past research considered *ad hoc* groups as single-task, ''laboratory groups'' of randomly assembled subjects to be studies merely as ''experimental, microscopic models'' of established groups, seen instead as natural groups [45]. However, Bormann [47], McGrath [23], and Mennecke et al. [30] pointed out the inadequacies associated with using single-tasks groups, in terms of the lower generalizability of results. Nevertheless, single-task groups have almost universally been used in laboratory experimentation, compared to field studies, where established groups are utilized instead.

While previous research has almost exclusively treated *ad hoc* groups as a factor partially accounting for discrepancies between laboratory and field studies, current research cannot continue to neglect the relevance of studying *ad hoc* group *per se*. We cannot continue to refer to established groups as ''natural groups,'' since nowadays *ad hoc* groups are functionally used as well, and no more employed only in laboratory studies. While established groups are still more traditional, they are to be considered as natural as *ad hoc* groups. We suggest to adopt the definitions given by McGrath et al. to distinguish *natural* groups, defined as ''groups that exist independently of the researcher's activities'' and used in field experiments, from concocted groups, which are instead ''brought together only for the purpose of laboratory experiments'' [23] (p. 41). Thus, group research studies can employ natural as well as concocted *ad hoc* groups. In addition, compared to concocted established groups, laboratory studies on concocted *ad hoc* groups will suffer from minor problems of results generalizability, since they represent a more adequate experimental model of their natural counterpart. We also suggest the following new definition of *ad hoc* groups.

Definition. An *ad hoc* group is a small- to medium-sized team highly dynamic in creation, participation, and release, whose members have no past experience of

working together and little or no expectation of collaborating again in the future. The temporal scope of an *ad hoc* group corresponds exactly to the time needed to carry out the collaboration in attendance.

3.2 Challenges and Needs in Supporting Remote *Ad Hoc* Groups

The definition above voluntarily omits the adjective ''distributed,'' typically used to further characterize an *ad hoc* group, because virtual *ad hoc* teams are more common and of our primary interest, there can be collocated *ad hoc* groups as well.

Our specific interest in supporting collaboration of *ad hoc* groups is twofold. We aim at understanding (1) the key challenges in *ad hoc* group communication processes and (2) the attributes of communication media to use in order to cope effectively with such challenges when *ad hoc* groups are distributed.

Very little is known today about the differences in group dynamics of *ad hoc* groups. In his research study, Tuckman only reported hypotheses on short-term groups development [51] (p. 79). He supposed that ''duration of group life would be expected to influence the rate and amount of development.'' Nevertheless, short-term groups would also be expected to ''essentially follow the same course as long-term groups [. . .] with the requirements that the performing stage be reached quickly,'' to the detriment of the other phases that are not ''as salient as task execution'' in task-oriented groups.

The study of short-term groups has been somewhat neglected by group research, especially GSS, since it was only accounted as one of the factors that could explain variance of experimental results. Nevertheless, useful insights have been gained from a review GSS research on the effects of group history and experience, in the comparison between established and *ad hoc* groups. Hall and Williams were among the first to report that conflicts and decision quality in decision-making tasks are moderated by group history [46]. While decision quality resulted positively related to outcome quality in established groups (i.e., the more the conflicts, the higher the decision quality), the relationship resulted reversed for *ad hoc* groups (i.e., the more the conflicts, the lower the decision quality). This result was later confirmed by Dennis et al., who also found that established groups did not communicate more than *ad hoc* groups, which in turn showed a greater equality of members' participation (i.e., no domination as for established groups' communication), but also less openly critic messages (i.e., more inhibited communication) [33]. Mennecke et al. found partial evidence in support of the major quantity of information shared by *ad hoc* groups [48]. Benbasat and Lim performed a meta-analysis of research on the effects of group history and found that decision quality is not significantly affected by group history, which instead was confirmed to negatively affect equality of participation (i.e., the

more the past experiences share by a group, the less equal the members' participation) [37]. In addition, with respect to traditional established groups, *ad hoc* groups typically exchange more task-focused, impersonal information, and exhibit less openness and trust [32]. Finally, Alge et al. suggested the need to distinguish between past and future groups for investigating the effects of groups' experience and motivation [49]. *Past* groups are teams nearing to completion of a collaboration, whereas *future* groups, instead, are newly formed teams just starting a collaboration. Past and future groups exhibit different level of motivation. Members of future groups are more likely to be motivated to engage in interactions than members of past teams who feel to be close to the end of the collaboration and thus, tend to exchange a lower amount of information. However, it is unclear how these results relate to *ad hoc* groups. Given our proposed definition, the characteristics of past and future teams blend in the temporary nature of *ad hoc* groups, in the sense that the limited temporal scope makes an *ad hoc* group a newly formed team, also close to the completion.

The technological challenges to be faced in supporting distributed, *ad hoc* groups stem from the limited temporal scope too. Given the rather occasional and temporary nature of *ad hoc* groups' collaboration, the adoption and maintenance costs of complex collaborative platform (groupware) can hardly be justified and sustained. The adoption of such sophisticated collaborative platforms has proved to be problematic even for established groups, in both traditional [52] and virtual organizations [2]. Hence, we argue that *ad hoc* groups, to be effectively nimble, should be supported by communication tools that have a low learning curve, so that dynamic engaging of new members is facilitated, and whose infrastructure and administration costs are minimal, so that dynamic creation is facilitated. This need for supporting dynamism turns out to require the adoption of either commonly available tools, such as instant messaging, e-mail, wikis, issue trackers, or systems that do not require administration and maintenance of any central resource by design [53–55]. In the latter case, P2P collaborative systems can support *ad hoc* groups in the sense that they build overlay networks that sit on top of the Internet, and almost exclusively use resources (e.g., disk storage, bandwidth) already available on the same hosts running the peers (i.e., the edge of the Internet).

To conclude this section, we show in Fig. 5 the research model updated to include the size and temporal scope variables, which characterize the group-related contextual factors.

4. CMC Theories

As geographically dispersed individuals more and more communicate via computer, understanding the effectiveness of the very many available media has become vital. Media are usually classified in the time/space matrix (see Fig. 6), according to

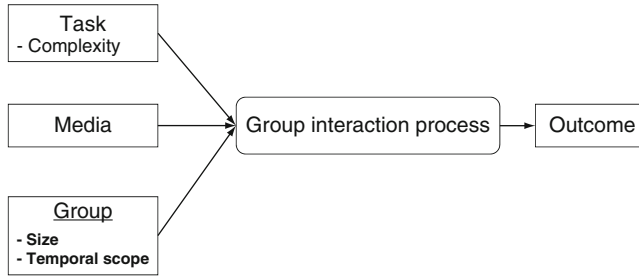

FIG. 5. The research model updated with group-related variables, size, and temporal scope.

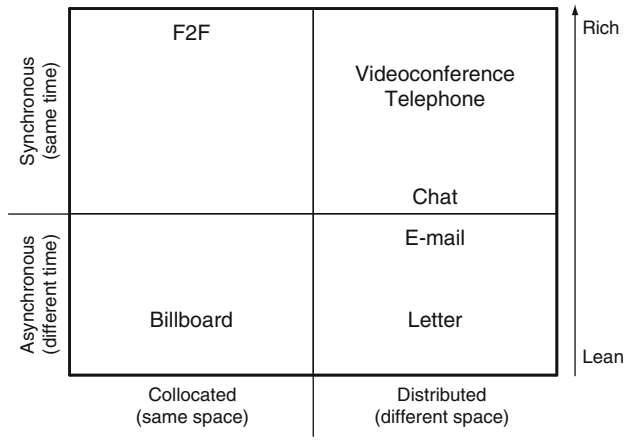

FIG. 6. Rich/lean media ranking in classic time/space matrix (adapted from Ref. [56]).

both the spatial dimension (collocated/distributed, i.e., *where* interaction occurs) and the temporal dimension (synchronous/asynchronous, i.e., *when* the interaction occurs). For instance, F2F communication allows synchronous interaction and requires physical collocation of individuals. Instead, e-mail allows asynchronous interaction and does not require collocation.

Media can also be classified according to another dimension, richness. We can intuitively epitomize *richness* as the ability of media to convey a larger amount of information in different forms. The figure above shows the media along the media richness continuum. F2F is the richest form of communication, since it conveys information via audio and video channels, but also through cues like gesture and

posture. Consequently, videoconference is richer than telephone, since the latter lacks video as information channel, whereas e-mail is richer than letter, since electronic mail can also attach multimedia content. Many CMC theories have provided different definitions of media richness, but, despite such differences, the resulting rank of media richness has never changed from the one presented before. Besides, many CMC theories have agreed on the inadequateness of text-based communication for complex, collaborative tasks, suggesting that, as complexity increases, so should the level of richness of the media used.

Despite the negativity of the aforementioned technological and theoretical premises, the last decade has witnessed the success of many open-source projects which are coordinated through the almost-exclusive use of text-based technologies, such as web sites, e-mail, and IM. These technologies, although not novel, have found their own way in supporting collaboration. E-mail is the most used collaborative tool to date, and a place where new collaborations emerge [57]. IM, although initially banned as an application intended only for teenagers, has found a number of uses in the workplace, including opportunistic interactions, and a ''signaling'' function by which people negotiate their presence and availability [58, 59]. Web sites and their natural evolution, the Wikis, foster collaboration throughout knowledge sharing [60]. Open-source development provides just one of the scenarios where text-based communication is effectively used to perform complex collaborative tasks. As already pointed out, interaction of individuals is deeply influenced not only by media characteristics but also by tasks requirements and group characteristics like history and experience.

In the following, we review the fundamental theories on CMC and media selection. Sections 4.2 and 4.3 discuss the Social Presence Theory and the Media Richness Theory, respectively. The theory of Common Ground is introduced in Section 4.4. Section 4.5 presents the Media Synchronicity Theory. Finally, the Cognitive-Based View is discussed in Section 4.6.

4.1 Social Presence Theory

Social Presence refers to the degree to which one perceives the presence of participants in the communication. Social Presence theory argues that media differ in the ability to convey the psychological perception that other people are physically present, due to the different ability of media to transmit visual and verbal cues (e.g., physical distance, gaze, postures, facial expressions, voice intonation, and so on) [8]. Some mediums (e.g., videoconferencing or telephone) have greater social presence than other mediums (e.g., e-mail), and media higher in social presence are more efficient for relational communication (i.e., building and maintaining interpersonal relationships), as they involve social/personal issues and thoughts.

Social Presence presumes the outcome of an interaction to be determined by the capacity of the selected medium to support the type of communication required. More specifically, Short et al. argue that F2F interaction, thanks to the wider capacity of conveying social presence, is more effective for relational communication than text-based media, such as e-mails, which do not transmit any cue and are then, more effective for task-focused communication.

Finally, Social Presence theory has also been found to be a strong indicator of satisfaction, that is, the higher the sense of social presence conveyed by a medium, the higher the satisfaction perceived by participants when communicating [61].

4.2 Media Richness Theory

One of the most widely applied theories of media selection is Media Richness theory by Daft and Lengel [10, 11]. Media Richness, which builds on the theory of Social Presence, argues that communication media differ in their ability to facilitate understanding. Daft and Lengel have defined information richness as the capacity of information ''to change understanding within a time interval'' [9]. Thus, in Daft and Lengel's terms, what differentiates richer media from leaner media is the amount of information a medium could convey to change the receiver's understanding within a time interval. This capacity depends on several factors, such as the ability of the medium to transmit multiple cues, immediacy of feedback, and language variety. The perceived sense of social presence of a medium is proportional to the medium richness. As a result, rich media with a wide communication capacity also have a high level of social presence. F2F interaction is the richest media, due to its capability of expressing message context in natural language and conveying at the same time multiple cues via body language and tone of voice, and it is supposed to change understanding of participants in communication in a shorter time interval. The second richest medium is videoconferencing, because, although it still grants the use of natural language, and the access to some visual and verbal cues, it conveys a lower sense of social presence to conversation participants. E-mail, chat/IM, and letters are instead the leanest media because, when adopted, communication exchanged by participants is conveyed on a single channel, that is, text, be it written or typed.

Like Social Presence Theory, also Media Richness theory presumes that the outcome of an interaction is determined by the communication capacity of the selected medium. While Social Presence theory relates performance primarily to the type of interaction required (relational vs. activity focused), Media Richness Theory asserts, instead, that performance depends on the appropriateness of the match between media richness characteristics and information requirements of the task (clarification vs. additional information). Indeed, Media Richness Theory

postulates the existence of two complementary forces that act on participants when they process the information exchanged when communicating (see Fig. 7). One force is *uncertainty*, which is defined as the ''difference between the amount of information required to perform a task and the amount of information already possessed'' [11]. This definition builds on earlier research work about information theory (i.e., as information increases, uncertainty decreases [62]). Uncertainty is reduced obtaining additional data and seeking answers to explicit questions. The other force is *equivocality*, which is the existence of multiple and conflicting interpretations about a situation [11]. As uncertainty is more related to the amount of information available, equivocality is more related on the quality of information available: Equivocality means ambiguity and reflects confusion and lack of common understanding, whereas uncertainty means the absence of sufficient data necessary and reflects the inability to process information properly.

Equivocality is reduced by seeking for clarification, reaching agreement, and deciding what questions to ask. The postulation of the existence of these two complementary forces has also implications on the selection of the most effective medium to use. Media Richness theory posits that rich media are better suited in equivocal communication situations (where there are multiple, even conflicting,

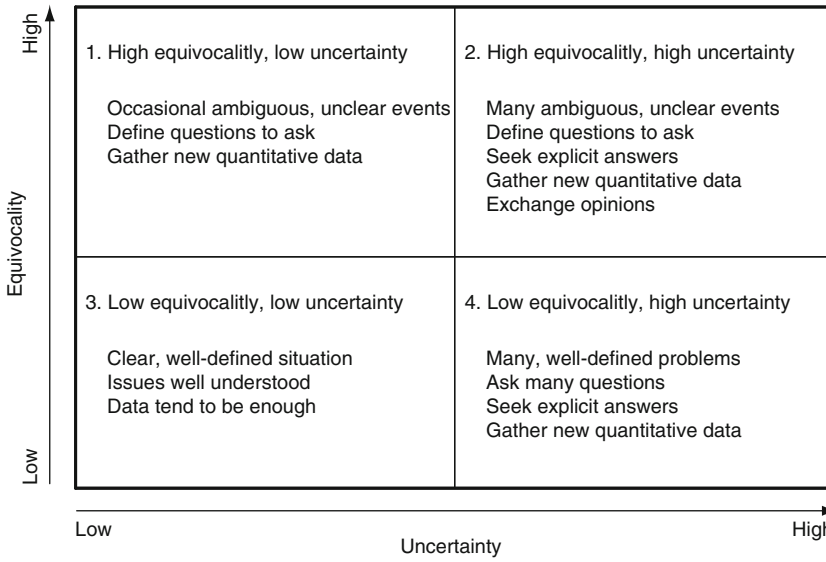

FIG. 7. The uncertainty and equivocality forces that act on individuals during communication (adapted from Ref. [11]).

interpretations for available information), whereas lean media are best suited in uncertain communication situations (where there is a lack of information). Equivocality is often symptomatic of disagreements and, thus, providing sufficient clarifications can reduce it. Rich media interaction (e.g., F2F), is preferred in situations of equivocality, as it allows for rapid feedback and multiple cues, thus facilitating the convergence to a shared interpretation. On the other hand, when messages are not equivocal, lean media are preferred. Thus, uncertainty can be reduced by obtaining sufficient additional information using media like e-mail or written reports. Therefore, in short, Media Richness proposes that task performance will be improved when tasks needs are matched to the medium ability of conveying information.

Finally, we notice that Daft and Lengel have treated equivocality and uncertainty as independent constructs. However, it must be pointed out that a new amount of data can also generate ambiguity, and that equivocal scenarios may need more data to converge as well.

4.3 Common Ground Theory

The Common Ground theory by Clark and Brennan is a fundamental theory in the CMC field [12]. It subsumes all the existing theories of communication in that it describes the basic process of grounding, a process orthogonal to all forms of communication, which encloses the essential goal of communicating: Reaching a common understanding. Indeed, *grounding* is the interactive process by which communicators exchange evidence in order to reach a mutual understanding, updating moment by moment their *common ground*, that is, the amount of shared information already owned.

Communicating is more than simply sending off messages. Speakers must assure themselves that receivers have correctly understood the message. Communication is a collective activity that requires coordinated action of all participants, and grounding is crucial for keeping track of the coordination. Individuals contribute to a conversation repeating two steps, namely *presentation*, that is, the speaker presents an utterance to the receiver(s), and *acceptance*, that is, the receiver(s) accepts (accept) the utterance, giving evidence of correctly understanding what the speaker meant. It takes both phases for a contribution to be complete: Grounding and the communication itself are impaired if the speaker does not get any evidence of acceptance. Evidence can be either positive (the message has been understood, the speaker can go on) or negative (the message is misunderstood and the speaker must repair before proceeding). Such evidence can be provided by different grounding techniques that change with medium. Grounding techniques include, to name but a few, *acknowledgments* (e.g., nodding, saying ‘‘yes,’’ or typing ‘‘ok’’), *spelling*

(e.g., spelling one's family name), and *verbatim displays* (e.g., repeating word by word a telephone number). But also speakers can explicitly seek for evidence asking questions (e.g., saying ''right?'' at the end of an utterance). Questions asked from receivers are usually a form of negative feedback as they represent a request for clarification. However, the positivity or negativity of acknowledgments is not context-free.

Grounding techniques are deeply affected by media characteristics. Since text-based communication does not convey neither visual nor verbal cues (e.g., nodding, face expression, gaze direction are unavailable), it constraints the possible form of evidence that people can seek to acknowledgments (one would never use verbatim displays or spelling in text-based chat). Clark and Brennan go beyond the level of media richness and social presence and present eight properties that act as constraints on the grounding process (see Table II).

Participants in a F2F conversation usually establish common ground on the fly, as they have access to cues like facial expression, gestures, and voice intonation. Instead, when participants communicate over media, the fewer cues they have, the harder to construct it. As a consequence, according to Clark and Brennan's theory, ''people who have little common ground benefit significantly from having a video channel'' and, conversely, ''only people who have previously established a lot of common ground can communicate well over impoverished media'' (e.g., e-mail or IM) [2].

From the previous figure we notice that text-based communication lacks key attributes like *copresence* (owned only by F2F communication), *visibility*, and *audibility* that Common Ground Theory claims to be necessary for communicators unknown to each other for developing mutual understanding. *Simultaneity* refers to the ability of the medium to allow for full-duplex communication, that is, individuals can send and receive at once and simultaneously. Simultaneity is strongly related to *synchronicity*, which distinguishes between same time and different time media. However, no medium has all the attributes at the same time. Text-based communication offers two characteristics that even F2F and audio/video communication lack, namely reviewability and revisability. *Reviewability*, also called reprocessability, is the extent to which a message can be reexamined or processed again within the context of the communication event. Text-based media enable the receiver to repeatedly process the message to ensure accurate understanding. *Revisability*, also called rehearseability or editability, is the extent to which media enables the sender to rehearse or fine tune the message before sending. Text-based media enable the sender to carefully edit a message while it is being sent to ensure that the intended meaning is expressed exactly. Erickson and Kellogg [63] have drawn attention to these two powerful characteristics of text-based communication, which make it persistent, traceable, thus enabling the use of search and visualization technologies.

TABLE II
MEDIA CONSTRAINTS AFFECTING GROUNDING (ADAPTED FROM REF. [2])

Medium	Copresence	Visibility	Audibility	Synchronicity	Simultaneity	Sequentiality	Reviewability	Revisability
F2F	●	●	●	●	●	●		
Videoconference		●	●	●	●	●		
Telephone			●	●	●	●		
Chat/IM				●	●	●	●	●
E-mail							●	●
Letter							●	●

When a medium lacks one of these characteristics, it forces people to use alternative grounding techniques. This happens because the costs (i.e., the effort for the speaker, the receiver, or both) of using the different techniques of grounding change. Clark and Brennan count 11 different types of costs. For instance, *delay costs*, that is, the cost of waiting for messages to be completed, are paid by both speakers and receivers. Such costs have to be low in synchronous media, as long pauses would disrupt communication. *Production costs* of messages are paid only by speakers and are much lower in media carrying voice than in those text-based. In contrast, *reception costs* are only paid by receivers. Listening is generally easier than reading. However, reading may be less costly when messages content is particularly complex, to the point that they must be reviewed several times to allow for correct deliberation. Thus, grounding process is also affected by the purpose of communication (i.e., the task). This aspect, however, has not been examined in deep by Common Ground Theory. When individuals communicate, they try to reach understanding minimizing the effort for themselves and the others, paying as few of these costs as possible. This rule is known as the *least collaborative effort* principle.

4.4 Media Synchronicity Theory

Both Social Presence and Media Richness theories presume that the outcome of an interaction is determined by the communication capacity of the selected medium. Media Richness Theory relates performance primarily to type of information required by tasks (clarification vs. additional information), whereas Social Presence theory relates it primarily to the type of interaction (relational vs. activity focused). A number of empirical studies of media use have provided evidence that runs counter to the predictions [15, 22], thus pushing researchers to theorize that media selection is also affected by factors beyond richness.

Social Presence and Media Richness Theories have been refined by Media Synchronicity theory by Dennis and Valacich [13–15]. Social Presence and Media Richness theories are task-centric: A task is the key element to medium selection, but it is considered as a high-level construct—that is, relational or activity focused, equivocal or uncertain. As suggested by McGrath [17], tasks are composed of many subelements, processes, and activities which may need different media. For example, in Daft and Lengel's terms, resolving a task of equivocality would mean developing a shared framework for analyzing the situation, populating the framework with information of a shared meaning, and assessing the results to arrive at a shared conclusion for action. However, each of these steps may have different media needs, such that even tasks of uncertainty may include steps that require rich media [64]. Media Synchronicity theory posits that group communication, regardless of the task (whether equivocal or uncertain, relational or activity focused), is composed

of two fundamental communication processes, conveyance and convergence. *Conveyance* is the exchange of information, followed by deliberation on its meaning. It can be divergent, in that not all participants need to focus on the same information at the same time, nor must they agree on its meaning. *Convergence* is the development of shared meaning for information, in that participants must understand each other's views and agree. The constructs of conveyance and convergence are not different from the concepts of uncertainty and equivocality developed by Media Richness theory. However, Daft and Lengel have treated equivocality and uncertainty as independent constructs. Therefore, for resolving equivocality, Media Richness theory emphasizes the need to converge, whereas conveyance is left to tasks of uncertainty. Instead, Media Synchronicity theory argues that conveying information and converging on a shared meaning are equally critical for tasks of equivocality and uncertainty: New amounts of data can also generate ambiguity, and equivocal scenarios may need more data to converge as well. Thus, without adequate conveyance of information, individuals will reach incorrect conclusions, and without adequate convergence, the group cannot move forward.

Social Presence and Media Richness theories assume the existence of the richest medium in absolute, which is F2F communication. According to Dennis and Valacich, ranking media in absolute terms is not practical, though. They argue that media should not be ranked in order of their richness without consideration of context, and that attempting to recommend a single medium based on a high-level task is doomed to failure. Media possess many capabilities, each of which may be more or less important in a given situation. Media Synchronicity theory postulates that media have a set of capabilities, and that performance will be enhanced when such capabilities are aligned with the processes of conveyance and convergence. Thus, in Dennis and Valacich's terms, ''the richest medium is that which best provides the set of capabilities needed by the situation,'' that is, the individuals, the task, and the social context. Table III examines the capabilities of several media.

Symbol variety is the number of ways in which information can be communicated—the ''height'' of the medium—and subsumes Daft and Lengel's multiplicity of cues and language variety. The importance of symbol variety depends upon the piece of information that needs to be communicated. In general, conveyance should require a greater symbol variety depending upon the task. In contrast, convergence requires understanding others' interpretations, which can usually be communicated using a simpler symbol set. *Parallelism* refers to the number of simultaneous conversations that can exist effectively—the ''width'' of the medium. In traditional media such as the telephone, only one conversation can effectively use the medium at one time. In contrast, many electronic media can be structured to enable many simultaneous conversations to occur. The importance of parallelism depends upon

TABLE III
CAPABILITIES OF MEDIA (ADAPTED FROM REF. [15])

Medium	Symbol variety	Parallelism	Immediacy of feedback	Rehearseability	Reprocessability
F2F	Low-high	Low	High	Low	Low
Videoconference	Low-high	Low	Medium-high	Low	Low
Telephone	Low	Low	Medium	Low	Low
Letter	Low-medium	High	Low	High	High
E-mail	Low-high	Medium	Low-medium	High	High
Chat	Low-high	High	Low-medium	Medium-high	High

Media are listed as having a range of capabilities because they are configurable (e.g., e-mail may or may not enable the use of tables or graphics).

the number of participants. It is unimportant for small groups. For large groups, however, parallelism is very important to conveyance in enabling all members to participate. Usually, the greater the parallelism, the easier it is to generate divergent information (i.e., conveyance). Conversely, convergence will generally benefit from low parallelism because the focus of the process is on understanding others' viewpoint. As the number of conversations increases, it becomes increasingly difficult for the group to focus on one topic or issue, which may in some circumstances impede the development of mutual understanding (i.e., convergence). *Immediacy of feedback* is the extent to which a medium enables users to give rapid feedback on the communications they receive (i.e., the ability of a medium to support rapid bidirectional communication). It is important in improving understanding because it enables mid-course corrections in message transmission, so that any misleading elements in the message as sent can be quickly corrected. More immediate feedback can have significant benefits in improving the speed and accuracy of communication. Immediacy of feedback and parallelism dimensions define ''the level of synchronicity'' of media. *Rehearseability* and *reprocessability* match respectively with the attributes of revisability and reviewability defined by Clark and Brennan for the Common Ground Theory. Rehearseability is probably unimportant for simple messages, but becomes more important as the complexity or equivocality of the message increases because increased rehearseability will lead to improved understanding. However, media with high rehearseability tend to have lower feedback. *Reprocessability* enables the receiver to repeatedly process the message to ensure accurate understanding, thus fostering conveyance. Reprocessability becomes more important as the volume, complexity, or equivocality of the message increases. Increased reprocessability will lead to improved understanding, regardless of the information or communication process (conveyance or

convergence), although it is often more important to conveyance. Conveyance often produces information requiring deliberation, for which reprocessability is important.

In media selection, one must take into account that most tasks require individuals to both convey information and converge on shared meanings, and media that excel at information conveyance are often not those that excel at convergence. Thus, choosing one single medium for any task may prove less effective than choosing a medium, or set of media, which the group uses at different times in performing the task, depending on the current communication process (convey or converge).

According to Media Synchronicity theory, although the selection of the most appropriate medium (or set of media) depends upon all these five dimensions, the key to effective media usage is matching the synchronicity level to the level of conveyance and convergence required to perform a task. Indeed, Dennis and Valacich posit that media that support high immediacy of feedback and low parallelism encourage the high synchronicity, which is the key to the convergence process. Conversely, media that support low immediacy of feedback and high parallelism provide the low synchronicity, which is the key to the conveyance process. Although the formulation and the constructs names change, the task-media matching suggested by Media Synchronicity theory is the same one suggested by Media Richness Theory. Indeed, high-synchronicity media, with immediate feedback and low parallelism, are exactly F2F, and audio/video conference, that is, the richest media high in social presence that best fit equivocal tasks. High parallelism, instead, is not feasible when audio and video channels are available. Thus, low-synchronicity media with high parallelism are exactly e-mail, chat, and IM, that is, the lean media low in social presence, which best fit uncertain tasks.

Beside synchronicity, there are other factors that influence the effectiveness of media in supporting different groups, even those performing similar tasks. Group history—that is, the extent to which groups have worked together in the past—is a situational factor that can influence effectiveness because it can alter the perception of media richness of time. Established groups are more likely to have established norms (e.g., roles within the group), and well-established processing norms for the task performing. The group will be more likely to move directly to execution with less storming and norming. During performing, group members are able to work separately on their assigned tasks. Thus, performing requires more conveyance than convergence, although some convergence is clearly required. The need for media synchronicity is therefore lower during performing than during forming, storming, and norming. As a group matures they ‘‘are likely to become able to carry out all their functions, at least for routine projects, with much less-rich information exchanges’’ [15]. This means that (1) the communication requirements of groups will likely differ over time, depending upon shared experiences; (2) the perceptions about medium usefulness for a task and the group’s ability to perform a task in a

given medium change over time. As group members come to know each other better over time, they share common experiences that may be evoked by very simple messages that refer to those shared experiences. Therefore, over time established groups will require less convergence communication processes, or, equivalently, less use of high-synchronicity (high feedback, low parallelism) communication environment. Conversely, newly formed groups (e.g., *ad hoc* groups) will have fewer well-established norms and will likely spend more time in forming, storming, and norming, before moving to performing. This will result in more complex processes requiring more conveyance, and, especially, convergence. Before group members can effectively work together, they often need to have a better understanding of each other, and socially related communication activities that are best developed through media with social presence. Thus, newly formed groups, groups with new members, and groups without accepted norms will require more use of media with high synchronicity (high feedback and low parallelism), and symbols sets with greater social presence.

4.5 Cognitive-Based View

Researchers have long studied the effects of social presence and media richness on media choice, and the effects of media use. However, it is not always the sense of presence that is vital to communication, but also having sufficient information in the appropriate format and the ability to properly process it [65]. Furthermore, the original premise of Daft and Lengel's Media Richness theory was to understand how media effect a change in receivers' understanding. Nevertheless, the influence of media choices on the cognitive processes that underlie communication has been overlooked. Robert and Dennis described a Cognitive-Based View of media choice and media use, based on dual process theories of cognition, which argue that in order for individuals to systematically process messages, they must be motivated to process the message and have the ability to process it [16]. Communication is not only an exchange of information, but also an exchange of attention. Different media have different usage costs to the receivers. Running counter to past research (i.e., the more complex the task, the richer the media to be used), they argued that the use of rich media high in social presence induces increased motivation, but decreases the ability to process information, whereas the use of lean media low in social presence induces decreased motivation but increases the ability to process information (see Fig. 8). Robert and Dennis called the inverse relationship between motivation and attention with the ability to process a *media richness paradox*.

This paradox has profound implications on CMC research, since both Social Presence and Media Richness theories posits that F2F communication, as typical examples of rich/high-social-presence media, is better suited for highly equivocal

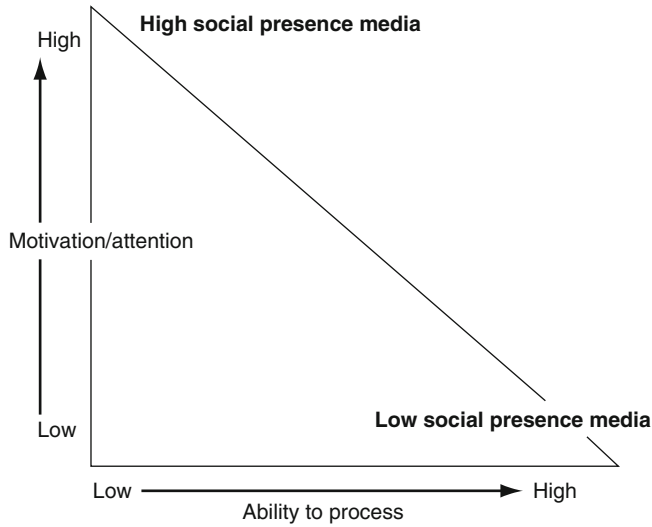

FIG. 8. Cognitive-Based View theory identified the inverse relationship between motivation and attention with the ability to process (adapted from Ref. [16]).

tasks. One of the criticisms often moved against these two theories is that they consider the ''perceived'' effectiveness of media from a sender's perspective. The cognitive-based model of Robert and Dennis reverses the perspective, analyzing from a receiver's point of view how media affect the change in understanding. In general, the greater the social presence of a medium, the greater the receiver's motivation has to be to participate in the communication process, but also the greater the sender's the ability to monitor attention. Thus, senders will require the use of rich media to ensure that receivers have high levels of attention and are motivated to process the message.

However, the level of social presence provided by media has an inverse relationship with the receiver's ability to process the message. One important media attribute is reviewability (or reprocessability), that is, the ability to allow the receiver to reprocess the information. In general, media with low social presence provide a higher level of reprocessability that allows the receiver to stop and think over important or difficult points. Also, the receiver can repeatedly access extra sources of information, and review the message until it is fully comprehended. In contrast, by social convention, media high in social presence do not allow individuals to elaborate at will, as they are supposed to respond quickly to avoid disrupting the conversation. Rich media high in social presence allow the receiver little ability to

access multiple sources of information or reprocess the information. This is a major drawback because individuals have a natural constraint on the amount of information they can accept, process, and recall. Thus, when complex messages are sent over media high in social presence, reducing the amount of time one has to process ends up increasing the information load: A receiver can quickly become overwhelmed with information in a state, commonly referred to as information overload, ''in which the amount of information that merits attention exceeds an individual's ability to process it'' [66].

Also the number of receivers may impact the relationship between attention, motivation, and ability to process. In large groups or audiences, some receivers may not actively engage in processing the messages and will assume others will do it for them. This is referred to as ''free riding.'' Free riding can go unnoticed because the sender is less able to monitor the behavior. While free riding can occur in either high or low social presence media, it is likely to be worse in low social presence media because monitoring the behavior of the receivers is more difficult than monitoring that of the senders. Past research has shown that members of electronic groups are more likely to ignore information [67].

As a conclusion, the use of rich media high in social presence should be used to assure attention for small amounts of information, whereas the use of lean media low in social presence causes a decreased motivation, but increases the ability to process large amounts of information during longer periods of time. Robert and Dennis argue that different media are needed for complex tasks where information overload may be generated. In such cases, the use of mixed media, or media switching, is motivated by the need to balance attention and motivation required by senders with the ability to process information of receivers. Depending on the task at hand, when senders want to get the attention of the receiver and motivate them for an immediate response, they should use a medium high in social presence. In contrast, when deep thought and deliberation are needed to process the information, the sender should use a medium low in social presence to give the receiver time to objectively elaborate on messages.

However, information overload is not the only risk when groups communicate F2F. The pressure on group members to conform on the view of the group majority has been acknowledged as the most severe dysfunctional aspect in F2F decision making [68]. The studies on group dynamics (e.g., see Ref. [51]) show that in group interactions there is a continuous interplay of task-oriented and relational process, as group members act certain roles while developing and maintaining some personal relationships. Thus, previous research on sociopsychological effects in CMC postulated that the reduction of socioemotional exchange contributes to increase group efficiency in the sense that less-rich communication media allow groups to pay less attention to interpersonal aspects of the interaction, and focus more on task.

Thus, groups interacting using lean media may benefit from using ''less social'' channels because the restriction imposed on the interpersonal information exchange allows for more-equal participation and greater attention paid to the messages, not to the individuals (i.e., less influenced by high-status member and less susceptible to the pressure of social consensus) [69]. For instance, the effectiveness in generative situations, like requirements elicitation, is less affected by ''social noise'' in communication. Instead, in problem-solving situations, like requirements negotiations, where social, emotional, and relationship concerns take time and effort away from task resolution, the use of ''depersonalized'' media may enhance group efficiency by leaving a greater portion of group-work time to task-oriented interaction [70].

To conclude this section, we show in Fig. 9 the research model updated to include the richness and synchronicity level variables, which characterize the media-related contextual factors.

5. Development of a Comprehensive Theoretical Framework

5.1 Managing the Context: The Effects of Task, Media, and Group Factors

The theories discussed in previous sections have framed a complex theoretical background for the selection of communication media for opportune remote group collaboration. Messages communicated to a group on channels that are inappropriate to the context may be misinterpreted by recipients or may be otherwise ineffective with regard to their intended purpose [71, 72]. In group research, context is defined by the group, task, and media factors. In Sections 2–4, we have analyzed each of

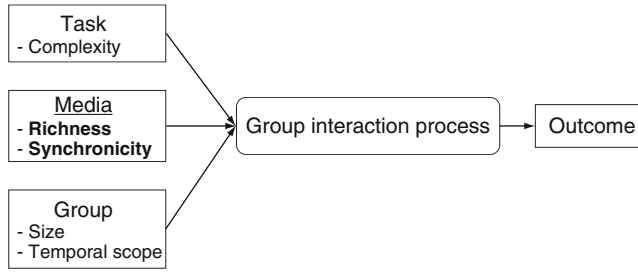

FIG. 9. The research model updated with the media-related variables, richness, and synchronicity.

these situational factors. In addition, the effects of these factors on group process and outcome also depend on their mutual interaction. Figure 10 shows the causal model updated to graphically represent the effects of these interactions. Given a specific group, its interaction process and outcome are heavily affected by the interaction occurring between task and media factors (A). For instance, task-medium mismatches may require communication participants to engage in compensating activities to clarify message content, leading to possible communication inefficiencies [64]. Likewise, given a specific task, group interaction process and outcome are heavily affected by the interaction occurring between group and media factors (B). For instance, group-medium mismatches may cause members of group unknown to each other to misinterpret message content due to the lack of shared experience, leading to possible performance inefficiencies [73].

How to measure group interaction process and its outcome largely depends on the type of task to be accomplished. For instance, if we again consider the definition of software requirements through elicitation and negotiation tasks (which we already compared, applying the Circumplex in Section 2.1), then group interaction can be evaluated through participants' perceptions, measuring the extent to which the process led to open participation of stakeholders, who were able to quickly resolve conflicts and overall, and how much satisfied they are with it. In addition, the outcome quality of both requirements elicitation and negotiation is reflected on a subjective level by the general consensus and satisfaction level attained by stakeholders at the end of the whole process, and, more objectively, by evaluating the quality of the requirements defined (e.g., by identifying defects through requirement documents inspections).

In the remainder of this section, we first discuss the theories for appropriately matching media characteristics with task and group. Then, we finally develop a comprehensive framework for the selection of communication media appropriate for the context, which consistently encompasses all the theories discussed so far.

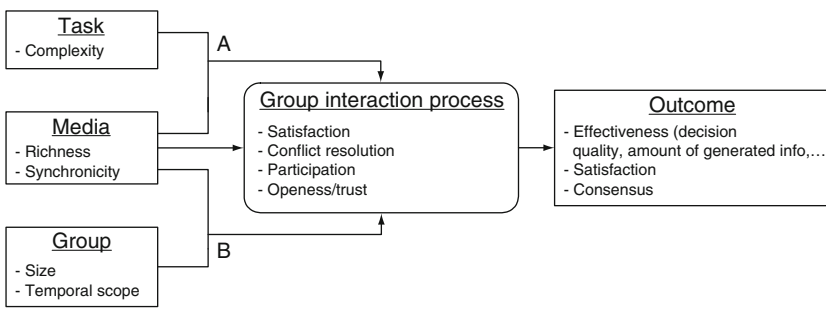

FIG. 10. The intertwined effects of media with task (A) and group (B) factors on group interaction and task outcome.

5.2 Matching Task and Media Characteristics

Although often conflicting, the CMC theories that we reviewed generally agree about the need to consider task characteristics for selecting the most appropriate media. As we already reported in Section 2.1, one of the most acknowledged limitation of McGrath's Task Circumplex is just its limited usefulness for determining technological support for executing groups task when group need to communicate over a medium. Thus, several frameworks have been developed to determine the best-fitting task-technology matches. In this section, we review the two most used frameworks proposed for task/technology fit.

5.3 Time-Interaction-Performance Theory

The Time-Interaction-Performance (TIP) theory, developed by McGrath and Hollingshead [17, 23, 74], has been among the first conceptual frameworks proposed to take into account the interaction of task and technology characteristics, in the evaluation of electronically mediated group interaction. TIP theory builds upon Task Circumplex and Media Richness theories, and hypothesizes that communication that occurs in the four tasks categories of the circumplex can be ordered by complexity and the amount of information required. In other words, the four task categories of the Task Circumplex, ordered by complexity, can be arranged in the same order along the media richness continuum hypothesized by Media Richness Theory (i.e., showing again that the more complex the tasks, the richer the information exchange required). Figure 11 illustrates the task-media fit attempted by the theory, with respect to the communication media.

The best-fitting combinations of information required by tasks and information conveyed by media lie near the main diagonal. Instead, the outer edges that are progressively distant from the diagonal represent less well-fitting to poor-fitting matches. For instance, generating tasks (e.g., brainstorming) may require only the transmission of ideas or plans, hence ''less-rich'' information. In contrast, tasks requiring groups to negotiate and resolve conflicts may require the transmission not only of facts, but also of affective messages or interpersonal communication, which are best conveyed by rich media. The figure shows that there are two types of poor-fit combinations: (1) when tasks require more information richness than selected media can deliver, groups are expected to suffer from problems of effectiveness and quality, forcing individual to exchange further compensative information; (2) when media provide more information richness than tasks require, groups are expected to suffer from problems of efficiency because media conveys not only facts, but also nonessential communication (e.g., interpersonal and affective messages), which brings distraction. In other words, the theory posits task-media fits are appropriate

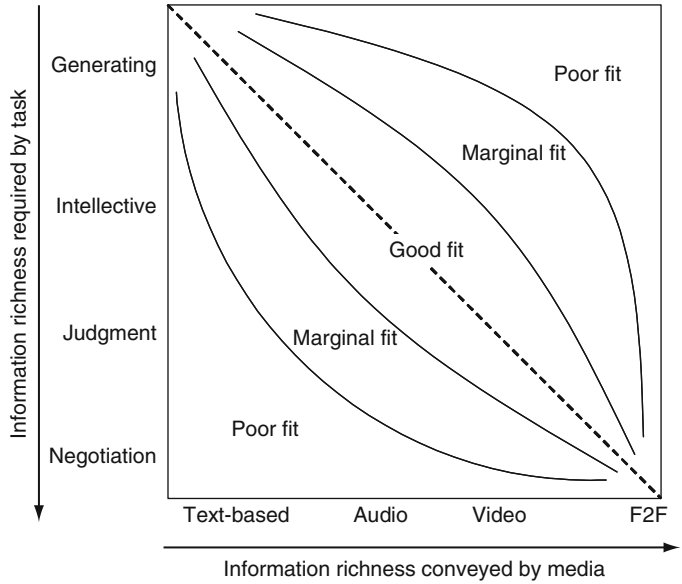

FIG. 11. The task-media fit suggested by the TIP theory (adapted from Ref. [74]).

only when the level of information richness of a medium is adequate to the complexity of the task. Thus, although TIP theory seems to only add to Media Richness theory an objective measure of task complexity, it actually argues that rich media do not always provide the best-fitting combination regardless of the task type.

5.4 Task/Technology Fit Theory

Consistently with what hypothesized by TIP theory, the theory of Task/Technology Fit (TTF), by Goodhue and Thompson [18] and Zigurs and Buckland [19], establishes a correspondence between task requirements and technology. TTF theory posits that, in a scenario of collaboration, the selection of an appropriate technology, which provides features and support ''fitting'' the task requirements, determines an increase of performance and, to some extent, of technology utilization itself (see Fig. 12).

Hence, TTF theory states that effectiveness of CMC varies on the type of task. For instance, tasks of idea generation that involve divergent thinking and limited member interdependence (e.g., in Task Circumplex, Type 1: planning, and Type 2: brainstorming) do not require information-rich media. On the other hand, more

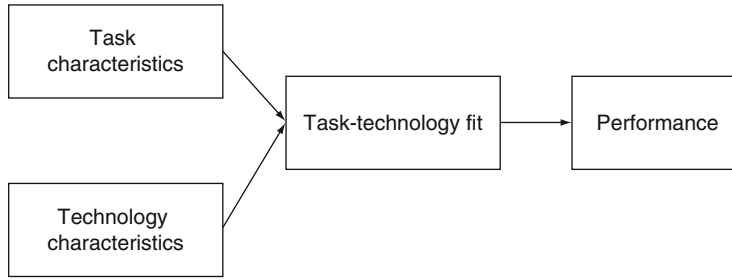

FIG. 12. Matching task and technology characteristics impacts performance and utilization (adapted from Ref. [19]).

intellective tasks (e.g., Type 3/4: problem solving, and Type 5/6: conflict resolution) involve a two-stage process: First, divergent thinking to identify all possible solutions, and secondly, convergent thinking to identify best suited solutions among those identified in the first step. Thus, convergent thinking involves a higher degree of member interdependence and requires information-rich media.

5.5 Matching Group and Media Characteristics

The TTF theory presented above completely neglects the effect of group in recommending the most appropriate matches. Conversely, the theory of Channel Expansion by Carlson and Zmud [20–22] posits that gaining experience with channel use and communication coparticipants[1] increases the perceived richness of that channel and the ability of individuals to communicate more effectively over it. As communication participants acquire these experiences (i.e., have a shared history of collaboration), they enhance their ability to encode/decode richer messages, for instance, referring to shared experiences or using shared jargon [22].

What this theory argues is that the scenario depicted by TTF theory in Fig. 12 describes a group collaboration at time T1, that is, when the group task is performed for the first time by a newly formed group, using a given fit (see Fig. 13). If this group happens to collaborate again for performing the same or a similar task, then the experience acquired on first iteration in collaborating with the same teammates over a medium (called appropriations and adaptations), will be reused in the next

[1] Actually, the theory identifies two other forms of relevant experience, namely experience with the messaging topic and the organizational context, for which Carlson and Zmud only found partial support. Besides, these forms of experience are not of interest here.

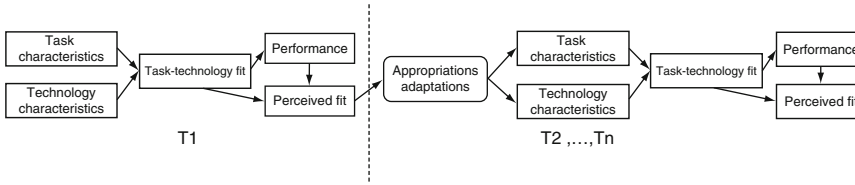

FIG. 13. Experiences influence recurring collaboration for a given task/technology fit.

iterations (T2,. . .,TN), thus positively influencing the perceived fit and group performance. This is a factor to take into account during empirical validation because group performance and task outcome is often evaluated through subjective data reports. However, it must be also pointed out that Carlson and Zmud found that, over time, the influence of experience (adaptations and appropriations) tends to diminish and eventually stabilizes.

Channel Expansion theory does not address the channel selection process, though. Instead, it is concerned only with the increasing perceived richness level of a given channel and the ability to communicate more effectively over it with time. Nevertheless, the theory can be used as predictive of the effects of temporal scope in matching group and media characteristics. Channel experience is gained through use and thus, it is related to the length of time a channel has been utilized. Likewise, experience with group members is developed through interaction and, thus, it is related to the group history, or the extent to which a group has worked together in the past. Hence, established groups with a shared history of previous collaboration, are expected to be able to communicate effectively also over impoverished media, like e-mail. Conversely, *ad hoc* groups are newly formed and thus do not have any shared experience that can help compensate for the leanness of the medium in use. Consequently, *ad hoc* groups are expected to benefit from the use of rich medium more than established groups. These results are consistent with the theory of Common Ground (see Section 4.3). Group with shared experiences have already established a certain amount of common ground and thus can communicate well even over leaner media.

5.6 Development of a Comprehensive Theoretical Framework

The theoretical frameworks reviewed on media effects, tasks, and group processes have depicted a complex research area. The complexity is reflected by the equivocality of the existing body of knowledge from previous studies conducted to

evaluate the (in)effectiveness of computer-mediated group interaction as compared to F2F. The consistent combination of all these group-, task-, and media-related theories resulted in a fully comprehensive framework, which encompasses all the forces, generated from situational factors, which act on the selection process of the most appropriate media for the context. Figure 14 illustrates a graphical representation of our general-purpose framework.

The figure above shows the inversely proportional, main characteristics of rich and lean media. Rich media (e.g., audio and video channels, F2F) are highly synchronous and low parallel, convey a high sense of social copresence of individuals, ensure a higher level of attention and motivation, facilitate mutual understanding (see the top box in the figure). Thus, rich media are more beneficial, especially for groups with no history, whose members are unknown to each other. One risk with rich media is the information overload, due to the multiple channels available at one and the low reprocessability of the information conveyed over them. Conversely, lean media (e.g., e-mail, text chat, IM) are lowly synchronous but highly parallel, convey a low sense of social copresence, motivation, and attention

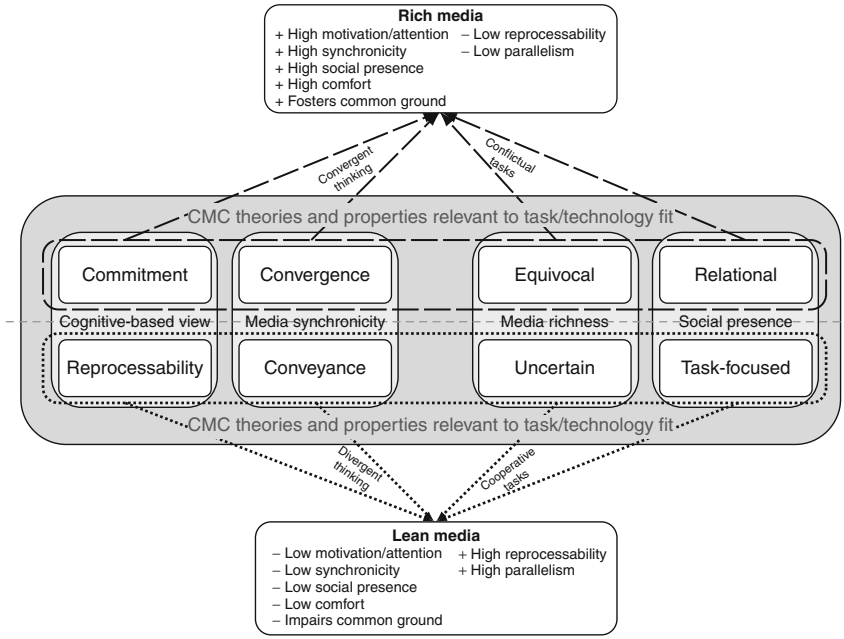

FIG. 14. The comprehensive framework for task/technology fit resulting from the consistent combination of group-, task-, and media-related theories.

(see the bottom box in the figure). Lean media are more effectively used by groups of individuals who share a history of previous collaborations. One advantage of lean media over rich media is the possibility to reprocess the information exchanged, which is otherwise volatile.

The CMC theories reviewed have been divided into task-centric and process-centric theories groups. Task-centric theories (i.e., Social Presence and Media Richness) consider communication as a task to be accomplished by individuals, whereas process-centric theories (i.e., Media Synchronicity and Cognitive-Based View) regard it as a process to be performed by individuals. All these theories, however, define communication through task or process dichotomies. The arrows represent the driving forces that act on the selection process, pushing for the selection of appropriate fits between tasks and synchronous media properties. These forces are not only useful for predicting and evaluating the goodness of TTFs, that is, poor (−), marginal (+/−), and good fits (+). In fact, here we also use the framework to ultimately compare the fits between synchronous text-based communication and distributed requirements workshops.

As an example of application of our framework, we use it to evaluate and suggest the best TTFs for running distributed requirements elicitation and negotiation workshops. According to Task Circumplex classification, negotiating software requirements is a complex, intellective task that involves different subactivities, both conceptual and behavioral, where conflicts have to be resolved to converge readily to one solution among the many identified, thus reaching consensus in a timely manner and enhancing the decision-making process quality. From the point of view of the task-centric theories, a requirements negotiation is a conflictual task characterized by high equivocality and member interdependence, which requires not only task-focused messages, but also social information to be exchanged. From the perspective of communication as a process, resolving ambiguities means that opposing individual views must converge into a single shared view. All these forces consistently drive to the selection of rich media for conducting effective requirements negotiation workshops and, consequently, also show that synchronous text-based communication and requirements negotiation represent a poor TTF. Hence, for instance, videoconferencing negotiation workshops represent a good fit (+), whereas synchronous text-based conferring negotiation workshop is evaluated as a poor fit (−).

According to Task Circumplex classification, elicitation is a creativity task, where new ideas or different solutions to a given problem have to be generated. Idea generation requires a low degree of member interdependence because it involves only divergent thinking. Thus, from the perspective of task-centric theories, elicitation is a cooperative, task-focused activity with limited degree member interdependence and consequently, a little need of communicating social information, which

may make participant more susceptible to pressure of social consensus and domination, and take time away from task-oriented interaction. The uncertainty existing in a generative task can only be reduced by conveying additional information. Hence, from the perspective of process-centric theories, the conveyance of information is better supported by lean media, high in parallelism (or low in synchronicity), which foster idea generation by allowing multiple individuals to contribute information at the same time. Thus, all these forces consistently drive to the selection of lean media for conducting effective requirements elicitation workshops. Nevertheless, in the evaluation of Task-Technology Fits, we must also take into account the existing counter forces. In fact, the use of lean mean has a detrimental effect on the level of satisfaction and motivation/attention perceived by participants, which, conversely increases as rich media are used. In addition, compared to established groups, members of *ad hoc* groups are expected to communicate less effectively over impoverished media, since they cannot use any shared experiences to compensate for the media leanness. As a conclusion, the framework evaluates that both lean and rich media (e.g., synchronous text-based and video conferencing) used for running distributed elicitation workshops represent marginal TTFs (+/−).

6. Conclusions

In this chapter, we have reviewed a large body of theories related to group and group tasks, as well as CMC theories. In particular, we reviewed McGrath's Task Circumplex framework, the most widely used model to categorize tasks, and objectively evaluate and compare their complexity in group research. This chapter also contributed to the study of a particular kind of short-term, dynamic groups, namely *ad hoc* groups, for which we have reviewed the existing literature and proposed a new definition (i.e., small- to medium-sized teams, highly dynamic in creation, participation, and release, with no past and future of collaborations, whose temporal scope corresponds exactly to the time needed to carry out the collaboration in attendance). Short-term collaborations represent an emerging scenario and, consequently, a relevant topic to group research.

Besides, we have reviewed the most prominent theories on CMC. We showed that the theoretical background on CMC is rather complex and equivocal. On the one hand, the theories of media richness posit that the more complex the task, the richer the medium to adopt. Namely, Social Presence, Media Richness, and Common Ground have overwhelmingly reported about the inadequateness of text-based communication, as compared to rich media, like F2F or video communication. Such disregard is due to the fact that lean media (e.g., e-mail and instant messaging)

lack the ability of conveying nonverbal cues that contributes to the level of social presence (e.g., gaze, tone of voice, facial expressions), which in turns fosters individuals' motivation and mutual understanding. On the other hand, however, sociopsychological and cognitive theories postulate that the depersonalization effect imposed by lean media can be beneficial for reducing both the information overload and the emotional side effects, like domination and social consensus pressure observed with rich media, thus increasing the meeting effectiveness in group communication. Media Synchronicity theory asserts that the effectiveness of CMC depends also on contextual factors other than media richness, such as communication channel synchronicity, task typology, and group temporal scope. Furthermore, Media Richness Paradox argued that the use of rich media high in social presence should be used to assure attention for small amounts of information, whereas the use of lean media low in social presence causes a decreased motivation, but increases the ability to process large amounts of information during longer periods of time. Drawing upon these theories, we have argued that, by understanding the paradoxical effects of rich media high in social presence, groups may be better able to select and use the most appropriate sets of media to accomplish their tasks.

As a result, we have built two general-purpose models, meant to support experiments in the field of distributed group research. The first model is intended to serve as a reference framework to define the context of the empirical study, thus helping to identify the task-, group-, and media-related variables involved. The second model, instead, consistently combines the most prominent theories on CMC and the Task Circumplex to graphically represent a theoretical framework on media effects, for describing, predicting, and comparing the goodness of Task-Technology Fits. These models can serve as references in setting up of experiments on distributed group research, as well as in the discussion of related findings.

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