

TEAMWORK IN DIFFERENT COMMUNICATION CONTEXTS: A LONGITUDINAL STUDY

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The increasing application of new technologies to work teams in organizational contexts makes necessary a careful study of both work group processes and results. In this context, previous research has provided evidence on how mediated communication and task type have a differential impact on group functioning and results (coordination of discussion, participation, influence of dominant members and normative control). However, in spite of advances in this area, there has been a lack of studies examining work group functioning when teams are permanent, probably because of the high cost of longitudinal studies. Temporal aspects do, however, play an important role in group processes and their results. From this perspective, the objective of this study is to analyze how group processes develop as they adapt to the different communication media and as a function of time and task type. Data were collected from a laboratory study in which 31 groups of 4 members participated. Groups were randomly assigned to different communication conditions (face-to-face with computer support, videoconference and e-mail), all groups performing different types of task (creativity, intellectual and conflict) and meeting on several occasions over eight work sessions.

En la actualidad, la creciente implantación de nuevas tecnologías de la información para el trabajo en grupo en los contextos laborales hace necesario profundizar en el estudio de los procesos y resultados del trabajo en grupo. En este sentido, la investigación realizada hasta el momento ha puesto de manifiesto el impacto diferencial de la comunicación mediada y del tipo de tarea utilizado tanto en aspectos del funcionamiento grupal como de resultados. A pesar de los avances en este ámbito, se observa una escasez de estudios que exploren el funcionamiento de los grupos de trabajo cuando éstos poseen un carácter permanente, probablemente por los elevados costes que supone llevar a cabo estudios longitudinales. En este sentido los aspectos temporales juegan un importante papel en las conductas mostradas por los miembros durante la interacción grupal y en sus resultados. Desde esta perspectiva, el objetivo del presente trabajo consiste en analizar cómo varía el funcionamiento de los grupos al adaptarse éstos a los distintos medios de comunicación a lo largo del tiempo y en función del tipo de tarea utilizado. Para ello, se ha realizado un experimento de laboratorio en el que han participado 31 grupos de cuatro miembros cada uno. Los grupos han sido asignados aleatoriamente a las diferentes condiciones de comunicación (cara a cara con apoyo electrónico, videoconferencia y correo electrónico). Todos los grupos realizaban distintos tipos de tareas (creatividad, intelectivas y de conflicto) y se reunían en varias ocasiones durante ocho sesiones de trabajo consecutivas.

As we enter the twenty-first century, there would appear to be a consensus among researchers in affirming that one of the most distinctive characteristics of the twentieth century was a high level of technological development and its progressive application to all areas of society. The emergence of automated systems has had an enormous influence on our society, which is even referred to using terms such as the *post-industrial*

society, cybersociety or technotronic society (Nelson, 1995).

Technological advances have been applied to diverse areas of social and working life in our society. Notable among current tendencies in work organizations is a substantial change in their structure and functioning. The need for flexibility in order to adapt to rapid changes in the socio-labour context means that organizations tend to adopt "networked" forms, in which there are neither internal limits nor hierarchical differentiation, but rather a predominance of cooperative relationships and flexible patterns of communication, with work teams becoming the basic structural units (DeSanctis and Poole, 1997; Alcóver and Gil, in press). At the same time, new, computer-based communication systems make possible these new forms of organization and

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influence teamwork by allowing the automatization of the distribution of information among group members and the structuring of group discussion, and by providing problem-solving techniques such as decision modelling or patterns for the planning of group activity (Johansen, 1988; Huber, 1990). It is, therefore, clearly interesting and necessary to study, from a psychosocial perspective, the effect of the implementation and use of these new information technologies on teamwork in the organizational context.

The study of groups within the framework of Social and Organizational Psychology has led to the development of various theoretical models that attempt to identify critical factors affecting the functioning and effectiveness of work groups (structural, ecological and motivational models) (Hackman and Morris 1975; Hackman 1987; Sundstrom, De Meuse and Futrell, 1990 and Guzzo, Yost, Campbell and Shea, 1993). All of these aim to analyze and explain group functioning on the basis of different types of variables (contextual, process and result). Moreover, they share the idea that group effectiveness is explained not solely by the final result obtained by the group, but also by the process followed in order to arrive at that result. McGrath (1984) defines group processes as "the behaviour pattern of its members". This refers to the patterns of communication that emerge between the group members, interpersonal actions, influences and contacts and the active use of available technologies. Interaction processes mediate the relationship between inputs (technology, task, members' characteristics) and results.

However, many of these models were developed for a traditional, face-to-face communication situation, so that it would be necessary to adapt them or to develop new models of functioning for groups working with new information technologies. From the 1970s, research teams in various countries developed with the aim of analyzing the influence of computer-mediated communication on group work from a psychosocial perspective (Peiró, Prieto and Zornoza, 1993; McGrath and Hollingshead, 1994).

The main findings obtained in this field indicate that group processes differ according to the technology used in the interaction. Numerous studies have found that groups that communicate electronically focus more on activities related to the task than groups that communicate face-to-face, invest more time in completing the task and have more problems to reach a consensus, and that group members participate to an equal extent

(Kiesler, Siegel and McGuire 1984; Siegel, Dubrovsky, Kiesler and McGuire 1986; Kiesler and Sproull, 1992; Hiltz et al. 1986). These have been considered as advantages of mediated communication, with groups being more efficient on investing less time in non-task-related interpersonal activities (Steiner, 1972). More negative socioemotional behaviour has been found in mediated communication, whilst it is more positive in rich media, such as face-to-face communication or videoconference (Smolensky, Carmody and Halcomb, 1990; Siegel et al. 1986; Dubrovsky, Kiesler and Sethna, 1991). On the other hand, some authors, far from finding a higher percentage of negative interpersonal behaviour in mediated communication (Spears and Lea, 1992; Strauss, 1997), have found that these groups even develop more prosocial behaviour than those that communicate face-to-face (Walther, 1995). As regards the level of conflict found, there are also two alternative positions. On the one hand are studies that find higher levels of conflict in mediated communication (Kiesler et al. 1984), due to the impossibility of transmitting non-verbal signals that regulate conflictive behaviour, on the other, there are those that state that groups whose interaction is mediated by new technologies experience lower levels of conflict than those that communicate face-to-face because they pay more attention to the task and less to interpersonal relationships (O'Connor, Gruenfeld and McGrath, 1993).

Thus, we can group the research carried out in this field according to two different theoretical approaches. The first approach is based on theories of "medium-richness" (Short, Williams and Christie, 1976; Daft and Lengel, 1986), and argues that it is the objective characteristics of the communication medium that determine group functioning. The less rich a medium, the more "cue filtering" there is, so that non-verbal or social cues cannot be transmitted during group interaction. This exclusivity attributed to technology has recently been questioned by several researchers, giving rise to a new theoretical perspective. This alternative approach is based on the theory of social information processing and on Social Identity theory, defining the group as an open and multifunctional system (Spears and Lea, 1992; Walther, 1994; 1996). These authors point out that technology can influence group functioning positively or negatively, since changes in interaction processes do not depend solely on the technology itself; rather, there are other relevant variables that affect this relationship, such as the structure of the group before using the technology, type of task or the time spent using the medium.

This approach therefore permits the adoption of a new concept of group based on a multifunctional system. The group has multiple functions that are of equal importance for its effectiveness, not only that of production, but also in relation to group well-being and the personal development of its members (McGrath, 1990).

Furthermore, the technology interacts with the type of task the group has to carry out (McGrath and Hollingshead, 1994; Strauss and McGrath, 1994), so that the influence of the technology on group processes and results will depend on the fit between the richness of the communication medium and the demands of the group's task. A task involving the generation of ideas does not demand the same level of coordination and interdependence between group members as an intellectual task or a mixed task in which group members show a conflict of interests, ideas or values (Argote and McGrath, 1993). Also, the fit between task and technology is not static, but dynamic, changing over time (McGrath and Berdahl, 1998). That is, as time passes, the group acquires experience in the use of the medium, so that the group adapts to its objective characteristics and develops new strategies for carrying out the task, which may mean that it accomplishes the task effectively with a less rich medium.

Thus, McGrath proposes that we consider the interaction of three elements: technology, task and time, and it is on the basis of these that he develops his model of group functioning (Time, Interaction and Performance, TIP, 1990, 1991), on which our study will be based. In this model, McGrath stresses the importance of time, starting out from the idea that groups working in organizations carry out activities that involve a certain temporal continuity, which makes it necessary to carry out longitudinal studies. Likewise, and in accordance with the conception of the group as a multifunctional social system, this author distinguishes three group functions: production, group well-being and personal development of group members. In order to develop these functions the group passes through a series of stages that are neither fixed nor sequential (McGrath and O'Connor, 1996). These stages are choice of goals, solution of problems, resolution of conflicts and execution. Thus, in each stage and for each function the process of group interaction may present different patterns.

Andriessen and Van der Velden (1993) propose another model of group interaction, adapted from McGrath's (1990), in which they distinguish two functions of group interaction: one oriented to the task and another oriented

to the socioemotional maintenance of the group. Furthermore, this model suggests that on performing the task the group will pass through two stages: that of preparation and that of execution.

From this longitudinal perspective, the empirical evidence obtained indicates that group interaction processes will differ according to the group's stage of development. In this line, Lebie, Jonathan and McGrath (1996) found that groups tend, over time, to decrease their communication in group processes related to the task (planning, composition and procedure), and that this is not the case in group processes of a socioemotional nature. That is, as the members adapt to the group and the task, they need to focus their energy less on the function of production and to be more oriented towards the group – to fulfil the functions of group well-being and support for members.

Andriessen and Van der Velden (1993) also argue that preparation activities will be more relevant during the initial stages of a group's life. After this initial stage groups tend to develop more or less fixed patterns of interaction, and invest less and less time in developing strategies or patterns of interpersonal relationships. These authors also found that the conventional interaction condition (face-to-face) facilitates, to a greater extent, the function of socioemotional maintenance of the group, in comparison to mediated interaction conditions. Moreover, the results obtained by Walther and Burgoon (1992) over time show that groups that interact by means of mediated communication focus less and less on the task and more on socioemotional relationships.

Thus, in general terms, the results of research in this field appear to indicate that groups using mediated communication need more time to adapt to the technology used and develop new strategies that permit them to be effective. This may initially condition the stability of their interaction processes and limit their performance (McGrath, 1993; Mennecke, Hoffer and Wynne, 1992). However, with the passage of time and continued use of the technology, group processes become established and differences that depend on the communication medium disappear.

PREVIOUS STUDIES BY THE UIPOT ON GROUP INTERACTION PROCESSES IN MEDIATED COMMUNICATION CONTEXTS

The Work and Organizational Psychology Research Unit (*Unidad de Investigación de Psicología del Trabajo and de las Organizaciones*, UIPOT) at the University of

Valencia has extensive experience in the study of the influence of new information technologies on group work. Since 1989 this research team has developed a sequence of three projects, which, despite having similar objectives, differ as regards the complexity of the approach and design of the study in each case, which increases as a result of the findings obtained both by our own team and by other researchers.

The first two research projects focused on the analysis of the psychosocial factors involved in the structure, functioning and effectiveness of cooperative work in groups that communicated by means of new technologies to resolve a task, and of the influence of the technology on group processes and results as a function of the type of task carried out by the group. Both projects used two interaction technologies as alternatives to conventional face-to-face interaction: videoconference and e-mail. Both studies were carried out in the laboratory with samples consisting mainly of university students (though the sample in the first study also included teachers from the Psychology Faculty and professionals and workers from different sectors), and both were transversal in design (Zornoza, 1992; Orengo, 1994; Acín, 1995). The principal difference between the two studies resided in the inclusion in the second one of different types of group tasks. Specifically, and based on the group task model proposed by McGrath (1984; Argote and McGrath, 1993), three types of task were considered: idea generation tasks, intellectual tasks and value conflict tasks. The general objective of this second project consisted in analyzing the influence of the communication channel on group processes and results according to the type of task carried out.

In general, it can be stated that the theoretical approach followed by the research team was that which was predominant at that time, and which proceeded from the tradition defended by the theories of Social Presence (Short et al., 1976) and Medium-Richness (Daft, Lengel and Trevino, 1987). These theories used the argument of the filtering of social and non-verbal cues to explain the influence of the technology on group processes and results. However, in our studies we consider an additional variable that may influence the relationship between the technology and group functioning: *perception of the communication medium* (Peiró, Prieto and Zornoza, 1994; Zornoza, Ripoll and González, 1995).

The results obtained in our studies confirm, in a general way, the predictions made on the basis of this theoretical orientation. Groups that perform intellectual tasks in rich

media such as face-to-face or videoconference coordinate themselves better, develop decision strategies based on consensus, make more effort to accomplish the task, manage conflicts that emerge between group members in a positive way and present more positive socioemotional behaviour than when they interact via e-mail (Orengo, 1994; Acín, 1995; Orengo, Gosálvez, Fernández and Prieto, 1995; Orengo, Zornoza, Acín, Prieto and Peiró, 1996; Peiró, Prieto, Zornoza and Ripoll, 1999). The interaction between communication medium and type of task shows that in idea generation tasks there were no significant differences in the group interaction processes. Also, nor was there more negative socioemotional behaviour in the e-mail condition in comparison to videoconference and face-to-face in conflict of values tasks (Marzo, Rodríguez, Ripoll and Marín, 1995).

The third research project carried out in this line of work had as its main objective to analyze the group's adaptation process over time to the three interaction contexts designed for resolving the task (face-to-face with computer support, videoconference and e-mail). The study was a longitudinal one in which each group had to meet in several work sessions to resolve different types of task.

While it is true that this third research project shows some degree of continuity with regard to the theoretical approach of the previous ones, recent reviews of the relevant literature lead us to the consideration of alternative theoretical orientations related to new ways of understanding mediated communication. Thus, the new theoretical orientation, as we pointed out in the previous section, is based principally on two aspects: on the one hand, on the theory of Social Information Processing; and on the other, on the conception of the group as a socio-cognitive, open and multifunctional system (Walther, 1994; 1996). Our research team has incorporated this change into its most recent work (Gosálvez, in preparation; Solanes, 1999; Orengo, Zornoza, Prieto and Peiró, 2000). The results obtained confirm the importance of other variables, in addition to the technology, in the analysis of group processes and results. These other variables would include assertiveness and the social context in the prediction of uninhibited behaviour (Orengo et al., 2000), the interaction between the perceived characteristics of the technology and the objective or technical ones with regard to predicting group interaction processes (Solanes, 1999), and the importance of considering the interaction between the technology and time in the analysis of group results (Ripoll, Subirats, Torres and Marzo, 1998; Gosálvez, 1999).

It is precisely in this context, and focusing on group interaction processes, in which the objective orienting the present work emerges. Thus, based on the above considerations and the findings described, the general aim of this study is to analyze how group interaction processes change over time as a function of the technology used in the group interaction and the type of task carried out. For this purpose we formulated the following hypotheses:

Hypothesis 1. The processes related to the group's production function (coordination, involvement with the goal, motivation for effort) and those related to group well-being (positive and negative socioemotional behaviour) will present significant differences according to the communication medium. Thus, and in accordance with the literature based on theories of medium-richness, it will be the channels of least richness of information that present the lowest levels in these processes (e-mail and videoconference), except for the case of negative socioemotional behaviour, which will be higher.

However, these results will be modulated as a function of the type of task carried out by the group, in accordance with McGrath and Hollingshead's (1994) model of task-medium fitness. Thus,

- For *idea generation tasks* that require low levels of information richness, e-mail (EM) is expected to be the medium that obtains the best results in the functions of production and group well-being, followed by videoconference (VC) and face-to-face communication (FF).
- For *intellective tasks*, which require a medium level of information richness, VC is expected to be the medium that obtains the best results in the functions of production and group well-being, or it is at least expected not to present significant differences with regard to face-to-face communication.
- Finally, for *negotiation tasks* it is the groups that communicate face-to-face that are expected to develop the most positive interaction processes, given that these are complex tasks that require high levels of information richness for their successful completion. In second place for these tasks come VC and EM.

Hypothesis 2. We expect groups that use different communication media to show patterns of development over time that differ for each group function, modulated by

the type of task carried out (Lebie et al. 1996; Arrow et al., 1996; McGrath and Berdhal, 1998). More specifically, we expect:

That over time groups will develop work procedures that compensate for the medium's lack of richness. Thus, the production function will improve with the passage of time in groups that communicate by e-mail, causing to disappear the differences between media in generation of ideas and intellective tasks. Meanwhile, differences may be maintained or may emerge in complex tasks that require high levels of interdependence, such as those of negotiation

That with regard to the group well-being function the differences between communication media will be maintained in the positive socioemotional behaviour perceived by the group, and will even increase in negotiation tasks. As the group develops there is more focus on the functions of well-being and member support, and less time is devoted to the production function (Lebie et al., 1996). However, we expect the opposite for negative socioemotional behaviour. In this case, with the passage of time, groups that communicate by e-mail will learn to express their disagreements or preferences by developing symbols or codes that allow them to transmit non-verbal aspects, making interaction more personal (Walther, 1996).

We shall continue with a description of the design, the sample and the variables used.

METHOD

Design, samples and procedure

In the third research project, which provides the framework for this study, we developed an experiment that involved the participation of 124 students distributed in 31 groups of 4 subjects each. Participants were Psychology students from the University of Valencia and the Jaume I University in Castellón. Groups were randomly assigned to each of the experimental conditions according to the communication channel (face-to-face with computer support, videoconference and e-mail). Also, each group worked for eight sessions according to a longitudinal experimental design. In each session they had to resolve a different task, which could be generation of ideas, intellective or negotiation. These were alternated to allow us to analyze the time effect. To this end, the sequence of the tasks was as follows: in the first two sessions and the final two, the groups performed a task of an intellective nature. In the third and fifth sessions they carried out idea generation

tasks, and in the sixth session they performed negotiation tasks. At the end of each session the group members filled out a battery of questionnaires individually, and the interactions were recorded on video and/or on computer.

Variables

We shall now describe how we operationalized each of the variables included in the study: technology used for the group work, type of task, time and group interaction processes.

Communication media

The groups were distributed randomly to the different experimental conditions that made up the design, using one of the three communication media: face-to-face with computer support, videoconference and communication mediated by computer (e-mail). In *face-to-face communication* the members making up the groups were present in the same room and could use as a computer as support, to communicate with one another or to make their own notes. The sessions were filmed on video so that the information and the development of the session could subsequently be analyzed.

Interaction by means of *videoconference* was carried out in the laboratories of the Psychology Faculty in Castellón, using facilities comprising four workstations (Silicon Graphics R4600sc), equipped with a minicamera, a microphone and two speakers, and which permitted the user to connect to and disconnect from the network as he or she wished.

For the interaction by means of *e-mail* the members of each group communicated with one another through computer terminals. The software used consisted in an e-mail program installed for use with a local network. During the experiment, each member of the group was in a different section, and could only communicate with his/her colleagues via computer. The members had been introduced to one another previously, so that they knew who was in each post. They could send messages to individuals, to part of the group or to all the members at the same time.

Type of task

All the groups performed three types of tasks over the eight sessions in which they participated, following the model of Argote and McGrath (1993): generation of ideas, intellectual (decision-making with correct response) and conflict of interests.

Each group had to resolve four *intellective tasks*. In all cases these were logic problems with a single correct solution, and for which each group member had different information and the information from all of them was necessary to arrive at the correct solution. In one task they had to select the most suitable candidate to occupy the post of human resources manager in a company; in another, they had to ascertain the full names of the people who were going to be employed by a company; a third task involved correctly associating each person proposed with his or her profession, and the final task consisted in choosing among different areas of the city the most suitable location for a restaurant specializing in Valencian cuisine.

Furthermore, in another two sessions each group had to carry out a *generation of ideas* task. Specifically, in the third session they had to perform the task called "Slogans", based on that proposed by Pfeiffer and Jones (1980), and in the fifth session the task called "Culture Week", in which, individually, participants had to create a minimum of ten ideas for events to form part of the Psychology Faculty's Culture Week. In the second phase, participants, with their group, had to decide on a minimum of ten events that would take place.

Finally, in this experiment, all the groups performed two *cooperation-competition* tasks. In the fourth session, they carried out the task called "Five in a row". In this task, the four members of each group were divided into two subgroups that competed with one another in order to obtain as many points as possible. Subgroups scored highest when the participants in the game cooperated with one another. In the sixth session the members of each group were also divided into two subgroups for carrying out the task. In this case the task they had to carry out was called "Naranjas Nani". Each one of the subgroups had an interest in buying a given quantity of oranges, and had to compete with the other subgroup to obtain as many kilogrammes of oranges as possible. Once again, subgroups made most gains when they cooperated with the other subgroup.

Time

In order to analyze the extent to which an increase in experience in the use of a specific information technology by a group produces changes in group work processes, we used a longitudinal design incorporating the variable time. Specifically, we considered eight data-collection points (one for each task that each group had to resolve).

Group interaction processes

The variables considered in the present work are grouped according to McGrath's (1990) model, which highlights the multifunctionality of groups, distinguishing three functions: production (coordination of the task and involvement with the goal), well-being (negative socioemotional behaviour and positive socioemotional orientation) and personal development (motivation for effort).

- *Production function. Coordination of group members for performing the task.* This is made up of three items that indicate the extent to which the group is oriented towards carrying out the task in a structured and effective way, and how far it is coordinated and plans its efforts as a group. Its reliability is 0.76. The response scale is made up of five anchors (1-not at all, to 5-a lot)
- *Involvement in the group solution.* This is a self-report measure whose scale is composed of three items assessing the degree to which the participant feels responsible for and committed to the solution arrived at by the group. The response scale has five anchors (1-not at all, to 5-a lot). Cronbach's alpha is 0.76.
- *Motivation for effort.* This is made up of two items: "the group expected you to make an effort and become involved in the task" and "the people in the group encouraged one another mutually to achieve the greatest possible effort". Internal consistency is 0.55.
- *Group well-being function.*

Negative socioemotional behaviour.

This measure is made up of five items ("I felt frustrated or tense because of the others' behaviour", "I rejected the opinions or suggestions of the others", "I expressed negative opinions about the behaviour of others", "My opinions were rejected", and "Others expressed negative opinions about my behaviour"). Its reliability is 0.71. The response scale is made up of five anchors (1-strongly disagree, to 5-strongly agree)

Positive socioemotional behaviour.

Four items make up this variable (e.g., "The group members showed themselves to be friendly during the work session", "... everyone's opinions were heard" and "... they were respected"), with a response scale made up of five anchors (1-strongly disagree, to 5-strongly agree). Reliability is 0.76.

RESULTS

In order to test the hypotheses proposed in the present work, we carried out several transversal and longitudinal statistical analyses, as described below.

The objective of our first hypothesis was to explore the influence of the technology used by the group on its interaction processes. In order to test it we carried out analyses of variance for each of the interaction processes considered, as a function of the communication medium used by the group, after the initial data collection. With regard to the second hypothesis, which referred to the consideration of time, understood as adaptation or experience, in the analysis of the differences in work group processes as a function of communication medium, we carried out an analysis of variance at a second point in time and a repeated-measures analysis of variance. In this way we explored possible changes in group interaction processes between the two data-collection points (first session and final session for each group) as a function of the interaction of time and communication medium. In both cases, transversal and longitudinal, the analyses are modulated by the type of task performed by the group.

The results corresponding to the different statistical tests carried out are shown in Tables 1 and 2.

First of all we shall discuss the transversal results related to the testing of Hypothesis 1. These results correspond to the data that appear in the column of Time 1 for each type of task, in Table 1.

As it can be seen in Table 1, the results obtained show statistically significant differences in some group interaction processes as a function of communication medium used. Thus, in *idea generation tasks*, members of groups that communicate face-to-face with computer support or by videoconference show higher levels of coordination among their members ($F=5.14$; $p=0.007$), more motivation for effort ($F=3.89$; $p=0.02$) and more positive socioemotional behaviour ($F=7.75$; $p=0.001$) than those of groups that communicate by e-mail. Finally, and although the required levels of significance are not reached, it is observed that participants who communicate by e-mail tend to show higher levels of negative socioemotional behaviour than those using the other two media, followed by face-to-face communication with computer support and, further behind, videoconference ($F=2.91$; $p=0.06$). These results are in the direction expected in the first hypothesis, which supports theories based on "medium-richness". However, they are not as expected according to McGrath and

Hollingshead's (1994) task-medium fitness model. From this model we would expect that for creative tasks, which require low levels of coordination between group members, a less rich medium such as e-mail would favour group work.

As far as *intellective tasks* are concerned, the results obtained support our first hypothesis, since they indicate that the technology influences work group processes in a differential and significant way, videoconference being

the medium that obtains the highest levels in coordination (F=7.15; p=0.001), involvement with the goal (F=6.77; p=0.002) and positive socioemotional behaviour (F=4.65; p=0.01), followed by face-to-face communication and, finally, e-mail. Nevertheless, it is the groups that communicate using this medium, e-mail, that perceive the highest level of negative socioemotional behaviour (F=5.60; p=0.005). These results support McGrath and Hollingshead's (1994) task-medium fitness model.

Table 1
Analyses of variance of group interaction processes in different types of task (generation of ideas, intellective and negotiation) as a function of the communication channel use in Time 1 and Time 2.

		GENERATION OF IDEAS				INTELLECTIVE				NEGOTIATION			
		TIME 1		TIME 2		TIME 1		TIME 2		TIME 1		TIME 2	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Task coordination	Face-to-face	4.22	0.59	4.24	0.48	4.30	0.51	3.94	0.85	3.64	0.78	4.03	0.69
	Videoconference	4.33	0.52	4.21	0.44	4.42	0.42	4.12	0.51	3.94	0.63	4.11	0.49
	E-mail	3.92	0.67	3.98	0.91	4.01	0.61	3.68	0.91	3.75	0.98	3.74	0.92
Goal involvement	Face-to-face	4.33	0.52	4.35	0.51	4.51	0.32	4.25	0.63	4.10	0.60	4.45	0.46
	Videoconference	4.46	0.37	4.42	0.39	4.52	0.30	4.47	0.46	4.17	0.60	4.43	0.51
	E-mail	4.35	0.56	4.17	0.77	4.23	0.54	4.17	0.65	3.97	0.70	4.23	0.66
Level of effort	Face-to-face	4.08	0.56	3.88	0.53	3.90	0.66	3.91	0.84	3.58	0.86	3.99	0.53
	Videoconference	4.06	0.49	3.85	0.55	4.08	0.71	3.86	0.65	3.78	0.61	3.97	0.61
	E-mail	3.76	0.67	3.91	0.84	4.00	0.56	3.81	0.66	3.77	0.78	3.75	0.64
Neg. socioemotional behvr.	Face-to-face	1.74	0.59	1.75	0.67	1.66	0.58	1.64	0.74	1.94	0.86	1.78	0.68
	Videoconference	1.72	0.64	1.60	0.59	1.68	0.52	1.50	0.61	1.70	0.81	1.54	0.53
	E-mail	1.94	0.73	1.90	0.67	2.07	0.66	1.82	0.63	2.04	0.78	2.16	0.82
Pos. socioemotional behvr.	Face-to-face	4.76	0.32	4.56	0.46	4.58	0.55	4.38	0.66	4.33	0.55	4.33	0.57
	Videoconference	4.71	0.33	4.58	0.39	4.70	0.38	4.53	0.41	4.60	0.52	4.55	0.48
	E-mail	4.44	0.44	4.49	0.43	4.67	0.39	4.47	0.42	4.59	0.46	4.70	0.41

Table 2
Longitudinal analyses of group interaction processes in different types of task (generation of ideas, intellective and negotiation)

	GENERATION OF IDEAS						INTELLECTIVE						NEGOTIATION					
	Time		Channel		T * C		Time		Channel		T * C		Time		Channel		T * C	
	F	p	F	p	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Task coordination	0.07	0.79	4.48	0.001	0.86	0.43	25.9	0.001	6.50	0.002	0.06	0.94	5.27	0.02	2.33	0.10	1.84	0.16
Goal involvement	1.99	0.16	1.6	0.21	1.52	0.22	5.31	0.02	5.57	0.005	1.63	0.20	26.55	0.001	1.72	0.18	0.25	0.78
Level of effort	2.64	0.11	0.81	0.45	4.81	0.01	3.39	0.07	0.18	0.84	1.00	0.37	6.91	0.01	0.54	0.58	3.02	0.05
Neg. socioemotional behvr.	10.71	0.001	7.07	0.01	0.24	0.79	10.91	0.001	5.41	0.006	0.10	0.91	0.26	0.61	13.59	0.001	0.07	0.94
Pos. socioemotional behvr.	0.40	0.50	2.91	0.06	0.34	0.71	5.90	0.02	5.60	0.005	1.18	0.36	0.52	0.47	7.28	0.001	1.44	0.24

T * C = Interaction Time X Channel

Finally, and in the case of *negotiation tasks*, statistically significant differences are only found in positive socioemotional behaviour as a function of the technology used by the group. Thus, participants in the videoconference condition perceive the highest levels of positive socioemotional behaviour, followed by face-to-face communication with computer support and, further behind, e-mail ($F= 8.58$; $p=0.001$). These results indicate that for tasks requiring high levels of coordination between group members and the interchange of different ideas and interests, the communication medium used by the group does not have a significant influence on the way the group interacts. These findings do not support our first hypothesis.

We shall continue by discussing the results obtained in the analyses carried out to test Hypothesis 2. According to this hypothesis, we expected the communication media to show different patterns of development over time for each group function modulated by type of task. The results we shall discuss appear in Table 1, in the column Time 2, and in Table 2. These data reflect the changes experienced by the group with the passage of time (comparing the scores of Time 1 with those of Time 2) and in interaction with the communication medium used.

With regard to the *production function* we expected that with the passage of time the groups would develop procedures that allowed them to compensate for the lack of richness of the medium, being effective in performing the task in a medium with less richness than necessary. That is, we expected the differences due to the technology to disappear for creative tasks and intellectual tasks, and for them to persist or appear in tasks with a high level of interdependence, such as those of negotiation.

As can be seen in Table 1, for *idea generation tasks* the results indicate that the differences obtained as a function of the communication medium disappear on comparing the first time point with the second.

The longitudinal analyses, shown in Table 2, indicate that if we consider the scores of Time 1 and Time 2 jointly, there are significant differences according to the communication channel in coordination ($F=4.48$; $P=0.001$). The interaction between time and the communication medium is only statistically significant for motivation for effort ($F=4.81$; $p=0.01$). This result indicates that group members' perceptions with regard to motivation for effort evolve over time in a different way depending on the communication channel used. Thus,

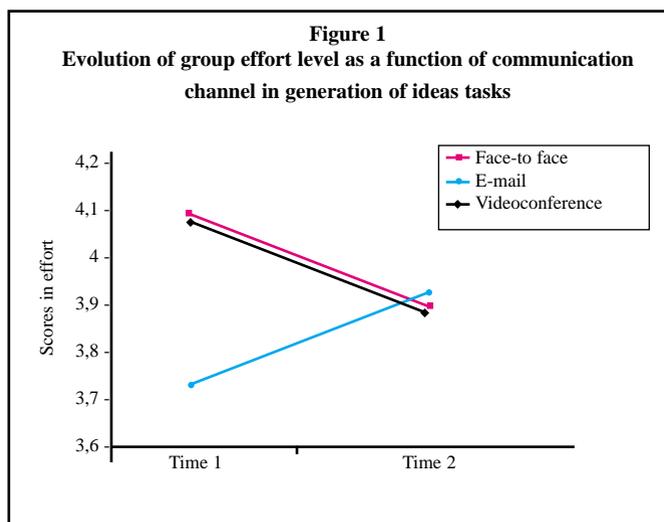
the groups that communicate by e-mail are those that feel more motivated to make an effort as time passes. However, the groups that use videoconference or communicate face-to-face with computer support perceive a lower level of motivation for effort as their experience increases (see Figure 1).

Thus, only motivation for effort increases with experience in the use of e-mail. Neither coordination level nor involvement with the goal increase, though the latter does not present significant differences as a function of the communication medium at either of the two time points considered.

As far as *intellective tasks* are concerned, the differences in the production function between the communication media are maintained with the passage of time, that is, if we compare Time 1 and Time 2 (Table 1), so that the expectations of the second hypothesis are not fulfilled. Thus, it continues to be the rich media, videoconference and face-to-face, that obtain the highest scores, at the second time point, in coordination ($F=3.40$; $p=0.04$) and in group members' level of involvement with the goal set ($F=3.07$; $p=0.05$).

If we consider the scores of Time 1 and Time 2 jointly (longitudinal analyses, Table 2), there appear significant differences in the production function as a function of both time and channel. In general, with the passage of time scores in all the group interaction processes decrease, perhaps because the groups become accustomed to performing these types of task. Even so, in none of the processes studied did we find a significant interaction between time and the communication medium used in this type of task, so that our second hypothesis was not confirmed.

As regards the *negotiation tasks*, the results obtained



support Hypothesis 2, since in this case, at the first time point there are no significant differences in the production function according to the technology used (Hypothesis 1). However, at the second time point such differences do appear, with groups coordinating better in videoconference and face-to-face than in e-mail ($F=3.08$; $p=0.05$).

The longitudinal analyses show a significant effect of time on the coordination of group members ($F=5.27$; $p=0.02$), on involvement with the goal ($F=26.55$; $p=0.001$) and on motivation for effort ($F=6.91$; $p=0.01$). Likewise, we found a statistically significant time-technology interaction effect for motivation for effort, as occurred in the intellectual tasks. This variable presents different trajectories over time in the groups that use different communication media. Thus, those participants who communicate face-to-face with computer support or by means of videoconference perceive themselves as more motivated to make an effort as their experience increases, whilst those that use e-mail practically maintain their perception with the passage of time and with increased experience (see Figure 2). It can be said, therefore, that the communication media present different trajectories of development and the differences with respect to e-mail increase, a finding that supports Hypothesis 2.

With regard to the *group well-being* function, we expected the differences between communication media to persist in the positive socioemotional behaviour perceived by the group, and that they would even increase in negotiation tasks; for negative socioemotional behaviour we expected the opposite.

In idea generation tasks at the second time point, the differences in positive socioemotional behaviour perceived by the group continue to be statistically significant

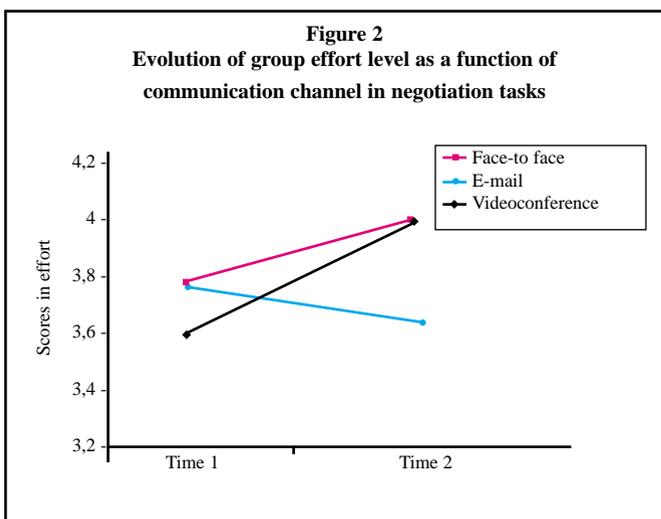
($F=3.66$; $p=0.03$). In this case, they follow the direction expected by the “social cues filtering” theories, so that the groups communicating by e-mail continue to present the lowest level, in contrast to the results expected by Walther (1996). The longitudinal analyses, shown in Table 2, indicate that if we consider the scores of Time 1 and Time 2 jointly, there are significant differences according to communication channel in the well-being function: positive socioemotional behaviour ($F=7.07$; $p=0.001$) and near-significance in negative socioemotional behaviour ($F=2.91$; $p=0.06$). There are only differences as a function of time in positive socioemotional behaviour ($F=10.71$; $p=0.001$). The interaction between time and communication medium is not statistically significant. Thus, Hypothesis 2 is confirmed as far as this type of task is concerned, with regard to perceived positive socioemotional behaviour.

As far as *intellectual tasks* are concerned, the differences are maintained in positive socioemotional behaviour as a function of the communication medium over time ($F=2.98$; $p=0.05$), that is, if we compare Time 1 and Time 2 (Table 1), so that the expectations of the second hypothesis are fulfilled. It continues to be the rich media, videoconference and face-to-face, that obtain the highest scores. Moreover, the significant differences in negative socioemotional behaviour disappear, since they do not attain the conventional significance level ($F=2.45$; $p=0.09$). Thus, when the groups become accustomed to performing this type of task via e-mail they change their perception of the socioemotional behaviour expressed by the group members, perceiving it less negatively.

When we consider the scores of Time 1 and Time 2 jointly (longitudinal analyses, Table 2), we find significant differences in the well-being function according to both time and channel. Even so, in none of the processes studied do we obtain a significant interaction between time and the communication medium used in this type of task, so that our second hypothesis is confirmed.

With regard to *negotiation tasks*, the results obtained also support Hypothesis 2. The differences found as a function of the communication medium for positive socioemotional behaviour at the first time point are maintained at the second point ($F=7.98$; $p=0.001$). Furthermore, there appear significant differences for the perception of negative socioemotional behaviour ($F=8.66$; $p=0.001$), with e-mail being the channel that presents the highest levels of this type of behaviour, so that these results are not in the direction expected in our

Figure 2
Evolution of group effort level as a function of communication channel in negotiation tasks



second hypothesis (Walther, 1996).

The longitudinal analyses show a significant effect of the communication channel on the group's socioemotional behaviour (positive socioemotional behaviour ($F=13.59$; $p=0.001$) and negative ($F=7.28$; $p=0.001$)). We did not find significant differences on considering the interaction time X communication channel. Subsequently, Hypothesis 2 is confirmed for positive socioemotional behaviour, and the opposite occurs for negative socioemotional behaviour, since the differences between media emerge over time.

DISCUSSION

As the reader will recall, the objective of the present work consisted in analyzing how group interaction processes change across time as a function of the technology used in the group interaction and the type of task carried out. This objective was divided into two hypotheses.

The first was based on theories of the richness of the communication media according to the type of information they allowed group members to transmit (Short et al., 1976; Daft and Lengel, 1986). According to these theories, the communication medium influences group work in such a way that rich channels (face-to-face or videoconference) favour it and poorer channels, such as e-mail, make it more difficult, as they filter non-verbal and social information (Kiesler et al., 1984; Sproull and Kiesler, 1992; Siegel et al., 1986). Nevertheless, McGrath and Hollingshead (1994) point out that the influence of the technology on group work will depend on the type of task to be performed, and more specifically, on the degree of fit between the richness offered by the medium and that demanded by the task.

Our results support McGrath and Hollingshead's (1994) idea that the influence of the technology on a group's work depends on the type of task it has to perform, but they are not always in the direction hypothesized by these authors. In idea generation tasks the results obtained show that groups coordinate themselves worse, express less motivation for effort and develop less positive socioemotional behaviour when they communicate by e-mail than when they do so face-to-face or via videoconference, even though the task may have low demand for richness of information. But the task-medium fitness model is indeed confirmed in intellectual tasks. These types of task require a medium level of richness of information, and it is videoconference that presents the highest scores in the functions of production

and group well-being. On the other hand, the results obtained for negotiation tasks do not support this model. In this type of task the communication medium only has a significant influence on the positive socioemotional behaviour perceived by the group, which is higher for videoconference and lower for e-mail.

In general, it can be said that the results obtained are in the direction proposed by the medium-richness theories. The richer media favour the functions of production and group well-being, whilst the poorer media, such as e-mail, continue to present lower levels. However, these effects are modulated by the type of task the group is performing, so that the influence of the technology differs across the three types of task considered in our study. When groups have to perform a task of an intellectual type they work better via videoconference, since the level of richness offered by this medium coincides with that required by the task.

Our second hypothesis proposed that communication media present different patterns of development over time for each group function, modulated by type of task. Patterns of change are neither simple nor consistent. The differences between media may persist over time, may decrease or emerge, or different patterns of development may be found (Arrow et al., 1996).

With regard to the *production function*, we expected that with the passage of time groups would develop procedures that allowed them to compensate for the lack of richness of the medium, performing the task effectively in a medium with less richness than necessary (McGrath and Berdhal, 1998). Thus, we expected differences dependent upon the technology to disappear for creative and intellectual tasks, whilst differences would be maintained or appear in tasks involving high levels of interdependence, such as those of negotiation.

This hypothesis is confirmed in creative and negotiation tasks, but not in those of an intellectual nature. With regard to idea generation tasks, the results show that when groups acquire experience in the use of communication media, differences in the production function disappear. With regard to motivation for effort, this presents different trajectories according to time and channel. Groups that communicate via e-mail increase their motivation for task-related effort with the passage of time, whilst such motivation decreases in the richer media.

However, when groups perform tasks that require the sharing and integration of the information possessed by each member (intellectual tasks), group work continues

to be more positive in the rich media than in e-mail across time. That is, the differences between media persist over time.

Negotiation tasks present different results from the above. With the passage of time there emerge differences according to the communication medium used, so that groups coordinate themselves better in rich media than when they use e-mail. Furthermore, motivation for effort presents different trajectories as a function of time and communication medium, so that groups that communicate by means of media that allow for greater richness of information (face-to-face and videoconference) increase their motivation as they acquire experience, whilst for those that use e-mail their perception remains constant, in contrast to what occurred in the creative tasks. These results may indicate that groups need more time to adapt to the technology when they perform more complicated tasks, as they need to integrate different ideas and points of view. It may be that they first need to become accustomed and develop strategies for completing the task, so that differences do not emerge according to the communication medium; rather, it is later, when the group has developed strategies for achieving the objective, that the influence of the technology becomes significant. The main effect of time is significant in the production function, whilst the main effect of channel is significant in the well-being function.

With regard to the *group well-being* function, we expected the differences between communication media to be maintained in the socioemotional behaviour perceived by the group, and even to increase in negotiation tasks. Lebie et al. (1996) point out that the patterns of change in socioemotional behaviours in face-to-face communication and in mediated communication suggest that several causal factors may be involved. The initial differences may be due to the novelty of the medium and the slowness of writing messages in e-mail communication. But with the passage of time, socioemotional behaviour increases in both media, so that more factors are involved. These authors point out that there are main effects of the technology and time, but not of the interaction between the two. This indicates that groups change their interaction patterns in a similar way in the two media, and that there may be differences that persist over time.

On the other hand, we expected the contrary to be the case with negative socioemotional behaviour, bearing in mind the results reviewed by Walther (1996) and the theory of social information processing. Walther stresses

the importance of experience in the use of mediated communication so that users perceive it in a more positive way and so that they learn how to develop positive socioemotional behaviour in its context.

Our results for generation of ideas and intellectual tasks support the hypothesis, since the differences are maintained in positive socioemotional behaviour (the rich media being those that present the highest scores) and disappear in negative socioemotional behaviour; in negotiation tasks, significant differences are maintained in both types of socioemotional behaviour, positive and negative. That is, in this more complex type of task, the differences between media in negative socioemotional behaviour do not decrease solely with experience in use of the medium.

In general, our results show that although the technology used has a significant influence on group work, it is not only its objective characteristics that change work group processes; rather, it is the interaction of the technology with other factors, such as the task or experience, that affect the differences that appear in the interaction processes of a group.

The type of task performed by the group appears as an important modulating factor in the relationship between the technology and group work. It is important to bear in mind that a fit must be found between the characteristics of the task and those offered by the technology, though our results only support McGrath and Hollingshead's (1994) task-medium fitness model for intellectual tasks. However, this fit is not static but dynamic, changing over time, so that it is the result of a triple interaction: task, technology and experience (time) (McGrath and Berdhal, 1998). The result of this interaction is complex, and there is a need to operationalize and measure more accurately the lack of fit found in the model. In our study, negotiation (competitive) tasks show the initial importance of time for establishing habitual procedures of group work, in order to subsequently analyze the differences introduced by the technology and seek a situation of fit.

It is also important to highlight the influence of the technology on the well-being function of the group, in this case on the socioemotional aspects of group interaction. For the three types of task, e-mail is perceived as the medium in which least positive behaviours emerge in comparison to face-to-face communication and videoconference, and these differences are maintained with the passage of time. This result supports the filtering of cues theories, and does not confirm those of Strauss

(1997) or Walther (1995; 1996). That is, the continued use of e-mail does not make the group perceive it more positively (Walther, 1996), even though it does reduce negative socioemotional behaviour. It may be that the group becomes accustomed to using the technology and learns to express its disagreements with or its rejections of others' ideas in a less explicit or less negative way, while it needs more time to develop new strategies that permit it to better express and transmit positive socioemotional aspects.

Thus, our results are in support of McGrath and Berdhal's (1998) call for a differentiation between the effects of the technology itself and those of the "novelty" represented by the use of that technology. Secondly, our study confirms the importance of analyzing the specific effects on work processes and results of the objective characteristics of the technology, effects that may persist and even increase over time, as well as those resulting from the interaction between the technology, the task, time and other factors, such as the group's perception of the communication medium it is using (Solanes, 1999). And thirdly, the present work highlights the need to take care in the design of the measures for the different functions and results of a group. In this regard, each technology offers different opportunities and constraints for the interaction of group members. Thus, the measure of coordination level, of conflict management or of the way of expressing agreements or disagreements does not have to be the same for all the communication media (Zornoza, 1992). Future studies might include measures of observation of group functioning combined with self-report measures, which would permit a more detailed analysis of the strategies developed by groups and of their evolution as a function of time and as a function of the technology used.

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