A COGNITIVE THREE-PROCESS MODEL OF COMPUTER-MEDIATED GROUP INTERACTION[1]

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Abstract

Current theories imply text-based computer networks are socially barren, but computer-mediated interaction (CMI) research contradicts this. A cognitive perspective suggests individuals in groups construct cognitions regarding the task (purpose), other people (relationships), and the group (identity), and these drive the interaction. Three core psychological process follow: resolving task information, relating to others and representing the group. This gives three types of influence: informational, personal and normative, and three group purposes: task resolution, interpersonal relationships and group unity. Group unity occurs when group members represent a common identity. The traditional communication threads of message content and sender context therefore require a third – behavioural position. Many-to-many exchange of member positions allows the group position to be transmitted to the group. A picture emerges of three parallel processes overlapping in behaviour, although CMI allows them to be isolated and investigated This model extends most theories of computer-mediated group interaction. It implies there is no "best" type of group interaction support, because there is no best process. The groupware challenge is to offer the flexibility to support all three processes in combination.

Key words: groupware, CMC, GSS, CSCW, conformity, social identity, group agreement, social influence

1. Introduction

Groupware developers have a vision. It is no less than the migration of human social life online. A future in which friendships, social groups, organizations and work teams operate in "cyberspace", transcending physical restraints. Unfortunately this vision seems a long time coming. Groupware has no "killer" application equivalent to e-mail, and its use is far below its potential (Grudin 1994). Electronic groups seem to have extra needs beyond those provided by simple networking, or by e-mail. Some suggest low bandwidth computer networks are inherently unable to support the emotional and social influence which creates agreement, confidence and trust in groups (Adrianson and Hjelmquist 1991; McGrath and Hollingshead 1991; Kraut, Galegher, Fish and Chalfonte 1992; McLeod 1992). If so, the groupware vision is postponed until networks can offer video-style multi-media interaction, matching that found in the physical world. We suggest this will not be enough.

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While research focuses on *computer-supported* face-to-face interaction (Fjermestad and Hiltz 1998), runaway practical successes, like e-mail and the Internet, involve *computer-mediated interaction* (CMI), or "pure" electronic interaction, where all interaction occurs via computer. CMI includes computer-mediated group interaction as well as communication (CMC). CMI practice seems to have moved ahead of the theory, leaving groupware designers without a valid model of what groups do. The issue in groupware development seems less one of people understanding technology than of technology understanding people. This paper suggests groupware needs to be built around core psychological processes. It presents a cognitive three-process (C3P) model of group interaction and influence. It proposes three layers of interaction instead of one or two, opening up possibilities beyond technology and task-focused models (Whitworth and McQueen 1999). Its cognitive focus implies human interaction is built from, but not constrained by, the physical medium of interaction, and offers a common basis for computer-mediated and FTF interaction – the human mind. Computer-mediated environments are new, but the people using them are the same, so the same psychological principles can apply. Focusing on psychological reality means groupware need not represent physical reality online, and that the challenge of electronic interaction is not the automation of face-to-face interaction (Hiltz and Turoff 1985; Lea 1991). The C3P model implies groupware needs should derive from human nature, not the nature of the physical world.

2. Theoretical background

One of the ironies of computer-mediated groups is even that when they produce better quality results than FTF groups, subjects can be dissatisfied with the interaction (Gallupe and McKeen 1990; Venkatash and Wynne 1991). Subjects may judge their FTF performance better, even when they actually perform worse (Adrianson and Hjelmquist 1991, p293). Group interaction can raise decision confidence while lowering decision accuracy (Boje and Murnighan 1982).

One explanation for this is there are two potentially independent processes operating: a task resolution process generating decision quality, and a social influence process generating confidence. This two-way division, originating with Bales' Task vs. Socio-Emotional (SE) distinction (Bales 1950), is common in groupware research:

> *Variables . . . can be categorized as relational and performance-orientated, respectively. Relational variables include such factors as group cohesion, social influence, and leadership skills, while performance-orientated variables include task correctness, decision quality, and degree of participation.*
>
> (Burke and Chidambaram 1995)

It implies that while computers effectively exchange task information, their inability to mediate social influence lowers confidence and agreement (Hiltz, Johnson and Turoff 1986). Hence they support intellective tasks better than social preference tasks (Tan, Wei and Krishnamurthy 1991), and reduce the power of the group over the individual (Horton, Rogers, Austin, Brimm and McCormick 1991; Kraut, Galegher et al. 1992). Reduced social influence has been attributed to low bandwidth computer text being unable to transmit rich, socio-emotional signals, resulting in uninhibited "flaming" and groups adopting more extreme (or polarised) positions (Sproull and Kiesler 1986). This approach implies computer networks need rich communication to transmit the rich signals necessary for social outputs like agreement and confidence (Daft, Lengel and Trevino 1987).

Considerable evidence suggests this view is simplistic. People seem to relate well via CMC (Walther 1994; Walther 1995), exchange rich messages (Lee 1994), and find it a "warm", friendly environment (Ord 1989; Boshier 1990). The "lean medium, lean message" approach also seems theoretically unsound (Fulk and Boyd 1991; Lea 1991; Lee 1994). The absence of social influence in computer groups is also questioned. Electronic groups cannot be more uninhibited (from less social influence) (Siegel, Dubrovsky, Kiesler and McGuire 1986) and more polarised (from more social influence) (Lea and Spears 1991). Some computer-mediated groups seem well able to generate agreement (Lea and Spears 1991; Whitworth 1997), and ethnographic Internet studies show groups with distinctive norms, beliefs, language and socialization, as found in all human groups (Giese 1996 May; Surrat 1996 May). CMI seems anything but socially barren. This contradiction between theory and practice can be resolved if Bales' SE dimension is really two dimensions.

In a study of computer-mediated teams carrying out a group writing task, the Bales Interaction Process Analysis (IPA) breakdown showed the expected task/SE division (Reid, Malinek, Stott and Evans 1996). While the SE categories *shows tension release*, *shows agreement*, and *negative reactions* were significantly lower in the CMC setting (as expected), the category *shows solidarity* was significantly higher than FTF (16.87% of acts vs 3.85%). The authors conclude: ". . . *it is essential to differentiate acts that function to regulate conversation (e.g. Shows Agreement) or express fleeting emotional states (e.g. Shows Tension Release), from those linked to group formation and cohesiveness (Shows Solidarity)"* (Reid, Malinek et al. 1996, p1034). A similar difference occurred in an earlier CMC study using IPA (Hiltz, Johnson et al. 1986). Bales's *socio-emotional* category seems to contain a social or group factor and an emotional or interpersonal one.

This distinction between group and interpersonal is central to social identity theory (Tajfel and Turner 1986), which redefines the group as a cognitive rather than physical reality (Abrams and Hogg 1990). It suggests interpersonal attraction is not the main cause of group unity (McGrath and Kravitz 1982), as members who dislike each other can still be strongly attracted to the group (Turner, Sachdev and Hogg 1983; Hogg and Turner 1985). Also large and small groups can exert equally strong effects on members, implying a common process (Hogg 1992). Since interpersonal attraction is an unlikely cause of unity in very large groups, such as "America", it probably does not cause it in small groups either.

The group vs. interpersonal distinction has emerged from psychology to CMI as the social identity model of deindividuation (SIDE) (Spears and Lea 1992; Reicher, Spears and Postmes 1995). It criticises the assumption that computer depersonalisation reduces social influence and causes deregulated behaviour (Postmes 1997). A meta-analysis of over 60 deindividuation studies (Postmes and Spears 1998) concluded that removing social presence (Short, Williams and Christie 1976) had no effect on normative behaviour. Anonymous CMI should cause a depersonalised, socially deprived state, yet, it can *increase* normative influence, and making groups co-present (and adding abundant social context cues) can *reduce* normative influence (Postmes and Spears 1998). The same result has been found for polarisation - when groups interacting only by computer were placed face-to-face (but not allowed to talk), polarisation reduced significantly (Lea and Spears 1991; Sia, Tan and Wei 1996).

These findings make no sense from a bipolar task/SE perspective. A new perspective is required, here proposed to be a cognitive one. A cognitive perspective extends Bales' two-process model, which has served well for over forty years, into a three process one.

3. A cognitive three-process model of computer-mediated interaction

This is a model of group interaction and influence (see Figure 1). It applies to groups exchanging information, whether computer-mediated or FTF. It excludes the effects of physical rewards and punishments on individuals, as these operate before, throughout and after a group interaction, and are well enough described by individual behaviour theories. The model's propositions are given at the end of each section

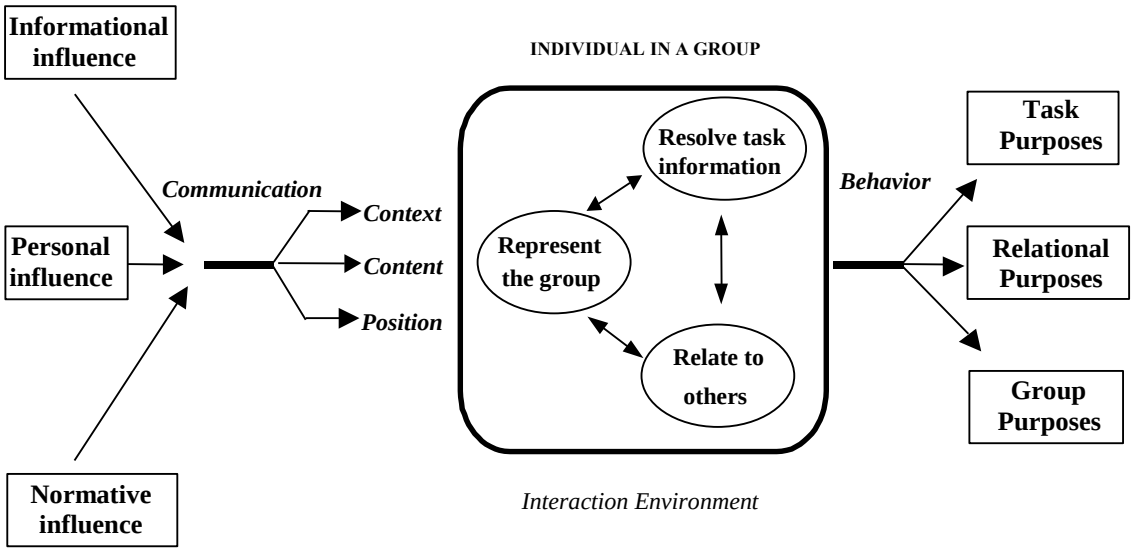

Figure 1. The C3P model

3.1 Model entities

Most models view groups from the outside, as if they were objective, physical systems. This model *takes the perspective of an individual within the group*, who sees:

1. **A task**.
2. **Other individuals.**
3. **A group**.

These essential "things" individuals address form the conceptual base of this model. They are all cognitive, created in the mind of the individual, but derived from physical reality. So task refers to perceived task, other individuals to perceived relationships, and group to perceived group identity. While one might initially consider a "task" something clearly definable in the physical world, considerable work in small group research finds tasks better defined in terms of behavioural intent. McGrath's task circumplex, common in groupware research (Tan, Wei et al. 1991), is defined this way, each task type describing a behavioural purpose, namely generating, choosing, negotiating and executing. However a subject could interpret a choice task to be an invitation to negotiate. The behaviours implied

by most tasks are not fixed. For example, consider the task "to entertain people". Task behaviours could include singing, telling jokes, or providing food. These have nothing in common except their effect. In fact, they do not even have that - a subject telling bad jokes that entertained no-one could also be carrying out the task (unsuccessfully) because *they were trying to entertain*. A task is therefore not a behaviour set but *behaviour to accomplish a stated goal* (Hackman 1969), leading to definitions like: ". . . the behaviour requirements needed to accomplish stated goals, via an explicit process, using given information*."* (Zigurs and Kozar 1994, p280). If subject goal is an inherent part of a task, and goals are clearly cognitive constructs, then task becomes an inherently cognitive concept. Likewise task difficulty defines a human perception, not a physical property. Cognitions add a layer to physical reality that cannot be ignored, as it connects more closely to the subject's actions. Fortunately cognitive and physical perspectives are not mutually exclusive (Lee 1994), and we can operationalize cognitions, like task difficulty, and deal with them physically.

Proposition 1: Group interaction is more validly described using cognitive than physical entities, although these views are not mutually exclusive.

Proposition 2. In group interaction, the main cognitive entities are task (perceived purpose achievable by behavioural action), other individuals (perceived relationships), and group (perceived group identity).

3.2 Interaction environment

In addition there must be *that through which interaction occurs,* also called *technological support* (Pinsonneault and Kraemer 1989), *physical setting* (Finholt and Sproull 1990), *technology* (McGrath and Hollingshead 1991), *electronic meeting system* (Nunamaker, Dennis, Valacich, Vogel and George 1991, July), g*roup support system* (Benbasat and Lim 1993) and *interface* (DeSanctis, Poole, Dickson and Jackson 1993). We use the term *interaction environment,* as it can apply to groupware and non-groupware environments, e.g. telephone, e-mail and face-to-face all provide interaction environments. For FTF interaction it is the physical world. Computer environments seem special, as they are new, but with familiarity should also become background. The C3P model sees groupware as primarily about human-human interaction, in all its forms, rather than technology. The technology simply offers a background environment which people can adapt to their needs (DeSanctis, Poole and Dickson 1992).

Proposition 3. The role of an interaction environment, whether technology or the physical world, is to provide a background for human-human interaction.

3.3 Core processes

The C3P model suggests individuals in computer-mediated groups deal with the task, other individuals and group using three primary internal processes of fundamentally different nature, namely *resolving task information, relating to others, and representing the group.* Processes occurring within a single individual tend to interact to give consistency. Defining processes as occurring within individuals avoids the nominal fallacy of reifying the group independently of group members (Allport 1924). Individual processes then combine to give group processes. Individuals look to others for informational, emotional and identity support, giving three forms of social influence: informational, personal and normative (Table 1). Finholt and Sproull propose three similar group processes, namely *interaction*

(information exchange), *influence* (of one individual on another), and *identity maintenance* (the group defining itself) (Finholt, Sproull and Kiesler 1990).

Individual process	Group Process	Focus
Resolving task information	Informational influence	What is correct? What makes sense?
Relating to others	Personal influence	Who do I like? Who do I trust?
Representing the group	Normative influence	What defines the group? What are "we" doing?

Table 1. C3P model processes

Proposition 4. Group members resolve task information, relate to others and represent the group, looking to the group interaction for informational, emotional and identity support, and consequently being subject to informational, personal and normative influence.

3.4 Process distinctness

Each process is considered *distinct,* with a different nature, conditions of operation and purpose:

1. *Resolving task information* is the process of dealing with task information and argument. It includes redefining the task aim (Reeves and Lemke 1991), and concluding a task is impossible or pointless also resolves it. It can involve analysis (from premises to conclusions) or rationalisation (from conclusions to reasons). The same process is involved in both cases. It is an apparently logical process, well described by the traditional decision-making paradigm of intelligence, design, and choice (Simon 1960), and widely recognised in groupware literature (Briggs and Nunamaker 1994). Informational influence occurs when literal information exchanged is taken as representing reality and internalised (Deutsch and Gerard 1965). Communication can be anonymous. Focusing on this process suggests the purpose of groups is information exchange (Huber 1984), leading to computer systems like the Co-ordinator (Winograd and Flores 1986) and Information Lens (Malone, Grant, Turbak, Brobst and Cohen 1987).
2. *Relating to others* is a one-to-one, interactive process receiving increasing attention in computer-mediated literature (Walther 1994; Walther 1995). This turn-taking, mutual-approach process seems designed to deal with the emotional arousal (Zajonc 1965) evoked by the presence of others (Short, Williams et al. 1976). Relating develops mutual understanding and trust, which allows intimacy and the exchange of affect. Trust also affects whether factual communications are internalised (Hovland, Janis and Kelley 1953). Relationships give interaction predictability, whether negative (hostility and distrust) or positive (friendship and trust), while anonymity prevents relational information carrying forward to future encounters (Gabarro 1990). Ritualised greeting procedures like the handshake illustrate interpersonal relating and e-mail illustrates software that supports this process.

3. *Representing the group* means supporting the group identity and norms. It operates regardless of right and wrong, or who likes whom, and causes groups to act as one. It is the foundation of social structure and the basis of conformity. It is what makes us group rather than solitary animals. If social animal groups had no cohesive process, they would wander apart, and the herd or flock would no longer exist. Normative influence is the primary means whereby groups stay together. It is neither rational nor emotional in nature. It operates whenever people form groups, although it is often "covered", as it were, by the other two more obvious processes. Few groupware products support normative influence effectively, though those that do report computer-mediated groups can enact agreement (Lea and Spears 1991; Whitworth 1997).

The distinctness of the latter two processes explains how anonymous CMI groups can enact agreement (Lea and Spears 1991; Postmes 1997). A physical group equates to the individuals in it, but a cognitive "group" is a social construct quite apart from its members. In this sense, a group is any set of people who consider themselves a group (DeSanctis and Gallupe 1987). Hence a group's identity can have an effect without the physical presence of its members. Indeed co-presence may reduce normative influence, by making personal influence salient, explaining why socially enacted agreement *reduces* when subjects see each other (Postmes and Spears 1998). This result runs counter to the expectations of media richness theories. That relationships are cognitive constructs likewise explains how CMC participants can feel intimate *from the inception of the interaction* (Walther 1995), as once the expectation of a relationship is evoked in the mind, it can immediately affect behaviour. Again, this result is surprising to any physical information exchange approach (like social information processing theory (Walther 1992).

Proposition 5. Each process has a different nature, conditions of operation, and purpose, and hence can operate independently.

3.5 Normative influence

Social influence can arise from compliance, internalisation or identification (Mann 1969). Compliance involves physical threat or bribe, but when pressure is released individuals revert to their original opinion. It lies outside the scope of this model. Internalisation occurs when a communication is accepted into the receiver's internal value system. This depends on both how the sender is viewed (the relationship) and the perceived validity of the message content (Hovland, Janis et al. 1953). However social influence through identification acts in another way. It uses the most fundamental of human perceptions, that of self, of who we are and what we stand for - our *identity*. Without a sense of self we could not operate as sentient beings, as we cannot exist psychologically in an existential vacuum. Hence a great deal of the behaviour of individuals involves them in developing and maintaining their idea of themselves. Once a self-identity is established, behaviour tends to conform to its expectations.

Groups provide ready-made identities. Social identity theory (Abrams and Hogg 1990; Hogg 1992) proposes that when individuals join groups, the group's "social identity" helps create, and becomes part of, the individual's personal identity (Tajfel 1978). They then "identify" with the group, which then defines who and what they are. They attach to *the group,* rather than the people in it. Group unity occurs naturally when members take on a common identity, leading to common behaviour and the dropping of idiosyncratic behaviour (Owen 1985). The latter causes information suppression in both face-to-face (Stasser and Titus 1985) and computer-mediated (Hollingshead 1996) groups. When group expectations

become self-expectations, disagreeing with the group is like disagreeing with oneself. It generates cognitive dissonance (Festinger 1957), which can only be resolved by agreeing with the group, getting the group to agree with us, or leaving the group. Clearly the first option is easier. Leaving a salient group has special potency, involving a psychological cost to our sense of self, as well as any physical consequences. The process proposed is impersonal, and is not based on personal interaction between individuals. Group members need do nothing at all to the "pressured" individual. They need not even be present. Yet normative influence is as powerful as any personal pressure, perhaps more so. Conformity experiments demonstrate this, where subjects will agree (wrongly) with a group, against their own better judgement, on a simple perceptual task, without coercion or persuasion (Asch 1952). This result was replicated with subjects in booths, who only knew the responses of others from an array of lights (Crutchfield 1955). The tasks were extremely easy, of no particular importance and involved participants subjects hardly knew personally. No attempts were made to influence subjects either by the experimenter or group members. The "group pressure" occurred without rich, face-to-face contact, and involved group members the subject did not know, had never met, and never did meet. Normative influence seems to require neither rich communication nor sender recognition, only simple group position information.

Proposition 6. When individuals join groups they seek to represent in their behaviour what they perceive as the group behaviour and/or expected behaviour (identity). This influence requires neither personal contact, rich communication nor sender recognition, only information about the expected group behaviour.

3.6 Parallel processes and multi-threaded communication

The split-brain studies in neuro-psychology demonstrate that cognitive processes can occur in parallel, i.e. the brain can (and usually does) multi-process (Sperry and Gazzaniga 1967). Hence we propose that the C3P processes are not only distinct, but operate in parallel. This requires that communication is *multi-threaded*, i.e. a single communicative act can contain more than one level of information (McGrath 1984), allowing different processes to access different "threads" of information, e.g. saying "I AM NOT UPSET!" in an upset voice gives sender context information that contradicts the message content. The C3P model goes one step further, proposing three not two information threads, namely: *content, context* and *position*. For example, saying *"This is good, lets buy it"* conveys:

1. **Content.** Literal information (e.g. the item is good).
2. **Context.** Sender information (e.g. tone of voice indicating one's attitude to the item).
3. **Position.** Information about the sender's action or intended action (e.g. to buy the item)

The literal message, residing within a contextual sheath of sender information, also contains a core of implied action. Position information from one person alone however is not usually normative, as this requires information representing the position of the group as a whole. How this is formed depends on the social combination method used (Laughlin, Chandler, Shupe, Magley and Hulbert 1995). In autocratic groups it may be the leader's position, but in democratic groups it is the majority position.

Normative exchange of position information could underlie apparently rational discussion. Hoffman took favourable minus unfavourable solution comments as a group "valence index" for decision alternatives (Hoffman and Maier 1961). Each person contributed any number of comments, or none at all, and negative ones cancelled positive

ones. Hoffman's valence index gave a group position estimate which, as expected, correlated strongly with decision adoption. More interestingly, there was a threshold effect (at about 15), independent from rational discussion, implying a non-reversible group cohesive process. A further study involved subjects selecting personnel purportedly following a rational two-phase procedure: reject the unacceptable then select the best. The valence index (which predicted group outcome) often passed the threshold well before the rejection phase finished, i.e. before the rational process was complete, group position predicted the group decision. When the group valence reached a commonly understood threshold, members considered the group decision made and normative influence caused agreement. Alternatives offered after a solution passed the adoption threshold were considered much less than those suggested before. Normative influence may thus tend to cause premature closure groups (Hirokawa 1983 Summer). If task analysis were the primary group purpose, discussions would begin with task definition, and the exchange of member information and argument, and end with individuals convinced (internally) of the best solution. This does not well describe what generally happens. Groups spend so little time discussing task strategy there almost seems to be a norm against it (Weick 1969), and they rarely fully exchange information (Stasser and Titus 1985). They typically begin by generating and exchanging solutions rather than analysing the task (Hirokawa 1983 Summer). This is exactly how a normative process would be expected to operate: each member states their individual position, without explanation or justification, then, if a common position is evident, the group decision is made. This avoids discussing various alternatives (which degrades confidence by expanding the information domain (Sniezek 1992)) and relating (which risks interpersonal conflicts). For cohesive groups, this can be a quick, effective decision method in a world where effectualness may count as much as correctness. If a group cannot form a majority, personal influence or appeals to reason may tip the balance. Changing a few positions may allow normative influence to bring the whole group around. Can group unity be generated by such a simple process? If it was more complicated, it probably wouldn't work.

What may confuse is that the exchange of group position information can involve the same messages that convey factual task information and personal context information. That cognitive processes intertwine at a behavioural level obviates a simple literal approach to group activity. For example, a decision may arise from any or all of informational influence (based on information analysis), personal influence (based on a trusted expert's opinion) or normative influence (based on the group majority position). Is it possible to isolate these processes other than in theory? We believe computer-mediation makes this possible. For example, "risky shift", or group polarisation, is the finding that groups make more extreme decisions than individuals when faced with the same problems (Kaplan 1977). Two explanations have developed: *persuasive arguments theory* (Vinokur and Burnstein 1974) and *social comparison theory* (Sanders and Baron 1977), corresponding to the C3P informational and normative processes. The first proposes individuals change position due to valid arguments. The second proposes they simply follow the majority, and no reasons are necessary. CMI allows these underlying processes to be disentangled, as it can present positions with and without arguments. Doing this shows that the addition of task information has no effect on distributed group polarisation (Sia, Tan et al. 1996). This is predicted by the C3P theory, as polarization arises from normative influence, a non-rational process. Such findings suggest group discussions may as much about rationale construction as information analysis (Pavitt 1994; Heath and Gonzalez 1995).

Proposition 7. In group interaction, the C3P processes operate in parallel, their effects over-laid upon communicative acts which are multi-threaded, and able to carry content, context and position information simultaneously.

3.7 Communication environment differences

Group interaction all at once exchanges information about the task, other people and the group itself. Each process places different demands upon the communication environment, especially regarding linkage (Table 4). Rational information exchange needs only simple one-way, anonymous communication. Relating however requires a two-way, signed, interactive linkage. A one-way transmission is not relating, and gathering information about another person is not relating to them. Nor is an interacting dyad considered equivalent to a group of two. We expect significant differences between dyads and small groups – for example dyads are capable of deeper reasoning than groups and less subject to "groupthink" (Panko and Kinney 1992). Dynamic groups, like a choir singing, require dynamic many-to-many interaction, where the group continuously affects the individual and individuals continuously affect the group. Information from many group members must be combined to give a single group signal. Analogue media, like sound, can do this - a crowd clapping gives one sound indicating the group view. From this perspective a group vote could be considered a communicative act, albeit from group-to-group rather than person-to-person (Hiltz and Turoff 1985). We prefer the term interaction, as communication implies an individual sender with a conceptual message.

Each process requires a different unit of research analysis (Table 4). Task resolution needs only one person, giving the individual as the unit of analysis. Relating requires two people, giving the dyad as the unit of analysis, rather than the individual (Fulk and Boyd 1991). When individuals represent the group, then "Groups not individuals are the fundamental unit of work " (Finholt and Sproull 1990). Depending on the process involved, the unit of analysis could validly be the individual, dyad or group (Bikson and Eveland 1990, p285).

Process	Linkage	Unit of Analysis
1. Resolving task information	One-to-many, one way (**1** → **n**)	Individual
2. Relating to others	One-to-one, two way (**1** ↔ **1**)	Dyad
3. Representing the group	Many-to-many, two-way (**m** ↔ **n**)	Group

Table 4. C3P process properties

Proposition 8. Each C3P process by its nature places different demands upon the interaction environment, e.g.:

1. *Informational: One-to-many, one-way, unsigned.*
2. *Personal: One-to-one, interactive, signed*
3. *Normative: Many-to-many, interactive, unsigned*

3.8 Independent variables

Table 1 illustrates how the C3P model classifies common independent variables from other groupware models (Hackman and Morris 1975; Dennis, George, Jessup, Nunamaker and Vogel 1988; Pinsonneault and Kraemer 1989; Finholt, Sproull et al. 1990; McGrath and Hollingshead 1991; Nunamaker, Dennis et al. 1991, July; Benbasat and Lim 1993; Fjermestad, Hiltz and Turoff 1993). The categories are mutually exclusive, as the model entities are distinct. They also seem exhaustive, since once environment, task, people and group properties are given, little else seems relevant. This categorisation differs from other models in that:

1. Computer technology has the status of an environment.
2. Task variables include individual perceptions of the task, like time pressure, elsewhere considered a contextual variable (Dennis et al., 1988; Fjermestad et al., 1993).
3. Interpersonal and group variables are distinguished, while most models merge the two (Dennis, George et al. 1988; Pinsonneault and Kraemer 1989; Finholt, Sproull et al. 1990; McGrath and Hollingshead 1991; Fjermestad, Hiltz et al. 1993), e.g. TIP theory classifies "group and member attributes" together (McGrath and Hollingshead 1991). Other models regard interpersonal variables like evaluative tone as "context" (Dennis, George et al. 1988) or "situational factors" (Pinsonneault and Kraemer 1989).
4. Most other models have a set of individual properties, like *individual factors* (Hackman and Morris 1975; Cook, Ellis, Graf, Rein and Smith 1987), *personal factors* (Pinsonneault and Kraemer 1989; Benbasat and Lim 1993) or *member characteristics* (Finholt, Sproull et al. 1990; Fjermestad, Hiltz et al. 1993). This categorization does not. Individual attitudes and skills are inherently added to the task, interpersonal and group categories through the cognitive perspective (e.g. a skilled subject makes a task easy).

Category	Examples	Category	Examples
Environment	• asynchrony • type • ease of use • media • facilitator • training	**Task**	• type • difficulty • equivocality • resources • time pressure
People	• friendships • appearance • anonymity • communicative structures • evaluative tone	**Group**	• size • norms • structure • roles • membership • cohesiveness

Table 2. C3P model independent variable categories

When users of four e-mail systems were asked a large number of questions regarding how they felt about the computer interaction, factor analysis produced four factors: *Interface* (the communication interface), *Performance* (system productivity), *Unexpressive* (sense of personal contact with others) and *Mode problems* (interface problems) (Hiltz and Johnson 1990). The first and last deal with communication environment. The others seem to match the task and interpersonal processes. The group representation process was not mentioned, perhaps because e-mail does not evoke group activity.

Proposition 9. The independent variables affecting group interaction can be classified into properties of the environment, task, people and group.

3.9 Dependent variables

Each C3P process has a distinct purpose, namely to resolve factual information and make valid task decisions, to respond appropriately to sender information and maintain good personal relationships, and to reflect group movements to maintain group identity and unity. This implies three categories of dependent variables (Table 3). A factor analysis of questionnaire results from a CMC writing project found not only an outcome index but also a richness index representing ". . . the relative frequency with which subjects felt able to get an impression of personal contact with others, to express their views . . ." (Hiltz and Turoff 1991, p63). The relational output, a sense of closeness, was considered distinct from task output. The third purpose in Table 3 describes the "capability of the group to work together as a unit" (Hackman 1983).

Purpose	Dependent Measures
To make valid task decisions.	• task learning • time taken • decision quality • decision quantity • errors
To maintain personal relationships.	• quality of relationships • number of relationships • attitudes to others • closeness • trust
To maintain the group social identity.	• agreement • norms defined • morale • roles

Table 3. Group purposes

If group interaction involves three purposes, group performance should be measured against all those purposes. Anything less will see group effort "lost". For example one of the most reliable and repeatable results in small group literature is that: ". . . individuals working separately generate many more, and more creative (as rated by judges) ideas than do groups." (McGrath 1984, p131). This has been attributed to a "process loss" arising from the group interaction (Hackman and Morris 1983). However, this approach leads to the paradox that groups meet, expend effort, feel they gain something, and yet produce less than if they had not met at all. Groups seem like machines producing negative work! That interacting groups are usually less task effective than their best member working alone (Lorge, Fox, Davitz and Brenner 1958; Hackman and Morris 1975) has led to the suggestion that the value of meetings is a popular illusion (Hackman and Morris 1983).

The C3P model suggests interacting groups recognize demands beyond the task, namely to relate and to agree, *and since these are valid purposes in themselves, their outputs should be recognised and measured*. The "group effectiveness problem" occurs when researchers consider task output only, as nominal groups brainstorm more ideas but don't create commonality. Face-to-face groups generate more agreement but brainstorm fewer ideas because creating unity suppresses individual diversity which reduces the number of different ideas produced. If we measure group "performance" by the number of *common* ideas, FTF interaction gives a gain, if by the number of *different* ideas, there is loss. The group effectiveness problem only occurs when the experimenter doesn't recognize any group purpose other than the task. Group effectiveness is better measured by group member goals than the experimenter given task (Lea 1991). Valued interaction outcomes like agreement, confidence, and trust are poorly described as "losses" (McGrath 1990). The task gains of electronic brainstorming (Nunamaker, Dennis et al. 1991, July) may be mainly due to computers removing normative influence (Casey, Gettys, Pliske and Mehle 1984). Simply isolating subjects seems to give the same or better effect (Pinsonneault, Barki and Gallupe 1999). Eliminating a valid group process like normative influence is again poorly described as a gain. The benefits of computer support seem to lie mainly in the anytime anywhere advantages of the computer environment.

Task output may represent only short-term gains. Personal relations usually continue over many tasks, and group membership may persist as friends come and go. The task time frame seems the shortest and most temporary of the three, as a single meeting often deals with many tasks. Being more permanent, personal friendships and group membership may represent more enduring concerns to the individual, and in the long term be of more value. We must be wary of regarding all "off-task" activities as purposeless diversions, e.g. a devil's advocate approach may improve task performance (Valacich and Schwenk 1995), but what is the effect on personal relations? Or group unity? If group performance is more than just task performance, these are not idle questions.

Proposition 10. An interacting group produces task, relational and group outcomes, and its effectiveness depends on all three. Measuring only one or two can result in an apparent "process loss".

3.10 Process interactions

The C3P model suggests the complexity of group interaction arises less from the complexity of individual processes than from their dynamic interaction. Interaction effects raise complex issues beyond this paper. Suffice to say social position can affect personal

relationships (Sherif 1966), relating can interfere with normative influence (Sia, Tan et al. 1996), normative influence can affect task information exchange (Stasser and Titus 1985), task information can change normative agreement (Whitworth and McQueen 1999), disagreements of fact can cause personal dislike, and personal dislikes can cause argument on issues of apparent reason.

Proposition 11. The complexity of group interaction arises from the dynamic interaction of three parallel processes.

3.11 Process primacy

The C3P processes normally complement rather than contradict, as each purpose has its benefits. Together they provide information about the entire communication situation, namely the *sender*, the *sent* and the *receiver*. For example if an unidentified telephone caller asks "How are you feeling today?" the reply is often "Who am I talking to?", because *who* we are talking to can change the meaning of *what* is said. The receiver's mental model of the sender affects the construction of message meaning (Lee 1994). It is less obvious that receivers also need *a mental model of themselves – their identity*, and this latter is just as "constructed" as sender relationship and message meaning. Who "I" am is an assumed situation "given", a fixed perceptual background to other processes, but we suggest this background is not fixed. It moves because who "I" am can change. For example, suppose a man talking to an unknown stranger discovers the other is really his son. He would experience a sudden shift in identity, causing the nature of the interaction to change. His identity is now "father" and will tend to behave as he believes fathers should. He may have disliked the stranger to this point, but fathers usually care for their children regardless of personal feelings. The identity change may redefine the personal relationship. Only when self identity and sender relationship have "defined the field" as it were, can even the simplest message content from another (such as "I need money") be resolved. Changing a significant salient group (like religion or culture) changes not only one's identity and expected behaviours, but also all relationships dependent on that identity. It is not difficult to see why identity is so important and normative influence so powerful.

If the three C3P processes match the elements of a communicative act, the natural order of the latter suggests the third process may be the primary one (in the sense of being applied first). Figure 2 summarises this, showing how different causal sources overlap in behaviour. Any process may dominate, so the interaction arrows go both ways. For example if good friends meet as enemies on the battle field will they shoot (as their uniforms require) or embrace (as their friendship demands)? Other things being equal, earlier processes should determine later ones, though process overlap may obscure this. For example, personal attractiveness can depend more on members proto-typicality (of group norms) than on personal liking (Hogg and Abrams 1988). Likewise, discussion of an action pre-defined by group values may really involve *justifying* a decision already made normatively

Matching C3P processes to the elements of communicative acts resolves the concern that if three processes are better than two, would not four or more explain even more? As has been observed:

> *The need to construct more robust conceptualizations is not simply a question of adding an infinite number of predictors. . . . The challenge is to refine our models of the core processes involved.*
>
> (Fulk and Boyd 1991, p 413)

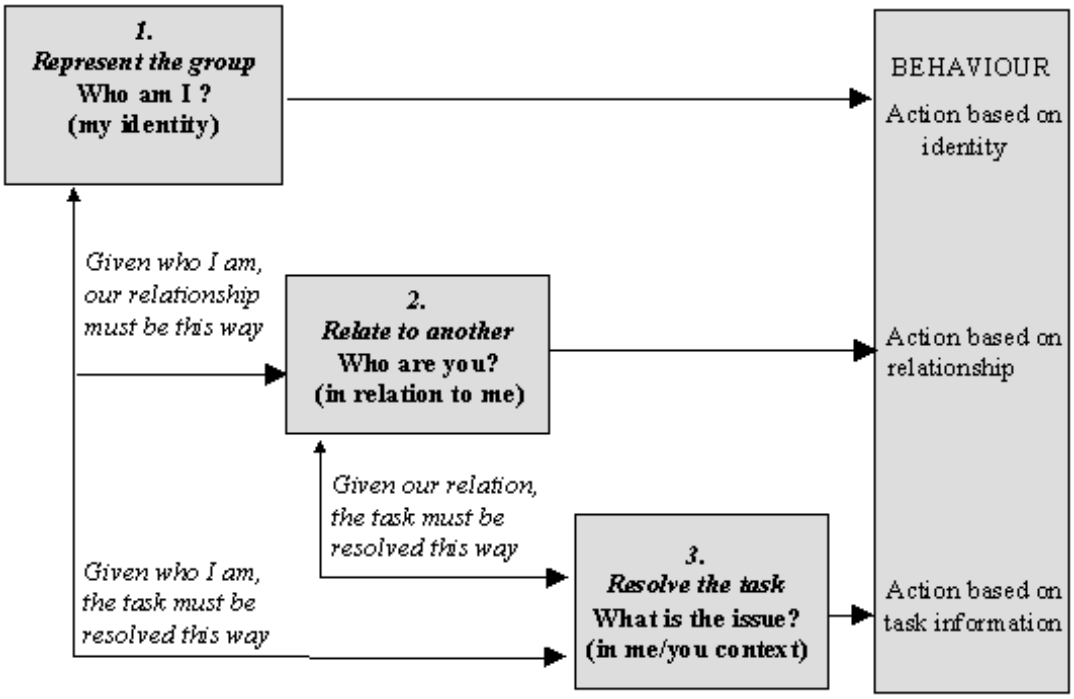

Figure 2. Process sequence and interactions

The C3P model proposes such core processes.

Proposition 12. The C3P processes define the basic elements of any communicative act, and the natural order these are defined (receiver, sender and message) suggests normative influence tends to pre-influence relationships, and both to pre- influence content analysis.

4. Discussion

4.1 Relation to other theories

The general area of computer interaction contains many theoretical models, each with its own focus. Some emphasise the communication medium, such as media richness theory (Daft, Lengel et al. 1987), others social effects, like adaptive structuration theory (Poole, D. R. Siebold and McPhee 1986), or the task analysis process, like process loss theory (Hackman and Morris 1975) and rational information exchange theories (Huber 1984; Winograd and Flores 1986). Recognition of two distinct levels of interaction is common, for example task vs socio-emotional (Bales 1950), informational vs normative(Deutsch and Gerard 1965), task vs social (Sproull and Kiesler 1986), or social vs interpersonal (Hogg 1992; Spears and Lea 1992). The concept of multi-level activity is not new, but most models use dichotomies.

TIP theory and its developments (McGrath 1991; Arrow, McGrath and Berdahl 1999), like the C3P model, see groups as multi-functioned, goal directed units continuously carrying out three interdependent functions in parallel. However the entities and processes differ. The TIP theory entities are *technology* (communication tools), *project* (a set of task purposes) and *group* (an organised set of people). The first matches the interaction environment, which the C3P model considers background. The second matches the C3P task process. However, the third treats the group and the individuals in it as equivalent. As

the entities differ, so the TIP processes of *production*, *group well-being* and *fulfilling member needs* are different. Group well-being includes both group identity and interpersonal support, conflicting with social identity theory and the SIDE experimental results. Fulfilling member needs seems to include both individual physical payoffs (which the C3P model does not address) and group interaction needs. The C3P model sees member interaction needs as being to resolve the task, relate to others and represent the group.

A cognitive approach extends the above theories, adding an extra process in each case. It suggests a balanced approach to group activity, as each different process gives a different perspective. For example, while task resolution aims to reduce ambiguity, when relating people one may *intend to be ambiguous* so as not to offend (Nagasundaram and Wagner 1992). Ambiguity allows tentative beginnings to conversation - if an ambiguous comment causes offence it can be qualified, rephrased, or even disowned. Ambiguity seems a valuable "social lubricant" and rich media can facilitate ambiguity (e.g. different channels can transmit contradictory meanings). Media richness theory suggests people need rich media to remove the ambiguity of equivocal tasks (Daft and Lengel 1986). However, without fail equivocal tasks also involve relating to other people, and here the role of media richness may be different. Subjects completing a collaborative writing task using CMC shifted their goal, from simply revising text to relating to a co-author, when voice was introduced, and preferred voice for tasks where relating to others was important (Kraut, Galegher et al. 1992). The choice of rich media for equivocal tasks could be to better use interpersonal relating, which can operate when reasoning fails. Rich media may therefore be preferred because *they support ambiguity rather than remove it.*

Classic task vs. socio-emotional dichotomies could be revisited with three-way divisions. Group member roles, typically divided into task and socio-emotional (Zigurs and Kozar 1994), could be divided into task, interpersonal and group, matching an earlier three-way division (Benne and Sheats 1948). The suggestion "we might expect that anonymity would reduce role clarity and strength." (Zigurs and Kozar 1994) may not apply to social group roles (like agenda keeper), as normative influence seems unaffected by anonymity. Decision making could also involve any process. Individuals can decide using rational analysis, who they trust, what the group is doing (or normally does), or any combination. Power can be seen as process capability, giving three types of power: expert power (based on task knowledge), referent or charismatic power (based on personal attractiveness), and legitimate power (based on representing the group) (Hodgetts 1990). This implies three types of leadership: expert leadership, charismatic leadership, and group leadership, contrasting with two-dimensional models, like Blake and Mouton's managerial grid of concern for production and concern for people (Blake, Mouton and Fruchter 1962). Perhaps *concern for group* could add another dimension to the grid. Finally, conflict can also be categorized into task, relational and procedural conflict (Jehn 1997).

4.2 Implications for groupware

The ramifications for CMI system designers of a three-layer group interaction framework are considerable, suggesting three support levels:

- **Level I.** Support for task analysis and resolution.
- **Level II.** Level I plus support for interpersonal relationships.
- **Level III.** Level II plus support for group norms and structures.

Most networks offer level I, e-mail systems add level II, and groupware offers the promise of all three. The latter is a more stringent concept than usual, where any network sharing of low-level resources is considered "groupware" (Holtham 1994). Each level adds a new type of information support. Level I systems allow the exchange of content information, including facts and reasons, and allow rational decision making. Level II systems allow the mutual exchange of sender information, and allow judgements of other people. E-mail users may seek conversation continuity by re-sending the original message in their reply. After several exchanges, most of the transmitted data may already exist on the destination computer. If the e-mail data structure properly reflected the psychological "conversation" entity, e-mail could add incoming messages to the conversation so far, presenting the result for view. Previously sent messages would be connected to the current one. Whose turn it is to contribute would always be clear, and checking one had replied to an "Inbox" message would no longer require a trip to the "Sent" area. Relating also needs valid sender information. The ability to "rehearse" messages before transmission is considered to improve (task) validity, as the sender can correct errors (Dennis and Valacich 1999). For relating however, rehearsability reduces validity as senders can pretend to be what they are not. It is the "errors" that may best reveal the sender's true feelings. Real-time video interaction should change this, but there may be other ways to introduce genuineness. Seeing relating as a process distinct from task analysis better allows its special requirements to be addressed.

Level III systems allow group feedback and action. Normative influence must be recognised as a distinct process. Using a one-to-one interface like e-mail for the many-to-many demands of group interaction can create information overload (Hiltz and Turoff 1985). For example, a manager using e-mail for an open discussion with 20 staff could expect 20 replies, each going to 20 people. A single question and response could generate 400 messages. Replies to replies could number 8,000. It is not difficult to see how information overload occurs. The problem is using Level II software for a Level III situation. A single vote interaction could replace the above 400 e-mails. Information overload is a known problem and voting tools considered a critical groupware function, yet empirical investigation shows only 7% of organisations using groupware actually use voting, and those that do consider its utility marginal (Beauclair and Straub 1990). This may be because computer voting has been designed as a rational rather than social tool (Whitworth and McQueen 1999). The software "tool kit" approach to groupware design (Daniels, Dennis, Hayes and al 1991) tends to isolate voting as *a single, blind, mandatory, formal vote*. We propose that face-to-face discussants continuously "vote" informally through their comment valences. These "votes" are public not blind (everyone hears everyone), optional not mandatory (one may keep silent), and ongoing (one can restate positions). In these discussions such informal "voting" usually makes the majority position clear, making formal voting unnecessary. The vote function in groupware should be based on informal not formal voting. Where this has been done, distributed electronic groups report *greater* agreement than FTF groups, rather than less (Lea and Spears 1991; Sia, Tan et al. 1996). Groupware designed specifically for normative influence may challenge the impression computer groups reduce agreement and increase conflict.

4.3 Future directions

What has been presented is the core of a model which must be validated, detailed and expanded. Validation requires verification of the model's basic propositions, that these

processes exist, are distinct, and each can operate without the others. CMI should allow processes to be isolated experimentally, by minimising two processes while supporting the third. For example anonymous interaction minimises interpersonal relating, no task information exchange (or no task at all) minimises task resolution, and hiding group position information minimises normative influence. It should be possible to generate agreement without task or sender information, create relationships without task or group position information, and resolve tasks without sender or group information. Isolating processes for the purpose of study seems a good way to reduce the complexity of group interaction (Casey, Gettys et al. 1984; Sia, Tan et al. 1996). Researchers will need to recognize and measure the appropriate processes, e.g. normative influence requires a measure of group unity (Whitworth and Felton 1999).

Detailing the model includes investigating process properties and effects across different tasks. If what has been proposed are inherent human processes, they will tend operate for all tasks. For example, brainstorming performance drops as individual diversity drops, so the agreement generated by FTF groups lowers performance, yet the normative process operates regardless. Process effects will vary with task type – in other situations normative influence may improve task performance. Process interference effects must also be detailed, e.g. anonymity may favour task analysis (Jessup and Van Over 1996) but not interpersonal relating (Er and Ng 1995).

Extending the model will require further theory development. It currently describes a simple group with simple relationships completing a simple task. However these model components can be recursive. Groups can exist within larger groups, giving a social structure. A conversation can be an episode in a relationship, and many tasks can combine into a project. Processes will also develop over time, giving phases within processes (McGrath and Hollingshead 1994).

5. Conclusions

Groupware research is at a crossroads, facing both theoretical and practical problems (McGrath and Hollingshead 1994). Controlled studies suggest computers add little to face-to-face (FTF) task performance, while reducing social presence (George, Easton and Nunamaker 1990; Chidambaram and Jones 1993) and the often quoted advantages of computer-supported brainstorming now seem simply by products of this reduced social influence (Casey, Gettys et al. 1984; Pinsonneault, Barki et al. 1999). The benefits of groupware seem mainly to derive from its social deficiencies. We suggest this is because in non-social situations, social processes can be disadvantageous. However most human situations are social, so groupware needs to cope with these as well. The C3P model postulates three distinct internal processes interwoven in group behaviour. Individuals in groups simultaneously resolve task information, relate to others and represent the group. Group interaction usually occurs on three levels at once. The first, and most obvious, involves the exchange of explicit task information. The second uses sender information in the message, especially context cues, to develop and affirm personal relationships. On the third (and least obvious) level, individuals seek information about the group, and carefully "position" themselves to maintain the group as a unit, and themselves within it. If normative influence operates poorly, the group may lack unity and fall apart. If interpersonal relating operates poorly, personality conflicts may side track affairs. If task resolution operates poorly, invalid decisions may be made. Each process has a different purpose and properties. Since favouring one process can disadvantage another, there is no "best" or most efficient

manner of group interaction, because there is no "best" process. Sometimes task resolution is critical, other times relating to others is the key to success, and sometimes the only important thing is that the group stick together. More often, all play a part.

If different situations favour different processes, it makes sense to allow users to "tailor" the interaction environment to their situational needs (Turoff 1991). To design groupware to change the nature of group interaction seems unwise. It seems better to support existing psychological processes, as they are sophisticated enough. The physical world already does this, so one way ahead is to create a cyber-duplicate of the physical world. A more feasible alternative is to simulate the physical world rather than replicating it, and some practitioners may already be doing this (Surrat 1996 May). Simulations are better when based on a valid model of what is being simulated. For example, if group interaction involves three overlapping processes, groupware should support three overlapping processes. The C3P model, if correct, offers a blueprint for groupware design as well as research.

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