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Sensemaking in Virtual Teams:

The Impact of Emotions and Support Tools on Team Mental Models and Team Performance

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Introduction

> *Consider a virtual software development team responsible for developing a web-based tool for a client. Their task is to create a completely new tool that will be custom made according to the client's specifications. The development team meets face-to-face periodically, but most of the time each member of the team works independently. Members of this virtual team typically communicate through electronic media, such as e-mail, chat or shared documents. Initially, different members may hold different mental models about the attributes of the final product and about the development process. But as the project progresses these mental models must somehow converge in order for the project to be successfully completed. They somehow coalesce into a team mental model.*

Building on this example, we integrate research in social psychology on sensemaking with research on team mental models and suggest that the evolution of a shared mental model concerning the project's goals and work processes relies on a recursive triangulation of two cycles: a direct cognitive cycle, in which the sensemaking process is influenced by, but also leads to, the team mental model; and an indirect, emotional cycle, in which individual intuition and emotions influence the sensemaking of team members and the emergent team mental model. We suggest that support tools hold critical influences over both of these cycles, helping to shape the sensemaking and the emotions of the team. We argue that the effects of support tools become particularly important when teams act in a virtual environment in which interactions are mediated by these tools.

We develop this argument by following the example of a virtual team working on the development of new software. We begin with an analysis of the idea and importance of team mental models, and the influence of the sensemaking process on the evolution of such models. We then shift our focus to the interplay between emotions and sensemaking at two levels of analysis (individual and team). Finally, we touch upon the effects of support tools on this interplay.

Mental Models and Shared Mental Models

People navigate their social and organizational environment by developing mental models. These models comprise mental descriptions of system purpose and form, and explanations of system functioning and system states; a model can also include predictions of future system states (Rouse & Morris, 1986, p. 351). Mental models translate reality into internal representations, and these translations guide the way people cope with requirements posed by reality (Park & Gittleman, 1995, p. 303). In this chapter we analyze the evolution of mental models in virtual teams where communication among members must rely on technological means.

As implied in the opening vignette, some sharing of mental models is critical to the functioning of virtual teams. Team members have their own individual mental models that represent their understanding of the team's goals and characteristics, and the connections between their own work and collective actions (Marks, Sabella, Burke, & Zaccaro, 2002). Individual mental models also include prescriptions about the roles and behavior patterns required from each member for successful completion of the collective team's tasks (Marks et al., 2002). So what happens when team members' mental models diverge? Resolving disagreements may be difficult even for actual, physical teams, where members can meet to iron out differences and compare or exchange ideas. How much more so, then, in virtual teams, which are prone to failures in knowledge sharing (Carmton, 2001; Cramton, Orvis & Wilson, 2007; Gratton, Voigt & Erickson, 2007).

Cramton (2002) suggested that key reasons for the problems frequently encountered by virtual teams include the inadequate sharing of knowledge, uneven distribution of information, differences of opinion on what information is considered salient, differences in teammates' rates of progress, and uncertainty about the meaning

of electronic silence. We suggest that these limitations add up to limited (or perhaps, at times, non-existent) overlap of the members' individual mental models. Thus, a key factor determining the effectiveness of a virtual team is the extent to which members' individual mental models come to share elements or overlap with the mental models of other members.

When the individual mental models of different team members are similar, a ***team mental model*** can be argued to exist. A team mental model can be defined as a "***shared, organized understanding and mental representation of the key elements of the team's relevant environment***" (Mohammed & Dumville, 2001: 90). Some authors have spoken of "***shared mental models***" (cf. Cannon-Bowers, Salas & Converse, 1993; Jeffery, Maes & Bratton-Jeffery, 2005; Kraiger & Wenzel, 1997; Marks et al., 2002). We prefer the term "***team mental model***" because, though we accept that such models are created through a process of sharing, we see the model as a quality of the team. When team members share a highly crystallized mental model, they work with a single understanding of each member's roles and responsibilities, and a single set of expectations about the team's needs, goals and constraints (Cannon-Bowers et al., 1993; Weick & Roberts, 1993).

Put differently, team mental models comprise the agreed-upon or convergent understanding that team members hold about the team and its tasks, including their circumstances, constraints and context (Feldman & Rafaeli, 2002). Team mental models both are derived from, and help team members formulate, collective explanations and expectations about the team's work processes; they facilitate communication and coordination of team activities, which in turn help develop and sustain situational awareness (Cannon-Bowers & Salas, 1997; Jeffery et al., 2005; Kraiger & Wenzel, 1997; Salas, Cannon-Bowers & Blickensderfer, 1993; Stout,

Cannon-Bowers & Salas, 1996). A key challenge for the creation of team mental models in virtual teams is the limited and constrained communication inherent to these bodies, and consequently, the limited opportunities for members to share and exchange elements of their individual mental models (Gibson & Gibbs, 2006; Mohrman, Klein & Finegold, 2003; Rico, Sanchez-Manzanares, Gil & Gibson, 2008). This challenge exists with regards to multiple elements or aspects of mental models, because of the limited and constrained communication in virtual teams.

Types of Team Mental Models

Previous research has identified several types of team mental models. Cannon-Bowers et al. (1993), for example, differentiated between four types. ***Task models*** comprise information regarding the task to be performed and related procedures, strategies, and environmental constraints. ***Equipment models*** refer to the tools and equipment required to accomplish the task. ***Team attribute models*** encompass information about the knowledge and preferences, skills, tendencies and abilities of other team members. Finally, the ***Team interaction model*** outlines how team members work with each other. The latter is particularly challenging in virtual teams, where aspects of individual performance (e.g., specific responsibilities assigned to each member) may be clear, but issues arising from interpersonal interactions may be murky and difficult to resolve.

Other scholars have suggested somewhat different, but conceptually compatible typologies. Kraiger and Wenzel (1997) suggested that team mental models comprise three elements: ***knowledge***, ***behavior***, and ***attitudes***. By ***knowledge*** they refer to organized and structured assumptions about the task, process, or reactions to the environment. By ***behavior*** they mean team members' mutual

expectations; and ***attitude*** encompasses interpretations and affective reactions of the team, its behavior in relation to its environment.

Marks et al. (2002) offered a broader conceptualization of team mental models, distinguishing between ***task-work*** and ***team-work***. They defined "task-work" as “a team’s interactions with tasks, tools, machines, and systems” (Bowers, Braun, & Morgan, 1997, p. 90). Task-work represents ***what*** it is that teams are doing. In contrast, team-work describes ***how*** teams are doing whatever they are doing (Marks et al., 2002). Continuing this line of thought, Mathieu, Hefner, Goodwin, Salas & Cannon-Bowers (2000) argued that in order to be successful, team members should be able to perform task-related functions while also working well together as a team i.e., they connect the performance of “task-work” to effective “team-work.” These dynamics, which operate at the team level, depend on the level of similarity between the individual models of different members. Here as well virtual teams are challenged by the limited opportunities to examine the extent of similarity.

What happens when mental models of individual members of a virtual team are not shared? Cronin and Weingart (2007) conceptualized this situation as involving ***representational gaps***, which they defined as “inconsistencies between individuals’ definitions of the team’s problem” (Cronin & Weingart, 2007, pg. 761). They note several ways in which such gaps can cause harm: Gaps can impede social and work processes, decrease coordination, create conflict, and, most importantly, lead to the misuse or misunderstanding of information. Representational gaps are particularly likely to occur in virtual teams, where the representations of individual members typically develop in completely different settings, and contextual effects can create completely different interpretations of the team (Griffith, Mannix & Neale, 2003).

Thus, multiple and different mental models may co-exist in the minds of multiple team members, with individual members of a team themselves likely to hold not one, but multiple mental models (Klimoski & Mohammed, 1994). Furthermore, teams are likely to contain multiple models representing the multiple members of the team. Virtual teamwork in particular occurs against a backdrop of confusing and potentially dissimilar or even incompatible mental models. An important question, therefore, is whether and how individual models converge into a team mental model, and whether and how the shared team mental model influences the outcomes and effectiveness of the team (Gibson & Cohen, 2003). As we elaborate next, the critical issue is the extent to which mental models of different team members are similar, meaning that they have shared or overlapping elements.

Team Mental Models, Team Performance and Team Outcomes

The extent to which the individual mental models of different members are similar can be viewed as an indicator of the extent to which team members work toward common objectives and have a shared vision of how their team will function. According to Mathieu et al. (2000), the existence of a team mental model allows coordinated actions and helps different members be "in sync". This statement implicitly assumes that the existence of a team mental model implies similarity among members' individual mental models. Recognizing this assumption is critical, as otherwise individual members may take for granted that their own mental model is shared by others (cf. Hinds and Weisband, 2003, p. 30).

In virtual teams, a failure to synchronize the mental models of individual members may create process loss and ineffective team processes (Rico et al., 2008). When the individual mental models of virtual team members coincide or overlap, members can anticipate or predict the activities and needs of others; this allows them

to adapt to changing demands, and the team's effectiveness is enhanced (Cannon-Bowers et al., 1993; Mathieu et al., 2000; Rico, et al., 2008). For example, Lim and Klein (2006) report on a field study in which teams whose members structured and organized their knowledge in a similar fashion found it easy to coordinate their activities. And Cannon-Bowers et al. (1993) noted that in order to adapt effectively to changing demands, team members must predict what their other members are going to do and what they need in order to do it.

Indeed, a spate of both theoretical reviews and empirical studies connect team mental models to team effectiveness (Marks, Zaccaro & Mathieu, 2000; Mathieu et al., 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Rentsch & Klimoski, 2001; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). For example, Marks et al., (2000) found that the development of team mental models enhanced team communication and team performance. Marks, et al., (2002) describe experimental studies that show team mental models to be associated with improved backup behaviors of team members and improved performance. And Mathieu, et al., (2005) showed that team processes partially mediate the relationships between the team mental model and team task performance. These effects appear to be particularly salient when team coordination and effectiveness are critical, which occurs primarily with complex or unpredictable tasks (Cannon-Bowers et al., 1993; Marks, et al., 2000).

A key question opened up by this analysis, however, is what it means that "a team has a mental model." A related question is how team mental models can be evaluated. These critical questions have received scant research attention, and clearly deserve a closer look.

Evaluations of a team mental model can refer to two aspects: (1) the ***accuracy or quality*** of the model for the goals or tasks the team performs; and (2) the ***similarity or overlap*** between the models held by different individual members[1]. In one of the few published discussions on this question, Marks, et al. (2000) argued that these factors (accuracy and similarity) interact in their effects on team performance. They further argued that the relationship between similarity and performance is stronger when teams hold mental models that are of relatively poor fit to the task; that is, when the members' individual mental models are all highly accurate, or well fit to the task, small differences between them become less important. This suggests that the two features (accuracy and similarity) are not fully independent, since with certain (e.g., highly accurate) models, similarity does not need to be sought or assessed. Striving for similarity becomes essential when the individual mental models of some team members are more accurate than the mental models of others.

In order for a team to develop a highly accurate (sometimes referred to as high-quality) team mental model, the sensemaking of different individuals must somehow be managed and navigated toward the more accurate model. This process depends on sense making of individual team members, but regards the extent of similarity of the emergent mental model that the sensemaking performed by different team members evokes. However, different team members may continue to hold differing individual mental models, even as a team continues to work toward a common model. This is particularly likely in a virtual team where individuals work independently and only periodically have the opportunity to compare their own assumptions (i.e., mental models) to those of others (Hinds & Weisband, 2003).

[1] Different concepts can be used to refer to this idea – we use the concepts of similarity, overlap and convergence of mental models interchangeably.

Thus, individual mental models (relating to the team's tasks, attributes of members, or team processes – i.e., the "what" and the "how" of the team's work) may continue to govern the behavior of team members, even if a certain team mental model has emerged. A full assessment of a mental model of a virtual team must therefore begin with an assessment of the types of mental models held by members of the team. It must then continue with an assessment of (i) the accuracy or appropriateness of each of these models, and (ii) the extent of these models' similarity[2].

Conducting such an assessment is complicated, however, and is another issue that has received insufficient research attention. Mathieu et al. (2005, p. 53), among the few to approach this question, suggested the following steps: (1) Assess the mental models held by a wide range of team members; (2) Cluster the models identified into similar types; (3) Determine the member quality or expertise that relates to the identified model; and (4) Consider the identified quality or expertise as a critical issue for indexing the team mental model.

Using this process in an empirical study, Mathieu et al. (2005) showed that the quality of both task and the team-process models were positively related to subsequent team process and task performance. In this study, team process partially mediated the relationship between the quality of the team mental model and team outcomes. In an earlier study (Mathieu et al., 2000), the quality of the model fully mediated the relationship. In other words, a convergent and accurate team mental model creates an effective team process which in turn leads to effective teamwork and task performance. Similarly, Lim and Klein (2006) reported on a field study that

[2] As noted earlier teams can have multiple types of models, such as a task model and an interpersonal model. Some elements of the models may be shared by all members and some may be maintained only by some or even one of the members. Likewise, some elements of each model may be accurate and some inaccurate.

assessed teams with regard to their teamwork and task work. Similarity of members' individual mental models of teamwork and task work predicted team performance.

However, as Lim and Klein (2006) note, except for the few studies described above, far too little research has explored the antecedents of similarity, accuracy or convergence in team mental models. Based on our review of available work, we call for additional examination of the impact of quality (accuracy and similarity) of a team mental model on team performance. We offer the prediction that team mental models characterized by greater accuracy and greater similarity allow members to anticipate how others will act and what support they will require, thus enhancing coordination and trust and reducing conflicts.

A key question this prediction opens up is how and under what conditions teams are likely to develop team mental models that can be characterized by greater accuracy or similarity. We contend next that collective team sensemaking is a critical prerequisite to these important outcomes.

Sensemaking

> *Each member comes to the team with certain conceptions, which are likely to be based on prior experiences and to be somewhat detached from the current project context. As they begin to work on the project, team members interact and learn about the conceptions of others, while also conveying their own. Through such interactions, team members also develop a mental picture of the environment in which they are working and may come to identify various constraints on the project work. Gradually, members develop a more refined understanding of the project, the project team, and the project environment; this acquired learning leads them to revise their individual mental models of the project and the team. Through recurring interactions the mental models held by different team members are likely to converge, leading to the evolution of a team mental model. This model may be more or less accurate for the task at hand, and may be more or less accepted by different team members. The extent of accuracy and the extent of agreement depend on various features of the people involved, but also on the tools and processes that they use as a team.*

Sensemaking – a concept introduced by Weick (1979; 1995) – is a critical term for understanding the emergence of individual understandings, or individual mental models, and their interplay with team mental models. Weick's analysis portrays organizational work as a stream of ongoing and unpredictable experiences in which people search for answers to the basic question of "***what's the story***?" (Weick Sutcliff & Obstfeld, 2005: 410). The cumulative answers to this question (which Weick labeled "Interpretation") lead to the development of cognitive mental models of a given work situation (Weick & Daft, 1983). Thus, as Hill and Levenhagen (1995) note, sensemaking is the process of the development of mental models. And as Nosek and McNeese (1997) explain, sensemaking is what allows decision makers to update their metal models and construct their knowledge of a given situation, which ultimately influences behavior.

The connection between sensemaking and team mental models has received some empirical research attention. For example, sensemaking was suggested to explain the development and communication of a new vision (which can be viewed as a new mental model) of a given business environment. Hill and Levenhagen (1995) specifically suggested that people first hold intuitive (affective-based) models of a given business environment, and then refine this view into formalized individual mental models as they learn more about the business. The refinement and formalization process relies on verbal or physical metaphors, which help individuals to articulate the parameters or elements of a situation (Weick, 1979).

The idea of sensemaking raises the important point that people are active agents in the creation of perceptions and assumptions that become the constraints and opportunities for their own thinking. Such constraints and opportunities are also important for other people with whom an individual works, as members of the team

may be influenced by or come to adopt the assumptions held by others. People are not necessarily cognizant of the sensemaking process, since retrospective sensemaking can occur; in retrospective sensemaking people can know what they are doing (and others may know what they have done) only after it was already done as well (Weick, 1995). For example, certain conceptions and actions may promote or stall an issue, but people may realize that such promotion or stalling occurred only after the fact. Leadership or other forms of guidance are essential influences over sensemaking, because people are likely to be overwhelmed by too much information, and spelling out values or priorities can help clarify the appropriate course of action (Dutton & Jackson, 1987; Weick, 1995).

In virtual teams, the sensemaking process takes place against the backdrop of a unique set of challenges. Information regarding the work context of team members is not easily available to members of a virtual team (Cramton, 2001; Hinds & Weisband, 2003), and members are often in ignorance of others' actions (Gutwin & Greenberg, 2002), which can lead to attribution errors. Cramton et al. (2007), for example, reported that members of virtual teams are more likely to make internal dispositional attributions, opposed to members of collocated teams that tend to make situational attributions, about the negative behavior of team partners. Cramton and colleagues (2007) attributed this to situation invisibility in virtual teams, and the limitations this imposes on information sharing[3]. Such attributions in virtual teamwork are a key part of what Weick defined as the interpretation element of sensemaking, and they set the stage for and influence the later stage of sensemaking – enactment.

[3] Sharing information about the work context of individual members can help develop mutual understanding (Fussell & Krauss, 1992) and help establish common norms of behavior of different (and geographically distant) team members (Hinds & Bailey, 2003). It may also help reduce conflicts in a virtual team (cf. Hinds and Mortensen, 2005).

Available analyses of mental models and of sensemaking have focused primarily on the cognitive part of the process. Yet as Hill and Levenhagen (1995: 1071) note, mental cycles are born in the minds of individuals as ineffable concepts with emotive content. Consistent with Weick's (1995) analysis, various episodes in a team effort are likely to evoke new emotions – making them, as Weiss and Cropanzano (1996:93) put it, "affective events," which in turn are likely to lead to modifications in team members' original mental models.

Another element that can provide a basis for shared understandings and a common pattern of meanings – that is, a team mental model – is the use of common work tools. Such tools can help promote communication and the sharing of information among different team members, helping to define the mental models in a virtual team and to improve their accuracy. We will discuss these tools later in this chapter.

The process of repeated sensemaking and emotion cycles continues to refine and ultimately defines the team mental model and team performance. In the remainder of this paper we describe and analyze this process in greater detail. A critical feature of the process that must be recognized up front is its recursiveness: Team mental models influence the sensemaking and the emotions of team members, but at the same time are also influenced by them (Jeffery et al., 2005). Built into the idea of sensemaking is active and continuous change in the team mental model: A virtual team working on a given task will face and interpret a new situation by calling on the existing mental model or models. The new situation ***ignites*** sensemaking, leading to ***interpretations*** that determine team members' behavior, or ***enactment*** of the new situation.

The results of a given sensemaking episode – the interpretations and behaviors it evokes – provide new information to team members. This new information ignites a new sensemaking process, in which members examine and compare their own assumptions and behaviors to those of others. The new sensemaking process will likely lead to modification of the team mental model, as different members come to see aspects of their mental model as inappropriate, or learn about how others view things. Such learning ignites further sensemaking, and through interpretation and enactment produces further refinement in the team mental model.

Thus, multiple team members are both influenced by and influential over the emergent team mental model. The team mental model is as much a product of the task at hand as it is a product of the interactions among team member. Individual team members working on their specific tasks are engaged in individual-level sensemaking, which leads to personal understandings and personal mental models as eloquently described by Weick and his colleagues (Weick, 1979; 1990; 1995). At the team level, individual mental models coalesce into a team mental model, which influences the way the team works and the team outcomes (Donnellon, Gray & Bougon, 1986; Klimoski & Mohammed, 1994).

However, the socially inspired process of sensemaking in a virtual team implicitly presumes a flow of communication and amicable social relations among team members. The diversity of team members, or the distance between members of a virtual team, may hamper such relations. Dahlin, Weingart and Hinds (2005), for example, found that when teams are functionally diverse, integration of information – which they define as the making of logical links between items of information – is more difficult to achieve. Such creation of linkages between individual information bits is paramount to the creation of a team mental model. In a similar vein, when

relations are stressed, untrusting or conflict-ridden, the sensemaking process is impeded (cf. Dunn & Schweitzer, 2005) which would influence the emergent team mental model.

Emotion and Sensemaking

> *Team members working on a project encounter a bug in the system they have developed, and one member expresses frustration and anger. Other members interpret this to mean that they are being held responsible for the problem, and they get angry as well. The resulting social disconnect among team members makes each one more resistant to accepting suggestions or ideas for change from his or her fellows; in other words, members remain committed to their own initial mental models. This reduces the synchronization of the mental models of different team members and increases the risk of errors or inaccuracies in the product.*

The link between sensemaking and emotion has been discussed explicitly in only a handful of studies (Maitlis, Vogus, & Lawrence, 2008; Myers, 2007; Rafaeli & Vilnai-Yavetz 2004). Yet, as Maitlis et al. (2008) aptly noted, emotion has always been hinted at as the motivation behind sensemaking in all its stages: the ignition, the interpretation and the enactment. Recently, Rhee (2007) has stated that the mechanisms behind the influence of group emotion on performance are still mostly unexamined. In this theoretical paper we suggest that sensemaking and group mental models is one of the mechanisms that link between group emotions and performance.

As suggested by our brief illustrative story, the relationship between affect and emotion is reciprocal and dynamic. Specifically, three complementary dynamics can connect emotion to sensemaking:

(1) ***Emotion (and in particular arousal[4]) is a cause of sensemaking.***

Sensemaking is triggered when a situation involves something out of the ordinary (like the bug in the vignette above) – an event or action that attracts attention through being puzzling, startling or unexpected (Weick, 1990, 1995; Weick, et al.,

[4] Arousal is commonly presumed to be a key aspect of emotion, meaning that the level of arousal differentiates between different emotions (cf. Russell & Feldman-Barrett, 199; Russell & Pratt, 1980.)

2005). Such events create arousal, which we recognize as curiosity or a need to interpret what has happened (Gioia & Thomas, 1996; Maitlis et al., 2008; Weick, 1995). Being central to emotion (cf. Russell & Feldman-Barrett, 199; Russell & Pratt, 1980), arousal connects emotion to sensemaking. High-arousal emotions (e.g., fear, anger, or frustration, but also joy and happiness) can be presumed to inspire a search for interpretations, thus evoking the sensemaking cycle described above.

(2) ***Emotions serve as information that influences sensemaking.*** Emotions can serve as an intrinsic cue about how one should judge a situation (Schwartz & Clore, 1983); emotions thus act as a source of information (Albarracin & Kumkale, 2003). Schwartz and Clore (1983; 2007) explicitly identified the *feeling-as-information* model, which suggests that people interpret the environment in part by reading their own affective states. Emotions influence not only how people interpret the environment but also the type of information processing tactics they employ (Chartrand, van Baaren & Bargh, 2006) and the decisions they make (Forgas, 1998).

In our opening story, the anger and frustration expressed by one member of the team was interpreted by others to be an implicit accusation, and an act of disassociation from responsibility for the problem. In other words, in the sensemaking process, the emotions of others can be considered information regarding those others' goals, inclinations, reactions, and likely future behaviors (Ashkanasy, Hartel & Zerbe, 2000; Rafaeli & Sutton, 1989, Riggio, 2001), and can also influence the emotions and attributions of other team members (Hareli & Rafaeli, 2008). Sensemaking goes wrong when emotions are misinterpreted; the anger of the person in our vignette could have been directed at himself, or at people outside the team, rather than at the other team members.

The valence[5] of the emotion that a situation evokes – whether positive or negative – will influence how the situation is interpreted (Russell & Pratt, 1980; Russell & Feldman-Barrett 1999; Watson, Clark & Tellegen, 1988), feeding behaviors and attitudes such as trust, cooperation, self-defense or aggression. An event might cause excitement (a positive emotion) or fear (a negative emotion), each leading to a specific set of interpretations and actions (Hareli & Rafaeli, 2008): evoked fear would lead to retreat from the situation, while evoked happiness and excitement would likely prompt greater connection. These behaviors are part of the enactment of the way the situation is interpreted, meaning they are part of the sensemaking process.

In other words, negative feelings such as anger, guilt, or anxiety are likely to be interpreted as a cue that there is some kind of a problem, and therefore to inspire more focused processing (or intensive sensemaking) (Tiedens & Linton, 2001). However, feelings of threat or risk have been shown to stifle thinking and create rigidity (Staw, Sandeland, & Dutton, 1981), making people less likely to revise their mental model of a situation. Note also that negative emotions do not necessarily inspire greater accuracy: sadness has been shown to impair the accuracy of various judgments (Ambady & Gray, 2002).

In contrast, positive feelings (happiness, joy or calmness) are subconsciously viewed as cues that everything is going well and that there is no need to be on guard (Loewenstein, Weber, Hsee & Welch, 2001). In such cases the unconscious tendency is not to engage in deep processing but rather to continue with the present course of action, or even expand into new terrain (Fredrickson, 2001; 2003). Thus, individuals experiencing positive emotions are likely to be open to new ideas and to allow expansions of the team mental model.

[5] Valence is the second critical aspect of emotion, distinguishing between positive emotions (e.g., happiness, joy, calmness) and negative emotions (e.g., anger, guilt, anxiety or sadness) (cf. Russell & Feldman-Barrett, 1999; Russell & Pratt, 1980.)

The extent to which emotions influence sensemaking may depend on the nature of the mental effort people invest in a situation (cf. Forgas, 1990, 1995). Forgas' analysis focused primarily on the individual level, but has been found relevant for the team level. For example, Forgas (1990) reported on a laboratory experiment that showed group affect to influence group judgments. In this study the valance of the affect of group members (positive or negative) was related to the extent to which groups adopted decisions that were more extreme than individual decisions (Moscovici & Zavalloni, 1969). When team affect was positive, decisions were positively polarized (meaning that they were more positive than when the same judgments were made by individuals alone). Negative affect did not evoke a parallel negative polarization effect, and Forgas (1990) suggested that the asymmetry may be due to the influence of negative affect on communication within the group. Since negative affect decreases communication, it did not influence the group outcome.

Similarly, Forgas & George's analysis (2001) suggests that team emotion influences the way teamwork unfolds, since teamwork is likely to involve situations that are relatively abstract and interpersonally complex. Extending Forgas and George's findings, in teams that handle more complex information and more complex processing the influences of affect over the team sensemaking process is likely to be stronger.

Part of the information conveyed by emotion relates to the emotions felt by other people in the team. Emotions tend to be "contagious" (Barsade, 2002; Hatfield, Cacioppo & Rapson, 1994), spreading between different members of the same team (Barsade, 2002) and converging in groups that work together (Totterdell, Kellett, Teuchmann & Bringer, 1998; Totterdell, 2000). Such contagion and convergence in

team emotion occurs even among members of virtual teams who interact only through electronic and verbal channels (Rafaeli, Cheshin & Israeli, 2007).

For people working together in a team, others' emotions may therefore become events that convey information and trigger sensemaking. Emotions are social entities, (Hareli & Rafaeli, 2008) meaning that not only the emotions one feels but also the emotions one observes in others provide cues regarding one's surroundings. The frustration and anger expressed by one member in our example above is a signal to others that there may be a real problem which needs to be addressed, adding an important element to the team mental model. If no one had expressed these emotions, team members might have converged on the assumption that the identified bug was "not really a problem".

Most profoundly, emotions ignite interpretations regarding communication. Positive emotions attract and connect people within a virtual team, while negative emotions create exclusion and social distance between team members (cf. Ratner, 2000). For this reason, emotion can be assumed to ignite interpretations about the extent of cohesiveness of the team (Lawler & Yoon, 1996). Barsade (2002) found that displays of positive affect by one member were enough to create more cooperation and greater success within co-located teams, and Rafaeli et al. (2007) extended these findings to virtual teams. When team emotions are positive, people may feel a greater sense of affinity to other team members, increasing their willingness to listen to and learn from other people and causing their mental models to converge. Positive team affect, therefore, can be predicted to create what Cannon-Bowers and Salas (1997) and Marks et al. (2002) labeled as the group mental model about team-work. Thus, individual emotions and team emotions can influence the quality of the emergent

group mental model regarding group process and teamwork. However, research on the nature of these linkages is lacking.

(3) ***Emotional reactions to certain interpretations of a situation trigger future sensemaking***. Interpretations of events are known to be a source of emotion (Ortony, Clore & Collins, 1988; Smith & Ellsworth, 1985). Sensemaking can therefore evoke certain emotions, which would then influence subsequent sensemaking following the two dynamics discussed above. For example, a person who blames a problem on the supposed negligence of a colleague might feel anger, whereas someone taking the responsibility on himself would feel guilt (Smith & Ellsworth, 1985); each emotional state will lead to a further, different sensemaking process. Sensemaking itself is likely to bring about a sense of composure or relief (Pennebaker, 2000) simply by virtue of resolving a question or bringing understanding to a situation (Weick, 2005). Moreover, the particular type of understanding produced by sensemaking of a situation – the content of the inferences – might itself evoke emotion. To illustrate, organizational layoffs are likely to trigger some anxiety: people may feel a sense of relief if they are not laid off, but also sorrow about losing their peers and fear about what the future may hold (Maitlis & Ozcelik, 2004). Each of this series of situations – the initial layoffs, learning that one still has a job but that others have left, the realization that one may still be laid off in the future – evokes emotions.

In virtual teams the interpretation of events was shown by Cramton et al. (2007) to create attributions about teammates, which can evoke emotions toward these teammates. Suppose, for example, a teammate is said to not have completed assigned work; attributing this to laziness would likely lead to anger (Smith and Ellsworth,

1985). But if it was known that this teammate had recently experienced a death in the family, fellow team members might feel sympathy rather than anger.

Virtual teams may also experience series of events as in the example of layoffs above, in which case a series of emotions may unfold (Ashforth & Humphrey, 1995; Weiss & Cropanzano, 1996). Indeed, as noted by Ashforth, Keriner and Mel (2002), routine work is saturated with transitions between events. Each transition creates a general sense of arousal, which, as noted earlier, would ignite interpretations and enactment and inspire modifications of a former mental model. Subsequent events would then continue to refine the content of the mental model (e.g., Do team members think their fellows will do their share of the work? Do they trust the other people in the team?), the accuracy of the mental model (e.g., Will team members actually do their share of the work? Are team members indeed trustworthy?), and the similarity or agreement between different members regarding the mental model (e.g., How many people trust other members of the team?).

Since members of virtual teams often rely on electronic means of communication, they have limited access to information about other team members, and misattributions are likely to occur (Cramton et al., 2007). Communication patterns that "screen out" certain members from team interactions constrain their social information and interpersonal exchanges, which can make the influence of emotional content more or less efficient and accurate (Gibson & Early 2007).

In short, here as well a reciprocal and dynamic relationship exists, this time between emotion and sensemaking: emotions evoked by interpretations of a situation guide further interpretations, which in turn guide individual actions, creating a new reality that can ignite new interpretations, in a process that Hareli and Rafaeli (2008) labeled "emotion cycles." These cycles are critical to emergent team mental models;

they operate behind the scenes and influence the sensemaking process through which team mental models develop. The accuracy of a team mental model will be influenced by the emotions in the team, as will the degree to which the mental model is shared, since certain emotions are more likely to inspire attraction, communication and sharing.

Thus far we have argued that the development of a team mental model depends on the sensemaking of team members, which itself both arises from and triggers the emotions of team members. A question this analysis begs is what can be done to improve the sensemaking process to evoke more positive emotions and more accurate team mental models. In the final leg of our argument, we suggest that the work tools used by a team can facilitate the sensemaking of team members toward the emergence of a more accurate and more convergent team mental model.

Tools to Support Sensemaking and the Development of Team Mental Models

> *Members of our virtual team work in three geographical locations. They have developed a routine of weekly virtual update meetings in which each member reports on his or her progress and problems, and they maintain a project wiki in which they can all add or edit entries. They also use shared documents that describe their work plans and progress. These documents are saved on-line which makes them available for periodical retrieval, reading and updating by members of the team. These tools provide members with a clear sense of the goals and progress of the project and of the views and progress of other team members. Members learn about how others view things, and adapt their assumptions and expectations accordingly.*

Multiple tools and procedures can support team efforts. Generally, support tools need to be assessed according to the extent to which they allow or facilitate collaboration among multiple team members. Virtual teams may suffer from insufficient shared experiences and less information sharing, most likely leading to less shared understanding (Hinds & Weisband, 2003). We suggest two key categories of tools that we believe can promote more effective construction of a team mental model: communication tools and information sharing tools.

1. Communication Tools

Communication is a key to team sensemaking, since team members need a window into other members' thoughts and perceptions in order to adapt their own, individual mental models (Hill & Levenhagen, 1995; Nosek & McNeese, 1997; Urch Druskat & Pescosolido, 2002; Weick et al., 2005). Communication among team members has been argued explicitly to facilitate the development of a team mental model (Jeffery et al., 2005). Through communication with other team members people can learn about the thoughts and perceptions of other members of their team, which provides a window into the individual mental model of other members. Without communication people continue to work within their own, personal mental models, and no similarity or convergence of the individual models will occur.

Communication tools influence the cues and information available about the mental models held by other people. Daft and Lengel (1986) proposed a theory on the *information richness of communication tools*, in which they connect the characteristics of different communication tools to the ambiguity or accuracy of the information they can convey. Media richness, according to Daft and Lengel (1986), is based on the quality of information conveyed by an interaction, which is assessed through four parameters: availability of multiple cues, use of natural language, availability of feedback, and availability of a personal focus.

Following Daft and Langel (1986), communication tools that are “rich”, such as web conferencing and video conferencing, allow use of natural language, provide feedback, and allow for personalization. Tools low in richness, such as a-synchronized text (e.g. letters or email) fail to provide one or more of these and according to Daft and Lengel (1986) create greater ambiguity. Thus, media-rich tools improve communication and increase the probability of an accurate understanding

between different team members, while media-poor tools increase the likelihood of inaccurate interpretations and flawed mental models. Supporting this analysis, Straus (1996), for example, found that virtual teams that relied on text-based electronic media exchanged about half of the words of teams communicating verbally and face-to-face. The social information that is left out of such messages was argued by Cramton and Orvis (2003) to be critical for the development of a team mental model.

With richer communication tools, less time is needed to resolve disagreements or misunderstandings. Rich communication tools enable a transfer of information that improves awareness of the real-time activities of others. For instance, use of rich communication tools enables collaborative partners to easily view or even create together the same work plans, flow charts, or product sketches. Such shared viewing is known to improve the evolution of shared understanding of the issues under discussion (Damian & Zowghi, 2003; Gutwin & Greenberg, 2002; Larrson, 2003). Similarly, Bell and Kozlowski (2002), propose that as complexity, dynamicity and challenge of tasks increase teams will adapt richer media.

Since sensemaking and the development of a team mental model necessarily rely on the availability of information to different team members, the richness of the communication media that team members can use, and the frequency with which such tools are used, clearly influences the quality of the emergent team mental model. Rich communication can improve clarity and understanding among team partners, thus improving the similarity or congruence of the team mental model (Cramton, 2001).

Consistent with this analysis, Cramton et al. (2007) have shown the downside of communication media that are low in richness. People interacting through computer-mediated communication were shown in their studies to maintain a

dispositional rather than a situational interpersonal attribution. Dispositional attributions tend to stifle team cohesion and members' willingness to adapt their conceptions to those of others, suggesting that low-richness communication tools are not likely to benefit the team mental model. For example, unlike the vignette described in our opening of this section, in a team relying on communication with low richness individuals are likely to conclude that team members located at another location are unreliable and uncommitted to a joint project, even if local technological failure do not allow other members to make progress. In addition, with media-poor communications, feedback is limited and delayed (Byron, 2008), leading to increased ambiguity and misunderstandings which can stifle sensemaking and hamper the quality of the team mental model. In this vein, a team's ability to exchange ideas, to plan, and to reach consensus was shown by Kayworth & Leidner (2000) to improve when the information richness of the support tools they used became richer. Finally, work teams that rely primarily upon tools low in communication richness are less likely to use relational communication and thus less likely to perceive each other accurately (Walther, Anderson & Park, 1994) – and therefore less likely to narrow the gaps between their respective mental models. Similarly, the use of leaner communication tools may impede the emergence of an accurate mental model because of the lack of feedback. Byron (2008) for example suggests that the lack of synchronic feedback when using email is due to less information available to team members, which hampers the accuracy of the interpretations of the situation. This is true, especially when a team's task is complex, rich communication tools are essential to help teams converge on a high-accuracy mental model (DeLuca & Valacich, 2006). In this vein, a team's ability to exchange ideas, to plan, and to reach consensus was

shown by Kayworth and Leidner (2000) to improve when the information richness of the support tools they used increased.

However, research on the extent to which (and under what conditions) rich communication tools improve the sensemaking process and the quality of emergent team mental models is very limited. Especially lacking is empirical research. The key question identified by our analysis is what communication tools are likely to make a team mental model more accurate or appropriate for the team task, and which communication tools would induce more sharing or more convergence of the team mental model.

2. *Information-Sharing Tools*

A second category of tools that can promote the development of high-quality team mental models comprises technologies that enable the sharing of work plans, progress reports and budget plans without rich communication. This category includes repositories in which shared files are stored and maintained, organizational wikis that allow sharing of discussions, documents and other textual information, organizational portals, web-based project management tools, etc.

Effective teamwork relies on suitable use of information sharing (Cramton & Orvis, 2003). Information-sharing tools ensure that team members are working toward the same plans and goals and have access to updated information on the project (cf. Orlkowski, 2002). They also allow team members to work on the same artifacts (such as source codes or documents). Thus, information-sharing tools can enhance the ability of team members to understand ***what*** others are working on, as well as ***how*** or **why** they are working on it. In other words, information sharing tools help people obtain a closer understanding of the mental model of other team members, namely the way other people view the team effort and context (Mohrman et

al., 2003), including the team goals (Bolstand & Endsley, 1999) and work processes (Cramton, 2001). These dynamics are particularly critical in virtual teams, where remote teammates have a hard time observing and obtaining important situational information about other members.

For example, information sharing tools can allow team members to see the work charts of the team, which include an indication of the progress of all the members of the team in the joint project. Such a view of all team members affords a better understanding for members of the rate of progress, constraints and progress of all other members, and of the team as a whole. Such an understanding improves the chances that different team members will develop a similar view on the project. At the same time, a development of a common understanding through information sharing tools decreases the chances of some major flaws in the individual and team mental model because the perspectives of all team members are integrated.

Thus, information sharing tools improve a team's ability to develop a high quality team mental model. Tools that open up information so that it is available to everyone make it more likely that individual sensemaking takes place within a common framework or context (Larsson, 2003). When the sensemaking of individuals is based on the same information base, they are likely to interpret the work structure and processes in more or less the same way (Damian, Lanubile & Mallardo, 2006). And ensuing enactments – behaviors following a certain interpretation – is also likely to be more in synch, because the point of departure of everyone involved is the same. Information sharing tools thus also increases the accuracy of perceptions, because the information stored reflects the knowledge of all team members (Damian & Zowghi, 2003), and offers an archive of common knowledge that can be reviewed and corrected by all (Myers, 2007). Successful leadership of virtual teams can assist in

the sensemaking process by creating explicit structure and routines for the team tasks (Bell & Kozlowski, 2002).

Information sharing has advantages even over rich communication in that the former allows information shared earlier to be easily accessed at any point throughout the project's life. (This is the critical difference between simply holding an electronic discussion over an unresolved issue, and storing inputs from multiple exchanges about this issue on an electronic board which allows people to view multiple posts). In this vein Hinds and Weisband (2003), for example, recommend using on-line team spaces and sharing information about day-to-day activities to facilitate shared understanding in virtual teams.

Project management tools such as Microsoft Project standardize project work by providing templates and guidelines for action. Such tools help establish a shared perspective on a project and its plans, status, and deliverables by providing a common framework and set of work practices. Hence, the use of project management tools can enhance the development of similar understandings (Engwall, Kling & Werr, 2005), or greater similarity between individual mental models. The use of such tools also improves accuracy of the team mental model because it helps team members understand who is working on what part of which system, where, when, and how, and increases the probability of correcting misaligned individual efforts (Orlikowski, 2002). Such tools also help develop a common language (Engwall et al., 2005) or a standard glossary (Smite, 2006) for a work team, both of which enhance the shared understandings among members of the project team.

The use of team support tools further reduces the probability of coordination faults or uneven distribution of information (Hinds & Mortensten, 2005, Cramton, 2001). Similar to the case that our opening story portrayed, Orlikowski (2002) argued

that use of information sharing tools that enable collaborative planning can improve team coordination and can help team members overcome their respective adaptation difficulties. Such tools also allow easier and quicker resolution of conflicts (cf. Qureshi, Liu & Vogel, 2006).

In short, information sharing tools enhance coordination and synergy of virtual teams, which can help improve the quality (accuracy and similarity) of the team mental model. Both models regarding the team task – the ***what*** (goals, constraints, and tools) and models regarding the team processes -- the ***how*** -- are likely to be more accurate and more similar when information-sharing tools are put to good use. However, here as well the empirical research on which we could rely for our analysis is very limited. We use this platform to call for additional research on whether, when, and how the use of information-sharing tools can lead to more refined and focused sensemaking. Particularly essential is research on the influence of the use of these tools over the quality of the emergent team mental model and ensuing team performance.

Support Tools and Emotions

> *One of the team members, Lucy, believes that she has put in effort and achieved results above and beyond her assigned role. Another team member, John, posts a notice on the team forum stating that the Lucy has done a good job but there is a lot more work to be done. Paul posts a notice to the effect that the deadline is approaching and there is a need for intensive effort from all team members. Lucy feels that her efforts have not been sufficiently recognized and that she is not getting the respect she deserves. The other members of the team feel anxious and stressed by the approaching deadline despite the fact that the project is going as planned. Lucy relieves her frustration by withdrawing from the team and paying more attention to her own work. The other members get angry at Lucy, and a general air of alienation takes over the team, causing them to lose their stamina and fall behind schedule. A member who realizes what is happening suggests a two-day retreat in which members can air their concerns.*

The effects of team support tools –both communication tools and information sharing tools – on sensemaking and ensuing mental models may also occur through

their effect on emotion. These effects have received the least amount of research attention, but they are another critical leg of our argument, an additional channel of influence over sensemaking and team mental models. Drawing on a very limited body of literature we briefly suggest the effects of communication tools and information-sharing tools over emotion separately.

Communication Tools and Emotion. Expressing and understanding emotions has been argued to be heavily reliant on non-verbal cues (such as facial expressions, direct gaze, tone of voice, etc.) (cf. Critchley, Rotshtein, Nagai, O'Doherty, Mathias, & Dolan, 2005; Ekman, Friesen & Ancoli, 1980; Kock, 2005; Mehrabian, 1972). Communication tools vary in the degree to which they enable non-verbal cues; yet even where these are limited, emotions are still argued to have an effect (cf., Byron & Baldridge, 2005). Research suggests that users of text-based support tools communicate emotions to others, intentionally or not (Thompsen & Foulger, 1996; Walther & D'Addario, 2001). And emotion plays a role in how people interpret various messages, and the judgments they make (Forgas, 1995).

In regard to sensemaking, it has been found that in the absence of clear cues about the emotions of others, individuals are likely to fill in seeming gaps with information that they draw from a cognitive schema (Brewer & Treyens, 1981; Meindl, Stubbart and Porac, 1996). Studies have shown that individuals can and do express emotions in text-based support tools (email and instant messenger), though attempts to convey emotions are often misinterpreted (Byron, 2008). Findings regarding the interpretations of emotions in text based communication suggest a severe risk of miscommunication. Byron and Baldridge (2005), for example, found that the interpretation of emotions could be highly inaccurate, with the same cues at times perceived as representing completely different, and potentially contradictory

emotions (for example, the length of a message was perceived as indicating both happiness and anger).

Yet there is some indication that verbal exchanges can offer valuable and relatively accurate emotion information. Hancock, Landrigan, and Sliver (2007) reported that individuals had no difficulty expressing negative and positive affect in a text-based medium and that the affect was accurately perceived by recipients. Hancock et al. (2007) also showed that how messages were delivered (or how an emotion was displayed) differed significantly as far as amount of text, the use of affective terms, punctuation and even the pauses between responses. Additional confirmation that people can infer emotion from text is afforded by the high degree of agreement typically observed when raters are asked to identify the affect in texts (Bestgen, 1994; Mossholder, Settoon, Harris, & Armenakis, 1995).

However, the fact that people can identify affect in text does not mean that the affect which textual communications create in team members is a valid representation of the sender's intent. Email is an example of a communication tool that is very commonly used and that relies on text-based communication with very limited non-verbal cues. Byron (2008) provided a theoretical examination of the emotional influences of email, and noted two important biases in e-mail reading, which she labeled *neutrality* and *negativity*. In the ***neutrality effect*** Byron refers a decrease in perceptions of positive emotions in texts; in the ***negativity effect*** Byron refers to an increase in the perceived intensity of negative emotions in texts. Offering some empirical support for the negativity effect, Walther and D'Addario (2001) found that negative cues tend to override other cues in computer-mediated communication.

A key problem with most forms of communication open to virtual teams is the lack of traditional nonverbal cues. One category of cues that is available and can be

used to express – or at least attempt to express – emotion is para-verbal cues. In spoken language, para-verbal refers to tone of voice and intonation (e.g., speaking in a loud voice conveys more anger). In written text para-verbal cues may include the use of punctuation, use of capital letters, and emoticons. Initial research indicates that the use of these cues is inconsistent in text-based communication (Rezabek & Cochenour, 1998; Witmer & Katzman, 1997), since norms regarding the use of para-verbal cues in writing have not yet developed. It appears, therefore, that such cues cannot be reliably used by team members to interpret the emotions of their teammates, or to judge the appropriateness of their own emotional reactions.

In short, research findings are only beginning to accumulate and thus far offer insufficient understanding of the relationship between communication tools and emotion. With more text-based communication some biases seem to exist, but not a lot more can be said. Going back to the relationship between emotion and sensemaking, there does appear to be another channel whereby communication tools influence sensemaking: Clearly some dynamics connect the type of communication channels and tools used to the emotions that team members feel. But findings are too preliminary and limited, and another call for additional research is in place.

Information Sharing Tools and Emotion. When members of a virtual team are limited to computer-mediated communication they are deprived not only of nonverbal emotional cues, but also of cues about the social context or social status of other members of the team, and the lack of these cues can have a substantial influence over social interactions among team members (Owens, Neale, & Sutton, 2000; Sproull & Kiesler, 1986). The effects of status differences that typically guide and govern social interactions can be erased, for example, if people do not have any information about social status. People may also draw various conclusions about other

members, forming various attributions. However these attributions may suffer from biases: A lack of context and interaction information was argued by Cramton (2001) and Kankahalli, Tan and Wei (2007) to increase the extent to which people make personal attributions in interpretations of conflict situations. With more personal, rather than situational attributions, the nature of emotions elicited is likely to be different, as are ensuing emotion-sensemaking and sensemaking-mental model cycles.

For example, if a problem arises in a virtual team, people are likely to draw inferences and make attributions for the reason or cause of the problem. While the real reason may be situational or contextual reasons (e.g., technology failure, staff shortage), a lack of rich-media communication is likely to lead people to make personal attributions (e.g., poor motivation or poor ability of the team members in whose domain the problems occurred). Following these personal attributions emotions of anger are more likely to surface, rather than empathy or solidarity that an understanding of the situational causes may have evoked.

Members of virtual teams are likely to hold uneven information about various issues, in addition to the cultural and organizational differences that set them apart. These multiple differences are likely to lead to different interpretations of the same project issues (cf. Cramton, 2001; Hinds & Weisband, 2003). Such conflicting interpretations may escalate to interpersonal conflicts that involve negative emotions. Lacking awareness of the activities and constraints of others reduces the sharing of common contexts and can lead to different interpretations of events related to task execution (Gutwin & Greenberg 2002; Hinds & Mortesten, 2005). This may cause misattribution of faults to a person instead of a situation, and again may result in negative interpersonal emotions. According to Myers (2007), the fact that in virtual communication interactions are available for review and replication creates a situation

in which every interaction gets a lot of attention, and some might come to seem more important than they actually are. This can lead to escalation of conflicts that in face-to-face communication might have been resolved faster and more easily.

At the same time, the use of information-sharing tools can reduce the probability that negative emotions will arise. This is when information sharing tools are used in a way that evens out coordination faults or uneven distribution of information (Cramton, 2001; Hinds & Mortensten, 2005). Information sharing tools that ensure complete visibility of information to all team members are a means to increasing collaboration and trust among team members. By increasing collaboration and trust a more positive emotional atmosphere is created in the team. By keeping people well informed about the progress, constraints and plans of their team mates are viewed through a context and situational lens, rather than a personal lens. By encouraging the adoption of a project or team-level view, information sharing tools help ensure that problems are more likely to be constructively solved by creating individual sensemaking processes that evoke a more accurate individual mental model and inspire higher similarity in the team mental model.

Summary

A summary of our analysis is depicted in Figure 1.

Insert Figure 1 about Here

At the core of our argument is the relationship between team performance and the development of a team mental model of the team-task and team-processes. The team mental model, as depicted in Figure 1 is composed of the mental models of individual team members, and is developed in a recursive cycle in which individual

sensemaking of team situations involve ignition of a need to make sense of a situation, interpretation of the situation, and enactment of an understanding (a new mental model) of the team and the situation.

Individual and team mental models refer to a certain set of assumptions about the content of the team task, and about team work processes. They also need to be assessed according to the accuracy of these assumptions given the way the team task is construed by various stakeholders. In addition, since a team mental model necessarily refers to some hybrid of the mental models of individual members, it (the team mental model) needs to be assessed according to the degree of similarity between the mental models of different individual team members. So as Figure 1 depicts both individual and team mental models are to be assessed according to the content they embed and the accuracy of this content. A unique feature of the team mental model is the extent of similarity in it, meaning the extent to which the mental models of different individual members and the emergent hybrid of these individual models are similar to each other. With a team mental model that holds greater similarity team processes can be expected to flow more smoothly and to suffer from less conflict.

Thus, sensemaking is an individual level cognitive process that produces individual level mental models. The cycle of bold arrows in Figure 1 depicts the recursive and continuous change of individual and team mental model created by the dynamic sensemaking process: Members of a virtual team working on a given task constantly face and interpret situations -- occurrences in the flow of team work -- by calling on existing mental models. Each new situation ignites the sensemaking process, leading to interpretations that determine team members' behavior or enactment of the new situation. One sensemaking effort – ignition, interpretation and

enactment -- provides a new mental frame for all team members, that likely leads to some modification of the individual and team mental models. People may learn about inappropriate aspects of their previous model, or about how others view things. Such learning ignites further sensemaking, and through continuous ignition, interpretation and enactment people continue to refine their individual mental model, which influences the emergent team mental model. The recursive sensemaking process is a critical foundation of team work, and a critical influence over team performance.

As Figure 1 further depicts we posit an additional cycle of influence over team sensemaking – an emotion cycle, depicted in a double-arrow in Figure 1. This cycle refers to various emotional influences over sensemaking. As the figure summarizes, the influences can be of three types: First, high arousal emotions (e.g., anger, irritation, delight, or excitement) can create a trigger for sensemaking. Second, individually felt emotions can serve as cues or information about the situation at hand. A feeling of anger, for example, may create a sense that someone else has failed, which may ignite a sensemaking cycle in which identification of blame or responsibility is sought, and according interpretations and enactment is taken. Thirdly, certain interpretations may evoke emotions that themselves color the nature of a sensemaking cycle. Understanding that someone else has failed, for example, may evoke irritation, which can create impatience and abrupt rather than detailed processing of a situation.

A third body of influence over the sensemaking process – depicted in the broken arrow in Figure 1 – regards the tools used to support the work of a virtual team. In particular our analysis highlighted the importance of rich communication tools and information sharing tools. Effective support tools can promote effective team effort by facilitating individual sensemaking that takes into consideration the

perspectives of other people in a virtual team, which increases the extent of accuracy of the emergent team mental model. With the use of information rich and information sharing support tools interactions among team members help remove inaccuracies in each member's mental models, and help create a more accurate and more convergent (i.e., with high similarity) team mental model, which is a critical antecedent to effective team performance.

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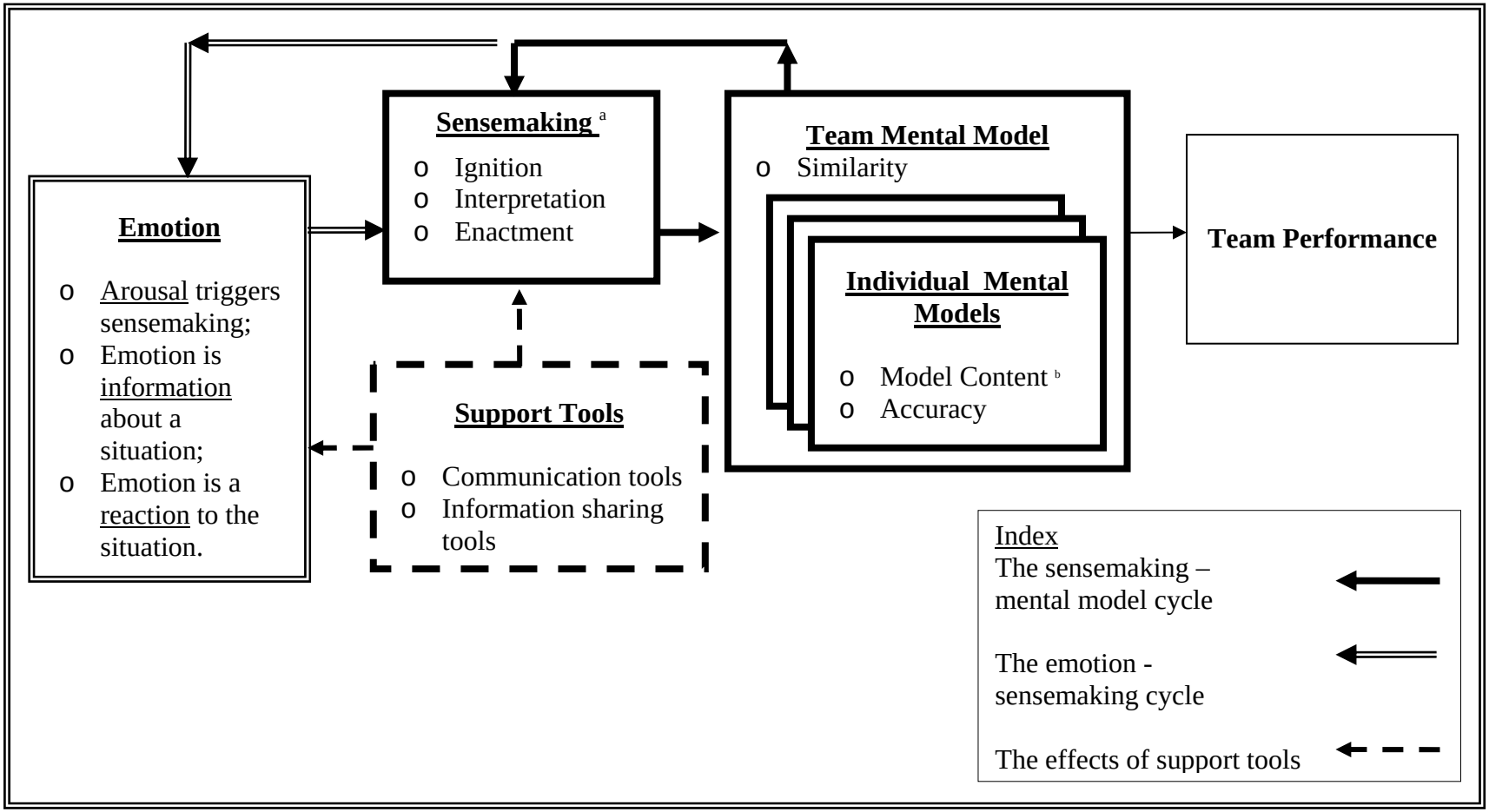
Figure 1

Team Mental Models in Virtual Teams: The Dynamics of Sensemaking, Emotion and Support Tools



[a] Sensemaking is an individual level cognitive process that produces individual level mental models. The bold arrows in the figure depict the active and continuous recursive influence between the individual and team mental models created by the dynamic sensemaking process: Members of a virtual team working on a given task face and interpret new situations by calling on existing mental models. Each new situation ***ignites*** a sensemaking process, which leads to ***interpretations*** that determine members' behavior or ***enactment*** of the new situation. The result of each sensemaking effort creates a new context for all team members, that likely leads to some modification of the individual and team mental model. People may learn about inappropriate aspects of the model, or about how others view things, and such learning ignites further sensemaking. Through interpretation and enactment people further refine their individual mental model, which influences the emergent team mental model. This cyclical process is a critical element of team work, and a critical influence over team performance.

[b] Models with different content may inhabit a team; models can refer to the "what" the team does and/or models that refer to "how" the team work is done. Assessments of the team mental model must identify the different types of models and then assess the degree to which each is appropriate as well as the degree to which it is shared by different members of the team.