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## **An empirical investigation of trust's impact on collective awareness development in virtual teams**

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**Abstract:** This study investigates the relationship between trust and collective awareness levels over time. The study also examines the multi-dimensionality of both trust and collective awareness in virtual teams. Hence, we adopt a longitudinal study to provide a preliminary step towards understanding the dynamic nature of trust and collective awareness in virtual teams. The results of our experiments show that (1) both trust and collective awareness levels increase over time; (2) during the project, task processes are more important than socio-emotional processes; and (3) higher (vs. lower) trust levels are associated with higher (vs. lower) collective awareness levels.

**Keywords:** virtual teams; collective awareness; swift trust; longitudinal study.

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## 1 Introduction

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*Virtual teams are here and they are to stay* (Bell and Kozlowski, 2002, p.45). Virtual teams are no longer considered a new organisational work arrangement. They are, instead, perceived as an established reality that needs examination and study given their potential to bridge space and time constraints and to reach appropriate skills for a given task (Cascio, 2000; Townsend *et al.*, 1998; Warkentin *et al.*, 1997). Consequently, we note a growing amount of research on information systems interested in virtual teams to resolve their management problems and to identify the fundamental factors of their success and performance (Avolio *et al.*, 2000; Cascio and Shurygailo, 2003; DeSanctis and Monge, 1999; Fairweather, 1999; Gresing-Pophal, 1999; Montoya-Weiss *et al.*, 2001; O'Sullivan, 2003; Zigurs, 2003).

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Changing characteristics of virtual settings introduce organisational changes that influence their management and their organisational mechanisms. Electronic communications and the absence of direct contact, cultural diversity, and a lack of time are new parameters of the virtual context. Such elements hinder interpersonal relationship building. This involves, among others, trust and collective awareness, two concepts known to be key factors in the success of every organisational form (Mayer *et al.*, 1995; Ring and Van de Ven, 1992; Weisband, 2002). This paper argues that they are of even

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greater interest in virtual teams. However, some conditions necessary to their development, such as cultural similarities, physical proximity, face-to-face interaction and time, are not available in virtual teams (Handy, 1995; Jarvenppa *et al.*, 1998; Townsend *et al.*, 1998). These new elements confer to trust and collective awareness a different nature from that of the more traditional context, and alter their establishment and development mechanisms.

Impacts of virtuality can also be noted in the nature of the relationship between trust and collective awareness. In the traditional team context, trust is identified as a contributor to collective awareness building and maintenance through the creation of shared norms and a shared understanding of the work context, and also through the development of social relationships between team members. However, given the new virtual parameters, changes are expected to occur in the nature of both trust and collective awareness and their relationship. Despite the growing number of research examining trust and collective awareness in virtual teams separately, no research, hitherto, has investigated the nature of their links. Our study seeks to bridge the gap in the literature concerning this topic.

The purpose of this study is to examine the following questions: How does the level of collective awareness evolve during the lifetime of virtual teams? What patterns of change does trust follow in virtual teams? What is the role of trust in collective awareness establishment and evolution?

This paper is organised as follows: First, we develop the conceptual framework and hypotheses (Section 2). Section 3 describes the methodology used. Section 4 presents the data analysis and results, and in Section 5, we discuss our findings. Finally, in Section 6, we conclude with limits and some pointers for further research.

## 2 Conceptual foundations and hypotheses

### 2.1 Virtual teams

Virtual teams are defined as groups of skilled individuals:

- separated in space and time
- extensively using information and communication technologies
- accomplishing a task limited in time (Jarvenpaa *et al.*, 1998; Lipnack and Stamps, 1997; Townsend *et al.*, 1998).

These characteristics distinguish virtual teams from traditional teams and announce what makes them virtual. However, they do not allow the identification of the different types of virtual teams. They instead implicitly assume that a unique possible configuration of virtual teams exists. More recently, typologies have been developed to clarify the concept and to examine the variability of virtual teams' characteristics and their impact on the team's design (Bell and Kozlowski, 2002; Casio and Shurygailo, 2003; Jarvenpaa *et al.*, 1998).

The proposed typologies are based on two fundamental elements. The first is the identification of virtual teams' key characteristics. The second deals with the assumption that they vary in a continuum. For example, geographical dispersion has many levels from low to high, leading to co-located or separated team members (Bell and Kozlowski,

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2002). Such different combinations of changing characteristics result in the existence of multiple types of virtual teams. There are three particularly relevant types of cases. ‘Pure’ virtual teams, considered the archetype of virtual teams, have geographically dispersed members, short-term lifetime, multiple member roles and no organisational boundaries. Traditional virtual teams have a more discrete life cycle, co-located members, unique member roles and stable organisational boundaries. The third type, called Virtual Project Teams (or VPTs), combines the characteristics of the two types presented above. VPTs may be composed of dispersed or co-located members who may know each other or be working together for the first time, and who combine electronic and face-to-face communication modes (Cohen and Bailey, 1997). In our paper, we are interested in this last category, which we use in our empirical study.

## 2.2 *Collective awareness*

Collective awareness has been defined in numerous ways, although many definitions do not share a common foundation. Schmidt (2002) argues that awareness is “being used in increasingly contradictory ways... In fact, it is hardly a concept any longer”. Dourish and Bellotti (1992, p.107) define collective awareness as “An understanding of the activity of others which provides a context for your own activity.” Other definitions are formulated to enrich the latter. In these studies, the authors point out many aspects that contribute to understanding collective awareness, such as coordination (Beaudouin-Lafon and Karsenty, 1992, p.171), presence and workspace sharing (Tollmar and Sundblad, 1995, p.181) and informal communication (Smith, 1996, p.59). Based on these studies, Daassi and Favier (2005) propose a working definition of collective awareness that takes into account member behaviours and their contexts: “Collective awareness refers to a common and shared vision of a whole team’s context which allows members to coordinate implicitly their activities and behaviours through communications” (Daassi and Favier, 2005, p.2).

In addition to several definitions given to collective awareness, some authors have tried to better apprehend the concept by identifying its elements or types (Gutwin *et al.*, 1996; Steinfield *et al.*, 1999; Tollmar *et al.*, 1996). Some of the types of awareness presented meet the same requirements and can be coupled (Daassi *et al.*, 2005). Prinz (1999) distinguishes task-oriented or activity awareness from social awareness. The former refers to awareness information focused on activities performed to achieve a specific shared task (Steinfield *et al.*, 1999). It consists, for example, in knowing what actions others do at any given moment. The latter includes information about the presence and activities of people outside the context of their work, their habits and levels of interest (Gutwin *et al.*, 1996; Tollmar *et al.*, 1996). This typology is broadly in line with Bales’s (1950) Interaction Processes Analysis findings, where he distinguishes task-oriented from socio-emotional processes.

In the virtual context, collective awareness is as important as in the face-to-face environment. Yet it faces more challenging issues owing to physical separation, electronic communications and asynchronous work. Virtual team members have to engage in shared understanding building over time while using computer-based communications. Establishing a climate of collective awareness in virtual teams needs time. According to McGrath’s (1991) Time, Interaction, and Performance theory, with time, participants interact, exchange information about each other, and accumulate knowledge about their team’s behaviours, work styles, schedules and habits. Frequent

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interactions and immediate feedback are necessary conditions for sharing information and for taking position in the team (Weisband, 2002). We can thus conclude that collective awareness evolves over time as members accumulate awareness information through interaction and working together. Our baseline hypothesis is:

*Hypothesis 1* In virtual teams, collective awareness increases over time.

The dynamic nature of collective awareness can also be drawn from the evolution of its dimensions. Both activity and social awareness increase over time with information exchange and accumulation. However, the relative importance of each dimension is different from one to the other. Activity awareness is expected to be more significant at the beginning of the project than social awareness. As virtual team members do not know each other and do not have prior shared work experience, their exchanges of communication and information are expected to be professional and task oriented (Hiltz *et al.*, 1986). Social interactions, personal information exchanges, habits and cultural values are secondary and grow over time. We can therefore posit the following hypotheses:

*Hypothesis 1a* In virtual teams both activity and social awareness increase over time.

*Hypothesis 1b* The level of activity awareness will be higher than that of social awareness during the lifetime of the project.

### 2.3 Swift trust

Virtual team members develop a particular form of trust which has been called swift trust (Jarvenpaa *et al.*, 1998; Jarvenpaa and Leidner, 1999; Kanawattanachai and Yoo, 2002; Kayworth and Leidner, 2001/2002). Swift trust has been developed for temporary systems that have similar characteristics to virtual teams. For Meyerson *et al.* (1996, p.177), "to trust and to be trustworthy within the limits of temporary system means that people have to wade in on trust rather than wait while experience gradually shows who can be trusted and with what. Trust must be conferred presumptively or *ex ante*". In virtual teams, members do not have prior shared work experience. Moreover, they do not have enough time to gather information about each other and to evaluate their behaviours. For these reasons, they presume from the beginning of the project that team-mates are trustworthy and expect that time will validate their judgement or not.

Building on social identification/de-individuation theory (Lea and Spears, 1991; Walther, 1995) and its applications in computer-mediated communication research, we contend that the role of people in asynchronous communication and distributed groups creates stereotypical impressions of their counterparts in order to facilitate group identification. The stereotype-creation mechanism is strengthened by the lack of information about members and the absence of social and cultural shared background characterising virtual environment. This psychological mechanism seems to occur in virtual teams in relation to the formation of swift trust. Stereotypical impressions are created about team members' trustworthiness based on the limited information available at the beginning of the project and other similar work experiences (Jarvenpaa and Leidner, 1999; Meyerson *et al.*, 1996).

As with traditional trust, swift trust is also built on cognitive and affective foundations (Kanawattanachai and Yoo, 2002; McAllister, 1995). Cognition-Based Trust (CBT) refers to ‘knowledge available about others’ and ‘good reasons’ that justify the need to trust (McAllister, 1995, p.26). Past studies identified competency, ability, responsibility and reliability as key elements contributing to cognition-based trust development (Butler, 1999; Mayer *et al.*, 1995; McAllister, 1995). Affect-Based Trust (ABT) is related to close relationships such as those in a family. It expresses the extent to which partners show care, concern and benevolence. It refers to emotions and sentiments between partners (Mayer *et al.*, 1995; McAllister, 1995).

The dynamic nature of trust in virtual teams has been proven in several studies (Jarvenpaa *et al.*, 1998; Jarvenppa and Leidner, 1999; Kanawattanachai and Yoo, 2002; Piccoli and Ives, 2003). In fact, the level of trust changes during the lifetime of the team. It increases as exchanges between team members intensify with time. Jarvenpaa and Leidner (1999) find in their study of the evolution of the antecedents of swift trust that an overall increasing trust level has been maintained in the teams studied. Kanawattanachai and Yoo (2002) show also that both CBT and ABT levels change over time, and they relate their evolution to team performance.

However, with the absence of individuating cues such as facial expressions or voice inflexions contributing to social context establishment, especially at the beginning of the project, virtual team members build their judgement on more rational elements. They evaluate their counterparts’ behaviours to judge if they are trustworthy or not using available information about their skills, expertise, past work experience and responsibilities. With the work’s progress, members accumulate knowledge about each other. In addition, they gain enough experience together to develop more affective trust based on affective elements. This is why in our study we believe that CBT is more important at early stages of the project than ABT. Building on these developments, we can thus assert the following:

*Hypothesis 2*     *In virtual teams, swift trust increases over time.*

*Hypothesis 2a*     *Cognition-based trust and affect-based trust increase during the lifetime of the virtual team.*

*Hypothesis 2b*     *Cognition-based trust is expected to be higher than affect-based trust through the course of the project.*

We also should note that given the fragile nature of swift trust, team members face a challenging issue consisting of maintaining a high level of trust and developing it (Crips and Jarvenpaa, 2000; Meyerson *et al.*, 1996). Meyerson *et al.* (1996) describe swift trust as a form of depersonalised action that develops through realisations and actions such as frequent interactions, immediate feedback or the respect of deadlines (Kayworth and Leidner, 2001/2002). Therefore, it is difficult for virtual team members to build, develop and maintain trust at high levels.

Previous studies have portrayed trust as an important factor in collective awareness building (Daassi and Favier, 2004). The remainder of our conceptual framework elaborates on the effects of trust’s dynamic nature on the evolution of collective awareness.

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## 2.4 Trust's effects on collective awareness evolution

Trust leads to open communication, citizenship behaviours and reinforced cooperation between members. The existence of trust enables people to face uncertainty about others and to learn to assess each other through electronic discussion and information exchange (Iacono and Weisband, 1997; Jarvenpaa *et al.*, 1998). By encouraging collaboration and frequent interactions, trust participates in initiating collective awareness building in virtual teams.

We expect that collective awareness levels depend on trust levels. In fact, maintaining high levels of trust or destroying them either intensifies or destroys the collective awareness climate. The vulnerable nature of swift trust renders it sensitive to faulty actions (Deutsch, 1958). Unproductive behaviours such as non-responsiveness, unequal participation and lack of socialisation may easily destroy trust (Jarvenpaa and Leidner, 1999; Kanawattanachai and Yoo, 2002). "When the other party feels that trust is violated, cognitively, he or she assesses the degree of violation. Affectively, he or she may get angry, experience stress and become disappointed" (Kanawattanachai and Yoo, 2002, p.192). It becomes hard therefore to maintain a high level of collective awareness, which may be altered by decreasing levels of trust. To explain these mechanisms, we consider that changing patterns of CBT and ABT levels are related respectively to activity and social awareness levels.

On the one hand, CBT builds on actions and behaviours of team members such as respect for deadlines, sharing information about task achievement, and showing interest in and commitment to what others do. This helps to generate knowledge about other members' activities and their accomplishments. On the other hand, the accumulation of personal information that serves to help participants socialise may contribute to establishing a shared social context. In addition, it strengthens knowledge of what members do outside their context of work, which corresponds to the definition of social awareness. We hypothesise that:

*Hypothesis 3a* High (vs. low) cognition-based trust is associated with high (vs. low) activity awareness.

*Hypothesis 3b* High (vs. low) affect-based trust is associated with high (vs. low) social awareness.

## 3 Methodology

To test our research model and hypotheses, we have conducted a quasi-experimental study. This section provides the context of the study. It defines participants, tasks, the data collection procedure and measures.

### 3.1 Study context

Forty five-person VPT (108 males, 92 females) consisting of post-graduate French students participated in a six-week project. Team size was chosen based on Bradner *et al.*'s (2003) study finding that smaller teams (less than nine) were more aware, better

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acquainted with their colleagues' personalities and work roles, more willing to communicate and reported higher levels of rapport. Participants were self-assigned to a VPT based on their interest in the proposed topics (*e.g.*, Knowledge Management, Data Warehouse, GDSS).

They took part in the project as part of their course. The exercise was included in their regularly scheduled courses, where it counted for 20% of the course grade. The teams were asked to prepare a report on the chosen topic and to present the results while respecting the deadline imposed by their tutor. Teams were given the same project instructions, requirements and deadlines. Several means of communication were offered to each VPT, including a shared online calendar, chat room, shared folders and an electronic mailing list.

### 3.2 Data collection and measures

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We collected data from a repetitive survey questionnaire. The survey was administered three times at the end of weeks 1 (T1), 4 (T2) and 6 (T3). The timing of the survey administration was chosen based on Gersick's (1990; 1991) finding that teams with a definitive deadline tend to experience dramatic change at the midpoint. Thus we planned to capture the levels of collective awareness and trust at the beginning of the project, at the midpoint and at the end. This procedure yielded a 91%, 88% and 96% response rate respectively for T1, T2 and T3.

Items selected for measuring cognition- and affect-based trust were mainly adopted from prior studies. We measured trust using a prevalidated scale developed by McAllister (1995) and adapted by Kanawattanachai and Yoo (2002). A new measurement scale to assess activity and social awareness levels was developed for use in this study. The measure consists of nine items, six assessing levels of activity awareness, and three assessing social awareness. For all measures, each item was rated on a seven-point Likert scale (from 1 = strongly disagree to 7 = strongly agree).

## 4 Data analysis

### 4.1 Scale validation

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Scale validation was assessed using Churchill's (1979) paradigm. We first demonstrated that the selected items must represent the concept about which generalisations are to be made. Exploratory factor analysis assessed how well items from a given scale index a common factor. The appropriateness of using factor analysis with each data was determined using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. For the three data sets, factor analysis was deemed appropriate.

Thus, we conducted an exploratory factor analysis separately for each survey on all individual responses using matrix correlations with varimax rotation. The results confirm that each of the items was loaded on its targeted factors. Reliability was evaluated by assessing the internal consistency of the items representing each construct using Cronbach's alpha. The analysis shows that Cronbach's alpha coefficient of each construct was above 0.70, indicating that the data was stable, dependable and predictable.



Scale reliability and validity were assessed via confirmatory factor analysis, performed using Structural Equation Modelling. We conducted three separate confirmatory factor analyses for T1, T2 and T3. As shown in Table 1, all loadings were greater than 0.70, indicating that all items were loaded in the target factors at all three times. Also, all goodness of fit indexes for all periods indicated that the model fit well with the data. Reliability was determined using the Jöreskog (1971) coefficient based on confirmatory factor analysis. The Jöreskog coefficient is considered more robust than Cronbach's alpha (Fornell and Larcker, 1981). As shown in Table 1, the Jöreskog coefficient of each construct was above 0.70.

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**Table 1** Results of confirmatory factor analysis of constructs for each time period

	<i>Time</i>		
	<i>T1</i>	<i>T2</i>	<i>T3</i>
<i>Cognition-Based Trust</i> (Construct reliability)	,83	,83	,86
Most of my teammates approach his/her job with professionalism and dedication.	,710	,745	,730
I see no reason to doubt my teammates' competence and preparation for the job.	,747	,732	,799
I can rely on other teammates not to make my job more difficult by careless work.	,779	,718	,785
Most of my teammates can be relied upon to do as they say they will do.	,756	,772	,790
<i>Affect-Based Trust</i> (Construct reliability)	,80	,78	,79
I can talk freely to my team about difficulties I am having at work and know that my team will want to listen.	,709	,731	,729
I would feel a sense of loss if one of us was transferred and we could no longer work together.	,857	,739	,714
I would have to say that we (my team) have made considerable emotional investments in our working relationship.	,703	,758	,801
<i>Activity Awareness</i> (Construct reliability)	,90	,88	,87
I am acquainted with the progress of our project.	,831	,817	,817
I always have visibility on the activities of the other members of my team.	,745	,720	,718
I am aware of the expected results of our project.	,780	,734	,707
I inform my teammates of my activity status.	,756	,736	,720
I am always informed of what occurs in our shared workspace.	,752	,739	,716
I am aware of my colleagues' availability.	,778	,756	,715
<i>Social Awareness</i> (Construct reliability)	,78	,82	,79
I am acquainted with how willing the other members are to communicate.	,737	,796	,720
I know the habits of the other members.	,765	,750	,732
I know the interest levels of my colleagues.	,722	,796	,778
<i>Goodness of fit index</i>			
Chi-square	113,4	119,4	99,2
<i>df</i>	98	98	98
<i>p</i>	,04	,06	,01
NFI	,913	,904	,921
CFI	,987	,981	,999
RMSEA	,022	,031	,013

Discriminant and convergent validity suggest that measures of the constructs are distinct, and that indicators load on the appropriate construct. Estimates of average variance extracted  $\rho_{vc}$  ( $\eta$ ) above 0.50 provide further evidence of convergent validity. Results for the test recommended by Fornell and Larcker (1981), comparing average variance extracted by constructs to the square of their correlation, were supportive for discriminant validity. As shown in Table 2, all square roots of the average variance extracted displayed in a diagonal of a correlation matrix were greater than the off-diagonal constructs correlation in the corresponding rows and columns for each separate time period.

**Table 2** Means, standard deviations and correlation of constructs

		Mean	SD	Correlation of constructs <sup>1</sup>			
				CBT	ABT	A-AWA	S-AWA
T1	CBT <sub>1</sub>	4.22	0.46	0.74			
	ABT <sub>1</sub>	2.43	0.25	0.415*	0.75		
	A-AWA <sub>1</sub>	3.15	0.49	0.712**	0.221	0.77	
	S-AWA <sub>1</sub>	2.08	0.34	-0.278	-0.359*	-0.276	0.74
T2	CBT <sub>2</sub>	5.05	0.43	0.74			
	ABT <sub>2</sub>	3.33	0.29	0.052	0.74		
	A-AWA <sub>2</sub>	5.43	0.43	-0.045	0.122	0.74	
	S-AWA <sub>2</sub>	3.41	0.45	0.134	0.101	-0.175	0.78
T3	CBT <sub>3</sub>	5.77	0.41	0.77			
	ABT <sub>3</sub>	5.06	0.58	0.326	0.74		
	A-AWA <sub>3</sub>	6.26	0.34	-0.136	-0.011	0.73	
	S-AWA <sub>3</sub>	5.05	0.66	0.091	0.449	0.271	0.74

Notes: \* = Correlation is significant at the 0.05 level

\*\* = Correlation is significant at the 0.01 level

<sup>1</sup> = Diagonal elements in the correlation matrix are the square root of the average variance extracted. For adequate discriminant validity, diagonal elements should be greater than corresponding off-diagonal elements.

Finally, we estimated a multi-group model that lets all structural parameters vary across subgroups. This model reproduced observed covariances precisely:  $\chi^2$  (306) = 411.1,  $p < 0.001$ ; RMSEA = 0.038. For a nested model, we equated structural parameters – presumed to be moderated by time changes – between subgroups. This nested model recomputed covariances ( $\chi^2$  (342) = 438.44,  $p < 0.001$ ; RMSEA = 0.035), but fit data worse than the unconstrained model ( $\Delta\chi^2$  (36) = 27.33, not significant). These results indicate that our measurement model was stable across surveys.

#### 4.2 Hypotheses testing

The data were analysed at the team level. We then calculated the average scores of the individual items for each team and used those scores in our analysis at the team level. Because a complete data set was required, the analysis included only respondents who submitted all three of the surveys considered (180 participants representing 36 teams). Analysis of Variance (ANOVA) is a popular statistical technique used to test for significant differences between means (Hair *et al.*, 1998).

#### 4.2.1 The dynamic nature of collective awareness

We expect that, in virtual teams, collective awareness increases over time (H1). Data is based on the calculated average of the two awareness dimensions. The average level of collective awareness at the beginning of the project (T1) was 2.62 on a seven-point scale, implying lower disposition of collective awareness. ANOVA revealed significant changes in the levels of collective awareness ( $F(2, 105) = 763.767, p < 0.001$ ) across surveys. To better understand the nature of these changes, we conducted paired t-tests comparing collective awareness levels at all three periods. The results showed that there was an important and significant increase in collective awareness from T1 (mean = 2.62, SD = 0.25) to T2 (mean = 4.42, SD = 0.28) ( $t = 28.14, p < 0.001$ ) to T3 (mean = 5.65, SD = 0.42) ( $t = 14.44, p < 0.001$ ).

We then compared the mean of the constructs' scores for activity awareness and social awareness using ANOVA to examine if and how they changed over time. We expect that activity awareness and social awareness levels increase over time (H1a). The analyses presented are supportive for the proposed hypotheses: activity awareness ( $F(2, 105) = 487.929, p < 0.001$ ) and social awareness ( $F(2, 105) = 308.351, p < 0.001$ ). For activity awareness, the results from paired t-tests showed a significant increase from T1 (mean = 3.15, SD = 0.49) to T2 (mean = 5.43, SD = 0.43) ( $t = 20.93, p < 0.001$ ) to T3 (mean = 6.26, SD = 0.34) ( $t = 8.62, p < 0.001$ ). For social awareness, the results from paired t-tests showed a significant increase from T1 (mean = 2.08, SD = 0.34) to T2 (mean = 3.41, SD = 0.45) ( $t = 13.88, p < 0.001$ ) to T3 (mean = 5.05, SD = 0.66) ( $t = 12.19, p < 0.001$ ).

At the beginning of the project (T1), the level of activity awareness (3.15, SD = 0.49) was higher than that of social awareness (mean = 2.08, SD = 0.34). To test H1b, we conducted a paired t-test comparing the levels of activity awareness and social awareness at all three times. The results strongly support H1b. The level of activity awareness was higher than that of social awareness for all three periods ( $t(35) = 9.46, 17.88, \text{ and } 10.79$ , for T1, T2 and T3 at  $p < 0.001$ ).

#### 4.2.2 The dynamic nature of trust

The same procedure was applied to test H2, H2a and H2b. Results showed that the trust level increased over time ( $F(2, 105) = 351.89, p < 0.001$ ). More precisely, the trust level increased significantly from T1 (mean = 3.33, SD = 0.30) to T2 (mean = 4.19, SD = 0.26) ( $t = 12.62, p < 0.001$ ) to T3 (mean = 5.41, SD = 0.41) ( $t = 14.91, p < 0.001$ ).

We expect that CBT and ABT levels increase over time (H2a). The analyses presented are supportive of the proposed hypotheses: CBT ( $F(2, 105) = 111.24, p < 0.001$ ) and ABT ( $F(2, 105) = 384.90, p < 0.001$ ). For CBT, the results of paired t-tests showed a significant increase from T1 (mean = 4.22, SD = 0.46) to T2 (mean = 5.05, SD = 0.43) ( $t = 7.73, p < 0.001$ ) to T3 (mean = 5.77, SD = 0.41) ( $t = 7.15, p < 0.001$ ). For ABT, the results of paired t-tests showed a significant increase from T1 (mean = 2.43, SD = 0.25) to T2 (mean = 3.33, SD = 0.29) ( $t = 13.82, p < 0.001$ ) to T3 (mean = 5.06, SD = 0.58) ( $t = 15.74, p < 0.001$ ).

We hypothesised that CBT will be higher than ABT throughout the project (H2b). We conducted a paired t-test comparing the levels of CBT and ABT at all three times. The results strongly support H1b. The level of CBT was higher than that of ABT in all three instances ( $t(35) = 25.36, 20.00, \text{ and } 7.12$ , for T1, T2 and T3 at  $p < 0.001$ ).

### 4.2.3 *The effect of trust on collective awareness evolution*

To test H3a, we conducted analyses of variance considering two levels of CBT based on estimated means for each team. To do so, we split teams into lower (less than 3.5) and higher (more than 3.5) CBT levels. Results strongly support H3a. The activity awareness level changes significantly depending on the CBT level ( $F(1, 106) = 10.56, p = 0.002$ ). Indeed, for a lower CBT level, the average of activity awareness was low (mean = 2.48;  $t = 21.16, p < 0.001$ ), while for a higher CBT level the average of activity awareness was high (mean = 5.02;  $t = 38.28, p < 0.001$ ).

Finally, the same procedure was applied to test H3b. Results show that the level of social awareness changes significantly depending on ABT levels ( $F(1, 106) = 162.16, p < 0.001$ ). Indeed, for a lower ABT level the average of social awareness was 2.63 ( $t = 27.25, p < 0.001$ ), while for a higher ABT level the average of social awareness was 4.70 ( $t = 34.66, p < 0.001$ ).

## 5 Discussion

This study attempts to examine if and how trust and collective awareness in virtual project teams change over time. Our first inquiry concerns the dynamic nature of collective awareness. The second research question deals with the patterns of change that trust follows. The final and third question seeks to reveal the effects of the dynamic nature of trust on collective awareness development.

The results confirm the dynamic nature of collective awareness over time. We found that collective awareness starts low and increases over time. Throughout the project, activity awareness was higher than social awareness. This suggests that teams in our sample were task oriented and more focused on their activities than on their socio-emotional climate. This is consistent with Baumann's (1998) findings confirming that time pressure has a direct effect on members' awareness, in addition to the indirect effect that would be expected with the reduced social interaction observed by Karau and Kelly (1992).

Yet over time, social awareness increases. This is because teams **acquired** sufficient social information about each other to know the other members' preferences, work styles, schedules and habits. According to Walther (1995) and Arrow *et al.* (2004), individuals can develop social relationships in computer-mediated environments when they are given enough time. In addition, the length of time the team members have worked together can significantly influence **their processes** (Brannick and Prince, 1997).

Our results concur with the predictions of the Social Information Processing (SIP) theory (Walther, 1992), which argues that, over a period of time, teams using technologies will gradually develop close relational ties, despite some initial difficulties. Chidambaram (1996) argued that as teams grapple with using technology, they will – in addition to exploiting the ability of the medium to support their activities – explore ways of exchanging socio-emotional communication with their team members.

Our results on the dynamic nature of trust are in line with a number of previous studies. **Iacona** and Weisband (1997), **Jarvenpaa** *et al.* (1998) and Kanawattanachai and Yoo (2002) revealed that trust has a dynamic nature. It develops swiftly during the early stages of the project in sufficient levels and intensifies as the project progresses. The characteristics of virtual teams presented above (*i.e.*, lack of time, dispersion, no shared

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history of relations) highlight what leads to the creation of swift trust. This also lends strong support to our results concerning the relative importance of trust's two dimensions. Virtual teams in our sample built trust on cognitive foundations more than on affective elements, such as the ability to respect deadlines and to meet fixed goals (Kanawattanachai and Yoo, 2002; Meyerson *et al.*, 1996).

A significant link between trust and collective awareness levels leads us to affirm that the former could be a powerful antecedent of the latter. Yet further studies are required to confirm this relation. As our research is the first to investigate trust's role in collective awareness creation and maintenance in virtual teams, we now make an appeal for the continued probing of our results in order to offer a broader glimpse into this new and expanding field of study.

## **6 Conclusion**

### *6.1 Research implications*

Several theoretical and managerial implications can be drawn from our study. On the theoretical side, our results are strongly supported by past research. It contributes, then, to enriching information systems literature on virtual teams, which remains a little explored field. In addition, we conducted a first attempt to explain the relation between trust and awareness in virtual teams. Our results revealed a significant effect of trust on collective awareness initiation and evolution.

On the managerial side, while our study was conducted with students, it can nevertheless offer considerable insight to managers for the improvement of virtual teams' establishment and performances. Our findings point out the importance of managing the cognitive elements relative to team members' skills and behaviours. This action is necessary for both trust and collective awareness management. In any case, virtual team managers have to pay close attention to team members' actions, especially at the beginning of the project. This period is crucial for the future steps of the project. It determines the ability of members to maintain high levels of trust and awareness (if they began with high levels) or to fail to overcome low levels of trust and awareness (if faulty actions and behaviours destroyed them) (Jarvenpaa *et al.*, 1998; Kanawattanachai and Yoo, 2002).

### *6.2 Limitations and further work*

Our study has some limitations that can be taken into account for further research. First, while a preliminary test shows considerable empirical support, it is important to note that experiments with students are highly problematic. In fact, students often show other reasons for and reactions to participation than do the business people they are substituting (Dennis *et al.*, 1990). Alternatively, future research may also examine the relation between trust and collective awareness in real organisational settings and ensure the Global nature of Virtual Project Teams (GVPTs). Furthermore, it would be useful to examine teams with a longer duration to replicate the current results. Second, the quantitative approach adopted in our study only gives insight on how the two concepts studied change over time. More qualitative studies based on content analysis of e-mails and discussions exchanged between team members might elucidate on what mechanisms

and factors trust and awareness establish and develop over time. Finally, the effects of trust and awareness on virtual team performance were not examined in our study. Possible extensions might consist in determining how the dynamic nature of trust and awareness and the combination of cognitive and affective dimensions could affect virtual team performance.

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