

The effects from technology-mediated interaction and openness in virtual team performance measures

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As globalisation continues concurrent with mergers and acquisitions, transnational organisations are increasingly turning to the use of virtual teams in which members collaborate through technology-mediated interaction. Although collocated teams and virtual teams share many common characteristics including performance measures, the nature of the environments differ along several dimensions. In particular, members of virtual teams cooperate on global projects while resident in their home geographies and cultures and using various technologies to facilitate. From that context, this field study investigated virtual team performance using organisational culture as a framework.

Keywords: Virtual teams; Boundary permeability theory; Boundary permeation theory; Social identity

1. Introduction

Boundary permeability theory (Workman 2001) asserts that cultural collectivism and individualism define the openness norms for information sharing and cooperative behaviour between groups, and that cohesion reflects the degree of agreement regarding those norms. Social identity theory (Tajfel and Turner 1979, 1986) posits the epistemological weighting hypothesis (Gass and Seiter 1999) in which conformance to norms depend on how closely an individual's norms match those of the group. It postulates that we gain knowledge as both active trial and error, and passive observation through the social processes of communication and observation, which affect our behaviour to the extent that we come to identify with and become de-individuated by the group (Zajonc 1969).

Consequently, the degree to which people comply with the demands of the group depends on the weighting we place between personal and social knowledge acquired through the group's communications and social enculturation processes (Zajonc 1968; Gass and Seiter 1999). If cohesive norms encourage openness to outsiders then cooperation increases with non-group members. If cohesive norms discourage openness it may lead to objectification (Deutsch and Gerard 1955) and amplify comparative dissimilarity in which outsiders are viewed in stereotypical

terms (Tajfel and Turner 1986; Shaw and Barrett-Power 1998). As such, cooperative behaviour internally and externally to the group relies on social and communicative enculturation processes (Heald *et al.* 1998; Shaw and Barrett-Power 1998).

When computers mediate social interaction, social identity is constrained (Daft and Lengel 1986), which results in a variety of both positive and negative consequences. For example, in a study of technology mediated decision-making effectiveness, Murnighan (1981) identified a number of characteristics associated with proximal contact (the degree of face-to-face interaction) and technological intermediation (communication intensity over a technology medium). In particular, as proximal contact decreased and intermediation increased the number and quality of ideas increased along with task versus relationship focus, while social pressure and cohesion decreased. Hence, computer mediation has far-reaching implications for how groups are socialised, structure themselves and cooperate, and these in turn have implications for performance.

As globalisation continues, there is a proliferation of transnational organisations (Daft 1998), particularly among those involved in knowledge work (ITAA 2003). One of the difficulties in transnational organisations is in the coordination of work that must transcend geographies

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and time zones (Hertel *et al.* 2004). A means by which such activity is conducted is to use virtual teams, where members who are geographically dispersed use technology media to communicate and coordinate their teamwork (Bell and Kozlowski 2002, Hertel *et al.* 2004). Most professional teams now utilise degrees or a hybrid model of technology intermediation (Bell and Kozlowski 2002). However, transnational teams, by virtue of their global dispersion, tend to rely almost, if not exclusively, on technological mediated interaction and thus represent the most extreme form of virtual work (Hyde 2004).

The UK, western Europe and the US utilise virtual teams extensively (Daniels *et al.* 2001, Hertel *et al.* 2004), and they are also emerging in India and Asia and many other parts of the world, and are increasingly transnational in their composition (Gartner Group 2000, Gibson *et al.* 2003). As with proximal teams, to accomplish their tasks virtual team members must communicate, plan and allocate sub-tasks, sequence, schedule and coordinate the work, problem-solve, derive products or solutions, and monitor performance (Bell and Kozlowski 2002, Hertel *et al.* 2004). However, global-transnational virtual teamwork must also cross the traditional work boundaries in terms of space, time, geography and discipline, while depending largely, if not exclusively, on electronically mediated communication (Townsend *et al.* 1996, Malhotra *et al.* 2001). In addition, they must accommodate diverse national cultural values and norms (O'Hara-Devereau and Johansen 1994, Earley and Mosakowski 2000).

Hofstede *et al.* (1990) promulgated Hofstede's (1983) seminal work on national cultures into the investigation of organisational cultures. Consistent with a differentiation paradigm where subcultures are seen in different organisational contexts (e.g. Sackmann 1992, Trice and Beyer 1993), there is reason to believe that cultural dimensions also extend to the level of teams (Suzuki 1997, Hofstede 1998, Workman 2001). At this level, cultural influences are observed in team characteristics that determine the organisation, distribution and coordination, communication and monitoring of work (O'Hara-Devereau and Johansen 1994, Daft 1998, Hofstede 1998). These characteristics are believed to affect global-transnational virtual team performance, but it is unclear how (Sonnentag 2000, Symon 2000), and needs further testing (Ellison 1999, Daniels *et al.* 2001, Bailey and Kurland 2002, Hertel *et al.* 2004). Thus using boundary permeability theory (Workman 2001) and Hofstede's (1998) organisational culture framework this empirical study investigated global virtual team performance.

2. Theory and hypotheses

Studies of proximal teams consistently show that teams acculturate ways of organising, coordinating, communicating, and monitoring work (e.g. Moses and Stahelski

1999, Stewart and Barrick 2000). Organic organisational cultures are results-oriented, have decentralised control and are outward facing, whereas mechanistic organisational cultures are formal, process-oriented, hierarchical and inward facing (Burns and Stalker 1961). In conventional proximally located teams performance generally improves as team cultures become more organic such that team members assume more responsibility and accountability, and the teams become more adaptive (Stewart and Barrick 2000). Yet while there are similarities between proximal and virtual teamwork, there are also important differences. In particular, proximal team membership enables communication and coordination of work in ways that are constrained in virtual teams as a result of distance, time lags and technology media that have varying degrees of richness (Daft and Lengel 1986). The virtual environment has less externally supplied structure, is more isolated, and creates greater degrees of ambiguity about tasks and interpersonal relationships than in proximal settings (Fussell and Benimoff 1995, Raghuram 1996, Jehng 1997, Workman *et al.* 2003). As virtualisation increases, research (Fritz *et al.* 1996, Raghuram 1996, Ellison 1999) shows that both formal and informal interaction decreases and it becomes increasingly difficult to model team members' approaches to tasks or monitor work progress or convey nonverbal information that establish normative or structural expectations, which constrict shared meaning, social identification and cooperation (Earley and Mosakowski 2000, Conner 2003).

In response, there are variations in the ways virtual teams organise, communicate, coordinate and monitor work when compared with traditional proximally located teams (Shaw and Barrett-Power 1998, Weiland 1999, Lim and Benbasat 2000, Chatman and Flynn 2001, Daniels *et al.* 2001, Griffin *et al.* 2001, Montoya-Weiss *et al.* 2001, Mohammed *et al.* 2002). To help compensate for the lack of structure and elevated ambiguity created by virtualisation for example, people often turn to formal structures such as written rules and procedures. When rules and procedures are lacking, people use the organisational hierarchy rather than each other as the primary method for managing group goals and overcoming ambiguity (Daft 1998, Griffin *et al.* 2001, Griffith *et al.* 2003). As a consequence, certain organisational culture characteristics that may impinge team performance in a proximal setting may pay dividends in virtual setting.

Hofstede *et al.* (1990) organisational culture framework consists of six factors that tap into four underlying dimensions: structure, relationships, primacy and boundary delineation. The process/results-oriented factor is centred on the procedural structure that guides how goals are accomplished and affects how employees organise and carry out their work. Hofstede (1998) distinguishes between procedural and political structure, hence the

normative/pragmatic factor is concerned with the formality in the political structure of the organisation. The employee/job factor is concerned with the extent to which an organisation is people- or task-oriented, and influences collectivistic/individualistic behaviour in sequencing and scheduling work. Similarly, the parochial/professional factor is related to group boundary delineation and role identity, which has implications for cohesion. The loose/tight control factor is related to primacy and indicates how tightly work is planned, allocated and monitored. The open/closed factor reflects boundary permeability, that is the degree to which information flows throughout the organisation and impacts information intensity and interdependence.

At the organisation level, each of these factors is conceptually distinct (Hofstede 1998); however, at the team level, research (e.g. Suzuki 1997, Kraut *et al.* 1998, Hertel *et al.* 2004) consistently shows that boundary permeability moderates performance. For example, teams may be individualistic in nature, yet have thin-permeable boundaries that are more amenable to cross-team interaction than collectivistic teams that form dense team boundaries (Workman 2001). Cross-team interactions may yield better overall efficiency and higher quality products regardless of individualistic or collectivistic propensity (Eby and Dobbins 1997).

2.1 Technology intermediation, structure and permeability

As research (Fritz *et al.* 1996, Raghuram 1996, Ellison 1999) indicates the nature of virtual work is more solitary than traditional office-based work. In addition to having the potential to increase solitude, virtual work is also less externally structured. Since virtual work is typically done remotely and communication is constrained to varying degrees by the richness or leanness of electronic media, there are fewer opportunities for virtual workers to share or model co-workers' approaches to work (Jehng 1997, Erben and Dafler 1998, Wieland 1999). Beyond the more solitary and unstructured nature of virtual work there tends to be increased levels of ambiguity in terms of tasks and interpersonal relationships (Workman *et al.* 2003). As people collaborate on problems, we use the information we gather to help us formulate mental concepts and understanding to guide us in our choices and decisions. When technology media intervenes in the collaboration, varying amounts of the information context is constricted. Using technology media for collaboration may elevate the ambiguity of some tasks in certain situations, particularly if tasks are poorly structured to begin with, and this affects how teams structure themselves (Kraut *et al.* 1998, Montgomery 1999).

Process-oriented teams use a mechanistic structure (Burns and Stalker 1961) and are concerned with the

means by which tasks are pursued. Their focus is on process improvement and they tend to have many elaborate written processes and procedures stipulating how work is to be carried out, and they strive towards risk avoidance. They work to standardise, eliminate variance and reduce ambiguity. Results-oriented organisations are concerned with the end products or services and are organic in structure (Burns and Stalker 1961). Their focuses are on action and end goals, and their work is such that the ends justify the means (Daft 1998, Hofstede 1998).

The study of proximal teams suggest that for dynamic environments, organic structures are more suitable than mechanistic ones because they enable tasks to be adjusted and redefined according to situational variables (Wageman 1995, Daft 1998). However, this assumption relies on having sufficient information to make effective decisions about courses of action (Daft and Lengel 1986). Virtual teams have less externally supplied structure than proximal teams because of physical distance and time lags in communications, as well as constrictions of media richness by various technology bandwidths that mediate remote communication (Workman *et al.* 2003). In virtual teams, both formal and informal interactions are reduced, and using certain media for collaboration reduces information, which may elevate the ambiguity of some tasks and may increase indecision about courses of action (Jehng 1997, Weiland 1999).

To help compensate for the concomitant ambiguity created by electronic mediation, people turn to formal structures such as rules and procedures. When rules and procedures are lacking, they use the organisational hierarchy as the primary method for managing group goals and overcoming ambiguity (Daft 1998, Griffin *et al.* 2001). Coordination is achieved by referring problems to a common superior higher in the organisation. Because the interaction among virtual team workers and management is constrained by technology, distance and time, increasing the specificity of the goals, processes and rules (i.e. increasing procedural formality) will augment the structure within the virtual team (Montoya-Weiss *et al.* 2001, Bell and Kozlowski 2002, Griffith *et al.* 2003).

Burns and Stalker (1961) asserted that organic organisations have fewer written rules and regulations than those that are mechanistic, and in organic organisations the rules and regulations that are written tend to be ignored. In the absence of formal rules and regulations when organisationally and geographically dispersed, people find their own way through the system to figure out what to do. If the hierarchy of authority is not clear or is constrained by time, geography and technology, goal incompatibility can arise when operative goals become the specific objectives of individual team members, often in opposition between one and another (Daft 1998). Procedural structure serves to regulate the degree of standardisation and the extent work

activities are performed in a uniform manner. Stated simply, the increased ambiguity and solitary nature of virtual work elevates the need for increasing process specificity.

Although the nature of virtual teamwork tends to be more ambiguous and solitary than proximal teamwork (Workman *et al.* 2003), some virtual teams make more attempts than others to interact (Conner 2003). Consistent with boundary permeability theory, which explains the permeability of boundaries between information flows among organisational units (e.g. Suzuki 1997) a closed team culture is highly compartmentalised with thick boundaries between in-group and out-groups, has few linkages and low interdependence. The thick boundaries between a closed team and other organisational units regulate the information flows reducing information intensity horizontally and spatially. An open team culture has transcendent entities, has many information intensive linkages among groups and is highly interdependent. An open team is possessed of thin-permeable boundaries between in-group and out-groups, and the exchange of information is intensified horizontally and spatially (Hofstede 1998, Workman 2001, Mohammed *et al.* 2002, Hertel *et al.* 2004).

If boundaries are indistinct, teams may reach out to take on more responsibility only to find other groups feel invaded, increasing the propensity for conflict (Daft 1998). Although it may lead to increases in external conflict, studies of proximal groups suggest that in complex environments, an open structure is more compatible than a closed structure because it enables the free flow of necessary information and resources, and best accommodates growth and change (Cole *et al.* 2002). Since virtual teams must rapidly assemble and import eclectic information to accomplish their tasks across functional, divisional, geographical and time spans (O'Hara-Devereau and Johansen 1994, Lipnick and Stamps 1997, Symon 2000, Griffith *et al.* 2003), and since virtual team assembly occurs with the involvement of many departments such as human resources and line managers (Hyde 2004), permeable boundaries that best facilitate information flows are likely to better support the dynamic nature of virtual teams (Bell and Kozlowski 2002, Hertel *et al.* 2004).

In addition, to compensate for informational gaps created by technology mediation, distance and time, increased peer-group referencing occurs in a virtual setting. 'As compared with individuals working within proximity of similar comparison others, individuals within a virtual context will engage in more attempts at selecting referents outside of the organisation' (Conner 2003, p. 141) to assess the distribution of workload, task progress and fairness in relation to distributive justice (Lipnick and Stamps 1997, Conner 2003, Griffith *et al.* 2003). This increases the need

for horizontal and spatial linkage, best facilitated by an open team culture. Therefore,

H1: Procedural structure in global-transnational virtual teams is such that (a) process-oriented teams will have better performance than results-oriented teams, and (b) openness strengthens this positive effect.

Normative teams concentrate on formalising the structure governing work behaviour, similarly to process-oriented teams that formalise structure through process specificity. They are characterised by a high degree of political formality and have extensive policies. The culture's emphasis is on obligations, and norms are more important than attitudes (Triandis and Gelfand 1998). Pragmatic teams concentrate on flexibility and are characterised by agility and have adaptable policies for governing behaviour (Hofstede 1998, Mohammed *et al.* 2002). In pragmatic teams, individual needs take precedence over team needs, and personal attitudes are more important than norms (Triandis and Gelfand 1998).

Studies of proximal teams suggest that while there is increased potential for internal conflict (Yang *et al.* 2000), pragmatic groups are most suitable to complex and dynamic environments because they enable groups to react best to changes in the environment (Daft 1998). However, since virtual teams are distributed across space and time, managerial functions are more difficult to perform; consequently, it is necessary to provide substitutes for leadership stipulated in policies and regulations (Daniels *et al.* 2001, Bell and Kozlowski 2002). In addition, the international context brings differences in cultural values and norms. Since normative influences are substantially reduced in a technologically mediated setting (Montoya-Weiss *et al.* 2001) institutional norms must be established to reduce ambiguity and internal conflict (Daft 1998). Unlike proximal groups where members often freely interact to derive team norms and behaviours and their contemporaneous nature better facilitates agility, effective virtual team performance requires specification 'not only of individual team member roles but also the interrelationships between the roles of team members' (Bell and Kozlowski 2002, p. 41). Stated more simply, when *ad hoc* formation of norms is constrained, formalising normative behaviours will increase structure. Supplemented by team openness, these factors have implications for performance (Daniels *et al.* 2001, Griffin *et al.* 2001, Montoya-Weiss *et al.* 2001). Consequently,

H2: Political structure in global-transnational virtual teams is such that (a) normative teams will have better performance than pragmatic teams, and (b) openness strengthens this positive effect.

2.2 Relationships and openness

Employee-centred teams operate on the principle of consensus and are collectivistic in nature. They derive feedback from team-mates and work collectively on problem-solving. Work sequencing in employee-centred teams tends to be negotiated, whereas in teams that are job-centric, work sequencing tends to be dictated by management or by means of expert power (Eby and Dobbins, 1997). Job-centred teams are individualistic in nature and operate on the principles of efficiency, cost and time (Eby and Dobbins 1997, Hofstede 1998, Workman 2001). They derive feedback from nonsocial sources such as a computer or documentation, and they work by themselves on problems and tasks (Workman 2001).

'The extent to which team members cooperate may be an important factor in objective team performance' (Eby and Dobbins 1997, p. 281); however, there are reduced formal and informal interactions in virtual teamwork that normally take place in a traditional office setting (Fritz *et al.* 1996, Raghuram 1996, Ellison 1999), and interactions that take place are constrained when compared with proximal exchanges owing to technology mediation, as well as distance and time (Fussell and Benimoff 1995, Jehng 1997, Konradt and Schmook 1999, Workman *et al.* 2003). Given these constraints, when the exchange of informational resources are facilitated by a team's openness, transnational virtual teams are likely to realise more positive benefits from a job-centred orientation than an employee-centred orientation (Ellison 1999). Thus,

H3: Interpersonal relationships in global-transnational virtual teams are such that (a) job-oriented teams will have better performance than employee-oriented teams, and (b) openness strengthens this positive effect.

Similar to employee-job orientation, parochialism/professionalism reflects a delineation between relationships and work. Consistent with social identity theory, which explains the formation of group identities (e.g. Chen *et al.* 1998), parochial teams form tightly integrated identities among team members and are inward facing. The definition of 'self' in parochial teams is interdependent with the team (Triandis and Gelfand 1998). They have been described in popular literature as 'clan cultures' (Kerr and Slocum 1987) indicating insularity and high cohesion. More than technical accomplishment, team identification produces psychological fulfilment (Eby and Dobbins 1997, Shaw and Barrett-Power 1998, Ellison 1999). In professional teams, the definition of 'self' is independent from the team (Triandis and Gelfand 1998). They are profession-centric and their focus is on expertise (Hofstede 1998). They identify more spatially across business lines with others in

their field, and they derive psychological fulfilment from their work (Cole *et al.* 2002).

Since many virtual teams are not only dispersed, but are transient, that is to say, they form to accomplish a specific task and then disband (Bell and Kozlowski 2002), changes in team membership force continuous compression in the forming, storming, norming, performing (Tuckman and Jensen 1977) type of group adjustments (Lipnick and Stamps 1997). Global transnational virtual teams are also functionally mixed (O'Hara-Devereau and Johansen 1994). Consequently, when facilitated by openness, a team culture in which the work is paramount is more likely to outperform team cultures in which team cohesion and interpersonal attachment is paramount. Stated formally,

H4: Organisational relationships in global-transnational virtual teams are such that (a) professional teams will have better performance than parochial teams, and (b) openness strengthens this positive effect.

2.3 Primacy and openness

Tightly controlled teams have strict management hierarchies, clear hierarchy of authority and decision-making tends to be centralised. Loosely controlled groups are more autonomous. Decision-making authority tends to be decentralised, and the decisions tend to be emergent and adaptive (Murnighan 1981, Hofstede 1998, Moses and Stahelski 1999). Since virtual teamwork is less structured than proximal teamwork and has elevated uncertainty (Workman *et al.* 2003), virtual team leaders must provide additional clarity and direction (Conner 2003).

Tighter supervisory control enables virtual team leaders to develop an understanding of contextual factors critical to performance management, including the ability to address work processes conducted by virtual team members with disparate worldviews (Bell and Kozlowski 2002). Virtual team leaders must also 'closely monitor any changes in the environmental conditions. Because virtual team members are distributed, they are less aware of the broader situation and the dynamics of the overall team environment. So, as external conditions change, such as modified task specifications, a new deadline, or changes in the team's goals, leaders need to facilitate adaptive and appropriate changes within their team' (Bell and Kozlowski 2002, p. 27). As autonomy increases, ambiguity increases concomitantly, particularly in a dispersed setting that is mediated by technology (Jehng 1997, Lim and Benbasat 2000), and this can have a negative impact on group performance (Montoya-Weiss *et al.* 2001, Conner 2003, Workman *et al.* 2003). Stated more succinctly, when constrained by media, distance and time, greater primacy improves performance-related structure. When complemented with team openness,

there should be greater mutual clarity of performance expectations. Hence,

H5: Primacy in global-transnational virtual teams is such that (a) tightly controlled teams will have better performance than loosely controlled teams, and (b) openness strengthens this positive effect.

3. Methodology

3.1 Organisational context

DigiGlue, a pseudonym, is a transnational organisation serving in over 220 countries and territories, and covering more than 140 nationalities speaking 70 languages. The operational headquarters is located in Paris, France and the company employs a staff of over 4,300 people, who work on integrated networks and information technology solutions around the world. Services include outsource software development, implementation of network solutions and security, such as firewalls, integration of telecommunications systems, and managed services for more than 40 per cent of the world's multinational corporations.

Because of their global reach and the dynamic nature of their business and client base, DigiGlue utilises global virtual teams for projects ranging from a few months to over a year, which require specific expertise for projects in a particular geography. Membership in virtual teams consists of approximately 2,000 personnel serving in various roles, such as network engineers, security specialists, system architects and designers, network administrators, software designers and developers, business analysts, database analysts, hardware specialists and team managers.

The virtual team managers have been trained in the DigiGlue's virtual team process, called Way Of Working (WOW). This involves the processes used for scheduling and assembling virtual team members who are drawn from their proximal teams and return to them when the virtual team project completes. The process also includes the protocols used for horizontal linkages with proximal team managers to coordinate work on the various projects, as well as the budgetary allocation for resources.

3.1.1 Sampling. Data were collected for 436 virtual team projects over a 27-month period. Dependent variable data were collected simultaneously with independent variable data as each project concluded. Project duration was an average of 7.11 months ($SD = 2.22$, range 2.4 months to 13.7 months). Teams consisted of members from 17 countries. The average team size was 8 members ($SD = 1.69$, range 5–12 members). The total response rate on the self-report data collection was 78 per cent, and the

average team response rate was 76 per cent ($SD = 1.67$, range 4–12).

3.1.2 Procedure. After the researcher signed a confidentiality agreement, entrée into the virtual proximal teams was brokered by the DigiGlue Executive Vice President (EVP) of Engineering, who provided the researcher with a company directory of the population under study, including location and email addresses by which participants would be identified and tracked. Individual virtual team and proximal team managers were informed by the DigiGlue EVP of Engineering about the purpose of the study and about the researcher conducting the study, and asked for their cooperation. Managers and team members were assured of the confidentiality of their responses. As each project was assigned, it was given a unique number along with planned inception and completion dates. The cover letter and data collection instrument were distributed to virtual members via email and attachment, and participants returned their responses directly to the researcher via email and attachment.

3.2 Measures

In knowledge work, performance can be equated to quality and quantity metrics. Quality has been defined by the number of errors (defects) found as a proportion of the size of a given project (defect rate), and quantity has been defined by the productivity rate, which is often measured against a project schedule and tends to correlate with project cost (Booch 1996). DigiGlue's stated performance objectives are to improve efficiency ('budget conformance') and production ('service delivery schedule conformance'), while delivering high-quality solutions ('fewer errors'). Therefore, variance of planned to actual schedule and the numbers of errors in software and configurations generated by the team as a result of the project constitute DigiGlue's key performance measures, which were maintained by virtual team project managers using various packages such as Microsoft Project.

The DigiGlue EVP of Engineering provided the researcher with the performance data and files consisting of percentage schedule variance (on a per person hour basis), percentage budget variance (in Euros), and percentage errors per person-hour for each project. Smaller numbers indicated better performance. The percentage schedule DV was scaled so that negative numbers indicate shorter than planned schedule on a per person hour basis. Budget and schedule variance were highly correlated ($r = .81$, $p = .000$) and thus only schedule variance was used in the analysis.

The percentage errors DV were positive numbers indicating the per cent of errors relative to person hours spent on the project. The errors data were captured by means of problem 'incident' reports to the technology

support group, which were logged into a problem database, and tying these incidents to the software change control logs that identified the changes made by the virtual teams. Errors were counted for incidents and reported during the Quality Assurance testing cycle and for three months after project deployment for each virtual team project. There was not a significant correlation between schedule variance and percentage errors ($r = -.03$, $p = .351$).

The independent variable data collection instrument used Hofstede *et al.* (1990) items (43 items) worded according to Hofstede's (1998) recommendations. Self-report data were also collected for nationality of virtual team manager and members, geography of target virtual team project, along with demographics. Items also collected self-report data about how the team's way of working was determined, whether by virtual team leader directive, team member negotiation, policies, top management, or customers, along with virtual team members' perceptions about the team's effectiveness relative to itself and compared to their experience in proximal teams.

To enrich and triangulate the self-report data (c.f. Daft 1998, Mohammed *et al.* 2002), artefacts were examined and counted for each virtual team project. For example, the numbers of written documentation for procedures, job descriptions, regulations, policies and standard practices such as TQM, ISO9000 and CMM were triangulated with self-report responses. There were significant correlations on each factor with the objective data.

Data screening was performed by using a combination of scatter plots and the examination of Mahalanobis distances (Tabachnick and Fidell 1996), which led the removal of 12 individual responses, leaving 1,197 individual responses and 436 virtual team projects. Since the data collection instrument was employed at the team rather than organisation level, instead of running a confirmatory factor analysis the instrument was analysed with component analyses using Varimax rotation. With eigenvalues set at 1.00, 19 items showed communalities less than .7 and were removed from the analysis according to Kaiser's rule (Stevens 1992, Tabachnick and Fidell 1996), leaving 24 items. One item from the professional/parochial orientation cross-loaded to the job/employee component (.73). Since there was no theoretical justification for support, it was removed. After removal of the items, cross-loadings were all under .38, indicating good validity among items and their constructs (Stevens 1992), and multicollinearity tolerances for the components all exceeded .855. Construct alpha reliabilities were .83 for the process–results orientation component, .79 for employee–job orientation, .77 for parochial–professional, .88 for open–closed, .82 for tight–loose and .86 for normative–pragmatic components.

Although sometimes controversial it is common practice to harmonically average team responses for team-level constructs (Hertel *et al.* 2004). The rwg (correlation within

group) statistic (James *et al.* 1993) was used to infer interrater agreement. Similar to other reliability indices, rwg indicates convergence among raters on variables associated with a component (where 1 is complete agreement). All rwg computed in this analysis resulted in positive scores. For process–results orientation, $\text{rwg} = .88$, for employee–job orientation, $\text{rwg} = .81$, for parochial–professional, $\text{rwg} = .84$ for open–closed, $\text{rwg} = .81$ for tight–loose, $\text{rwg} = .78$, and for normative–pragmatic, $\text{rwg} = .80$. Also, James (1982) suggested the use of two intra-class correlations (ICCs) for determining agreement among team members. ICC[1] suggests the extent to which members of a team agree (which range from .00 to .50 with a median of .12). ICC[2] suggests whether teams can be differentiated on the variable of interest, and should exceed .70. Across the dimensions, the minimum ICC[1] was .23 and the minimum ICC[2] was .79, which justifies averaging responses.

4. Results

Table 1 presents the means, standard deviations and correlations among study variables.

The hypotheses were assessed using a moderated regression analysis (Aiken and West 1991), which is a relatively conservative method for examining interaction effects as the interaction terms are tested for significance after all main effects have been entered into the regression equation. Controlling for project duration, and centring the data on the means to reduce multicollinearity among the interaction terms and their individual components, the effects were assessed at the team level for the two dependent variables: percentage of schedule variance, and percentage errors per schedule hour. The model is summarised in table 2.

Because virtual teams have less externally supplied structure, process formalisation should mitigate. Therefore the first hypothesis (H1a) tested whether process-oriented virtual teams (coded as higher scores) would have better performance than those that were more results-oriented. As seen in table 2, since better performance is reflected in lower scores, this hypothesis was supported for both performance measures: percentage schedule variance ($\beta = -2.69$, $p < .000$), and human-induced errors ($\beta = -1.83$, $p < .000$). Since openness should further augment structure by facilitating information exchange with other organisational units in the absence of formal process specificity, moderation was proposed. The test of the interaction hypothesis (H1b) confirmed that more process-oriented teams that are more open have incrementally better performance on both measures: percentage schedule variance ($\beta = -1.11$, $p < .000$), and human-induced errors ($\beta = -1.06$, $p < .000$).

In a similar fashion, hypothesis 2a stated that political structure in global-transnational virtual teams would result in normative teams (coded as lower scores) having better

Table 1. Descriptive statistics and correlations among the study variables.

Measure	Mean	SD	1	2	3	4	5	6	7	8
Results/Process	3.91	1.64	–							
Job/Employee	4.22	1.35	.15*	–						
Profession/Parochial	3.79	2.04	.04	.06	–					
Closed/Open	4.02	.99	–.03	.06	–.01	–				
Tight/Loose	3.88	1.03	.09	.14*	–.04	.10*	–			
Normative/Pragmatic	4.00	1.74	–.15*	–.08*	–.10*	–.07*	.06*	–		
Duration (in months)	7.11	2.22	.04	.05	.06	.06	.07*	–.05	–	
% Schedule variance	.07	2.03	–.27***	.23**	–.07	–.11**	.19**	.07	–.14*	–
% Error/schedule hour	.11	1.64	–.13*	.07*	.06	–.07*	.01	.02	–.26**	–.03

Note: Pearson's r ; $N = 436$; * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 2. Standardised regression coefficients and summary.

	% Schedule variance	% Error per schedule hour
Regression Model (Step 1)		
Constant	16.21	5.77
Results/Process	–2.69***	–1.83***
Normative/Pragmatic	.71*	.36 ns
Job/Employee	1.42***	.77*
Profession/Parochial	.15 ns	–.24 ns
Tight/Loose	1.12**	.89**
Closed/Open	.80*	–.93**
Model R^2	.50	.37
Adjusted R^2	.49	.34
Interactions Step		
Results/Process $\times$ Closed/Open	–1.11***	–1.06***
Normative/Pragmatic $\times$ Closed/Open	.62*	.83**
Job/Employee $\times$ Closed/Open	.73*	.24 ns
Profession/Parochial $\times$ Closed/Open	.38 ns	–.08 ns
Tight/Loose $\times$ Closed/Open	1.16***	1.14**
Model R^2	.60	.39
Adjusted R^2	.58	.39
Δ Model R^2	.09***	.05**

* $p < .05$, ** $p < .01$, *** $p < .001$.

performance than pragmatic teams. This was marginally supported for the percentage schedule variance ($\beta = .71$, $p = .032$), but was not supported for human-induced errors ($\beta = .36$, ns). The interaction hypothesis (H2b) stated that openness would enhance performance by facilitating information exchange to fill in structure. This was supported for both the percentage schedule variance ($\beta = .62$, $p = .039$), and for human-induced errors ($\beta = .83$, $p = .008$). Although political formality alone did not reduce the incidence of errors, a slight reduction in errors was observed when political formality was combined with openness.

Hypothesis 3a indicated that the nature of global-transnational virtual teams would benefit job-oriented teams (coded as lower scores) in terms of better performance over employee-oriented teams. This was supported

for the percentage schedule variance ($\beta = 1.42$, $p < .000$), and was marginally supported for human-induced errors ($\beta = .77$, $p = .047$). The interaction hypothesis (H2b) stated that openness would further enhance performance. This was marginally supported for the percentage schedule variance ($\beta = .73$, $p = .046$), but was not supported for human-induced errors ($\beta = .24$, ns).

Similarly, hypothesis 4a (H4a) asserted that professional global transnational virtual teams (coded as lower scores) would have better performance than parochial teams. This was not supported on either performance measure: percentage schedule variance ($\beta = .15$, ns), human-induced errors ($\beta = -.24$, ns), nor was the interaction hypothesis (H4b) supported: percentage schedule variance ($\beta = .38$, ns), human-induced errors ($\beta = -.08$, ns).

Finally, hypothesis 5a suggested that primacy in global-transnational virtual teams benefit tightly controlled teams (coded as lower scores) in terms of better performance over loosely controlled teams. This was supported for the percentage schedule variance ($\beta = 1.12$, $p = .002$), and was also supported for human-induced errors ($\beta = .89$, $p = .007$). The interaction hypothesis (H2b) stated that openness would further enhance performance. This was supported for the percentage schedule variance ($\beta = 1.16$, $p < .000$), as well as for human-induced errors ($\beta = 1.14$, $p = .003$).

As seen by the change in coefficients in table 2, team openness adds an additional 9 per cent ($p < .000$) to the variance accounted for relative to percentage schedule variance, and 5 per cent ($p = .002$) for human-induced errors.

5. Discussion

Increasingly, organisational and geographically dispersed employees work in virtual team settings. Organisations reduce costs with global virtual teams by reducing the human and non-human resource redundancy that would otherwise be required for global reach, and by enabling the

concentration of specific expertise, regardless of where that expertise is geographically located. While virtual teams share many similarities with proximal teams, there are also substantive differences. For instance, performance components are equivalent yet the natures of proximal and virtual teams differ in several important ways that affect structure, relationships and primacy (Bell and Kowzowski 2002). Thus there have been questions about whether the cost reductions associated with transnational virtual teams are offset by lower team performance.

Since team subcultures are instrumental in structuring the work processes and interpersonal relationships among workers (Chatman and Flynn 2001, Daniels *et al.* 2001), Hofstede's (1998) cultural dimensions were used in this quasi-experimental field study to examine cultural influences in the performance in transnational virtual teams, where workers are geographically dispersed and interact exclusively through electronic mediation. Two aspects of performance were examined: quantity and quality, where quantity was determined by the productivity associated with a project schedule (such as whether the team completed under planned time, on time, or over planned time), and quality was determined by the number of errors in software configurations that the team inadvertently created during the project.

Many studies (cf. Hertel *et al.* 2004) have also shown that cross-team communication and cooperation can influence performance outcomes. Consistent with social influence theory, communication and cooperation are regulated to varying degrees by team openness, which determines the permeability of team boundaries (boundary thickness). Since transnational virtual teams are dynamic, and since various aspects of team culture influence communication and cooperation, such as whether members form strong team identity and high cohesion, team openness was examined as a moderator of team performance.

This study indicates that global transnational virtual teams in which members formalise their process structures (means focused) outperform those in which teams concentrate on results (ends-focused) in terms of both quantity and quality. Although process-oriented cultures have been linked to better quality performance (Malnight 2001), this finding is at odds with much of the research literature about productivity in proximal teams (e.g. Daft 1998). However, because virtual teams have less structure than proximal teams leading to increases in ambiguity (Workman *et al.* 2003), process-oriented cultures supply much needed specificity about work processes to assist them in accomplishing their tasks. And since these teams are dynamic, additional structure is acquired by the interaction facilitated by increased team openness.

However, the same magnitudes in gains were not seen regarding political structure. While a team's orientation towards greater political structure had a mild positive affect

on quantity, there were no benefits in reducing errors. One consideration not taken into account in this conclusion is whether an increase in concentration of political structure focused on quality would yield measurable results. This idea is bolstered by the significant improvements realised when political formality is augmented by increased team openness. Teams that reach out for additional information and clarification on roles and responsibilities showed marked improvements in both quantity and quality.

Since relationships are affected by mediated interaction, which both reduces the amount of information conveyed (cf. Daft and Lengel 1986) as well as frequency and quality of interaction (cf. Jehng 1997), teams in which the job is paramount to interpersonal relationships saw better performance in both quantity and quality. Because virtual teams are formed and then disband in a compressed timeframe (Lipnick and Stamps 1997), virtual teams are more suited to task-oriented structuring that focus teams on the work rather than on each other. Moreover, since virtual team-mates are dispersed, those in which feedback is derived from non-social sources such as documentation and computers are better able to accommodate interactive constraints imposed by various media. However, when combined with team openness, there were mixed results.

Further examination of the enriched data indicated that particularly among relationship-oriented teams, impacts were felt in open team cultures as a result of requests for assistance from proximal team-mates and managers, which may have led to the marginal and insignificant findings. One of the complications of virtual teamwork is that members are drawn from proximal teams, to which allegiances remain and to which virtual team workers return. The coordination and management of such a matrix structure may create tensions as well (Mohammed *et al.* 2002). Also, open team cultures have been found to be more subject to conflict than more closed cultures, which may impact performance (Daft 1998, Griffin *et al.* 2001).

Finally, the concentration or dissemination of power (primacy) was observed such that more tightly controlled teams compared to those more loosely controlled, realised better performance. Explicit virtual team management apparently served to help regulate the forming, storming, norming, performing type of group adjustments (Tuckman and Jensen 1977), typically experienced by teams by serving to quickly establish expectations and guidelines for group objectives. When combined with increased openness, tightly controlled teams accrued additional performance benefits.

5.1 Limitation and recommendations

Since this study used a quasi-experimental technique—specifically we relied on intact groups—there are limitations regarding the certainty of the conclusions reached. Additional research is needed to confirm the findings. It is hoped that this

limitation is offset by the increased ecological validity associated with field studies over true experiments.

Although objective measures were used to triangulate and enrich the self-report data, they were not used for the analysis of the independent measures. This is largely because these data were incomplete. For instance, as an indicator of interaction, we were able to count the number of communications between team members and other organisational units using archived media such as email, discussion threads and Lotus Notes, but we were unable to obtain access to telephone conversations due to both technological and privacy issues.

We had little success with the professional/parochial component. Only two of Hofstede *et al.* (1990) items loaded above .7, and one cross-loaded to the job/employee component, and the results were insignificant. Additional items had been collected and were tested in an analysis for a better fit, with little appreciable effect. It may be that this component is more applicable to the organisation rather than team level. There is another possibility as well. There were indications of strong polarisation among French, British and US nationalities that led to signs of increased dysfunctional conflict in some projects. In proximal settings, these entrenchments may often be overcome with increased interaction (Shaw and Barrett-Power 1998); however, in dispersed settings, there is an impedance of social identification and higher tendency to objectify others (Fussell and Benimoff 1995, Jehng 1997). This may have had an impact on parochial teams in particular in terms of their ability to identify with one another.

We aggregated the independent measures to the team level. Doing so is a controversial procedure. To mitigate, we used rwg to suggest interrater agreement; however, this too is subject to criticism because systematic disagreement (half the raters rate high, the other half low) can be masked. Moreover, unlike most other measures of reliability, there are conditions in which negative scores can result. Since our scores were all positive and relatively high (well above the generally accepted .70 level), it is hoped that a sufficient level of confidence in agreement was achieved.

As globalisation and mergers and acquisitions continue, increases in virtual teams are expected in transnational configurations. Based on this study's findings, a greater emphasis on supplying structure through more process and political formalisation, greater primacy, an increase in job-focus is needed compared with proximal team arrangements. Efforts should also be made at thinning team boundaries and facilitating information flows.

Research into virtual teams at the micro-organisational level is showing consistencies relative to perceptual job-fit and the roles in which media play on various outcomes. Few studies have examined meso- and macro-level factors. Future research should continue to flesh out the sparse body of empirical literature as well as the continued development of theory.

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