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Abstract

The ability to collaborate is one of the key variables underlying the tenets of network-enabled operations. Research findings suggest that the effectiveness of networked teams depends on command and control (C2) structure, the degree of virtuality, interaction means, human factors such as personality, competencies and attitudes of team members, trust, reciprocity, altruism, and resulting group dynamics. However, little is known as to which degree C2 structure affects team performance when information is ambiguous, and about the moderating role of human factors.

This paper describes a multi-factorial research design developed to analyze the impact of C2 structures (hierarchy versus edge), reward structure (collective versus individual), and the degree of information quality on team performance, moderated by trust, reciprocity, altruism, personality-related team composition, and cohesiveness. The research design involves the application of a 2 x 2 x 2 experimental design to create eight experimental conditions under which team performance is measured using the simulation tool ELICIT ('Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust'), and assessment of the moderating effects of personality, trust, and cohesiveness.

In addition, qualitative interaction analyses will be conducted to advance the current understanding of team processes. The results will enrich the existing knowledge of relations between C2, personality-related team composition, trust and related attitudes, robustness of teams vis-à-vis unfavorable information conditions, and collaborative decision-making.

Keywords: Network-enabled collaboration, organizational structure, information quality, personality, attitudes

Introduction

In recent years, technology has made rapid progress in providing resources for locally distributed collaboration based on the idea of network-enabled operations and decentralized decision-making by empowered actors (e.g., Alberts, et al., 2001; Alberts & Hayes, 2003). In network-enabled operations, data and information are quickly available to all actors involved so that they may decide faster and better without having to be co-located. Yet, for the agile organization to function effectively and efficiently, technological resources are not sufficient. Human and organizational factors are considered crucial in C2 processes, both as potential inhibitors for, and powerful enablers of effective collaboration.

This research project is motivated by the follow-on work of several study groups of the Systems Analysis and Simulation (SAS) Panel of the North Atlantic Treaty Organization's Research and Technology Organization (NATO-RTO), in particular SAS-026, SAS-050, and SAS-065. These study groups address the assessment of C2 systems and processes with a view to the changing operational environment of the twenty-first century and the transformation of industrial age to information age military forces. The conceptual models evolving from this work stress both the importance of human and organizational factors for C2 and the view that the amount of available empirical knowledge about the impact of these factors is far from satisfactory, especially in the context of modern information technology and networked operations. The results of a previous study (Huber, et al., 2007) provide further motivation for the research proposed here, demonstrating that current assumptions on the impact of human and organizational factors on team performance need to be revisited in the light of modern communication technologies and edge organization contexts.

This paper presents a research design that may be employed to analyze the decision-making processes and performance of hierarchically and edge-like organized teams that are confronted with incorrect information and provided incentives either for individual or team performance. It is further assumed that individual dispositions and attitudes of team members moderate the effects of these conditions on team performance. A 2 x 2 x 2 research design and an experimental setting consisting of a series of ELICIT and Ultimatum games is presented. The ELICIT game simulates decision-making in edge and hierarchical organizations, enabling measurement of the effects of variations of the organizational design on team performance, i.e. team effectiveness and efficiency (Leweling & Nissen, 2007; MacKinnon, et al., 2007). The Ultimatum game enables assessment of the levels of trust, altruism and reciprocity in teams (Güth, et al., 1982). Assumed moderating variables, i.e. personality and team cohesion, will be measured by questionnaire.

The paper is organized as follows: After a brief review of the relevant literature and deduction of propositions, research design and measurement instruments, including the simulation tool ELICIT, are described. The paper concludes by highlighting relevant theoretical and practical implications of the expected results of the proposed research.

Theoretical Background and Propositions

In this section, the state-of-the-art in relevant research and current propositions in regard to assumed effects of organizational structure, information quality and reward structure on team effectiveness and efficiency, and possible moderating effects of team member personality and attitudes are summarized. The research questions underlying the propositions are mainly informed by the fact that, in real-life settings, teams are usually confronted with inconsistent information, changing organizational designs, different reward structures (individual and collective incentives), and varying levels of team cohesion, trust and reciprocity. Today, armed forces frequently operate in hierarchical C2 structures, and it is still an open question whether decentralized and flat organizations, such as edge organizations, outperform hierarchical organizations under varying conditions of

reward structure, information quality, and team composition with respect to team member personality and attitudes.

Organizational Structure

Recent empirical research implies that team effectiveness depends on structural parameters. In particular, flat organizational structures, e.g., edge organizations, appear to outperform hierarchical structures at least in specified contexts and in terms of specified performance measures (Leweling & Nissen, 2007; Ruddy, 2007). For instance, the effectiveness of teams as rated by both employees themselves and their managers has been found to be positively associated with the degree to which self-management and participative decision-making has been enhanced in teams (Campion, et al., 1993; Campion, et al., 1996). Similarly, Tata and Prasad (2004) found that not only the level of self-management in a team and micro-level centralization, but that also the level of formalization, may be related to effectiveness. Proposition 1 thus reflects a widely shared view.

Proposition 1a. Edge organizations outperform hierarchical organizations in team performance in terms of (1aa) effectiveness and (1ab) efficiency.

As teams continue performing the same specified task, learning can be expected to take place. This should be particularly true for teams that don't possess previous experience with the specific task at hand: as task-specific experience grows, additional learning is expected to constantly decrease – all else being equal. However, organization structure may influence learning. A team continuing to perform within a specified structure may experience a change in performance that is different from a team the structure of which has been changed, e.g., from hierarchy to edge, or vice versa. This may apply to both performance measures, effectiveness and efficiency.

Proposition 1b. Perpetuation and change of organization structure between the first and second experimental run (edge vs. hierarchical organization) exert different effects on learning in the team with respect to (1ba) effectiveness and (1bb) efficiency.

Information Quality

The ability of a team to handle incorrect information is one aspect of team robustness. Crucial for team performance is a team's transactive memory system (TMS) including expertise location, task-knowledge coordination, and cognition-based trust (Kanawattanachai & Yoo, 2007). Incorrect information hinders the development of TMS along all three dimensions. Development of TMS is positively correlated with team performance, as virtual teams with highly developed TMS can communicate in a 'smart' way, minimizing the volume and frequency of task-oriented communication without negatively affecting team performance (Kanawattanachai & Yoo, 2007; Pearsall, et al., 2007). Teams can be expected to establish TMS more easily under conditions of correct information, and therefore outperform teams having to deal with partly incorrect information.

Proposition 2. Teams operating with entirely correct information outperform teams operating with partly incorrect information in terms of (2a) effectiveness and (2b) efficiency.

Remuneration

According to the goal interdependence theory of cooperation and competition, people's beliefs about how their tasks and goals are related with those of others determine the way in which they interact, which in turn affects their performance and group cohesiveness (Beersma, et al., 2003; Dennis & Garfield, 2003; Deutsch, 1949). The relationship between reward structure and performance has been found to be contingent upon team members' personalities and the dimension of a task: Speed is enhanced by competitive reward structures, whereas accuracy is enhanced by cooperative reward structures (Beersma, et al., 2003). Money as an incentive is a highly competitive reward (Layard, 2005). Thus, an individual as opposed to collective reward structure is hypothesized to negatively influence the free flow of information and, as a consequence, team effectiveness and efficiency, the effect on efficiency being somewhat weaker than the effect on effectiveness as competitive reward structures at least tend to enhance task speed.

Proposition 3. Teams operating under conditions of collective remuneration outperform teams working under conditions of individual remuneration in terms of (3a) effectiveness and (3b) efficiency.

Interaction effects

Provided that one or more of the experimental dimensions selected for this paper, i.e., organization structure, information quality, or remuneration structure, influence team performance, it is reasonable to assume that the evaluation of the combined effects of these dimensions will provide significantly richer findings than the separate consideration of every single dimension. Yet, it is an open question to which degree organizational structure affects the ability to cope with the effects of different reward strategies and incorrect information in terms of team performance. Thus, the following proposition is deduced:

Proposition 4: Organization structure (edge vs. hierarchy), information quality (correct vs. partly incorrect) and remuneration structure (collective vs. individual) interact as to jointly affect team performance in terms of (4a) effectiveness and (4b) efficiency.

Personality and attitudes

In addition to organizational and information-related determining factors, the individual team members' personality structures, competencies and attitudes, and the team composition resulting from these characteristics, have been found to be critical for collaboration and team performance (Barrick, et al., 1998; Barry & Stewart, 1997; Halfhill, et al., 2005; Huber, et al., 2007; Paul & McDaniel, 2004; Piccole & Ives, 2003). In the following sections, selected variables hypothesized to affect team performance are described. Thereby,

trust and the attitudes underlying reciprocity and altruism as well as the personality factors referred to as the ‘Big Five’ in the current literature, i.e. emotional stability, extraversion, openness to experience, agreeableness, and conscientiousness. The taxonomy of the Big Five personality factors has evolved from extensive research efforts in the domain of personality psychology. Like the conceptually similar dimensions of the Myers-Briggs Type Indicator[®] (MBTI[®]) that have been found to be relevant for the performance of small networked C2 teams (see Huber, et al., 2007), the Big Five personality factors have been shown to be useful in predicting a wide range of human behaviors (Barrick & Mount, 1991; Barrick, et al., 1998; Costa & McCrae, 1992; McCrae & Costa, 1987; Mount, et al., 1998; Salgado, 1997, 1998).

Emotional Stability

Individuals high in emotional stability – the opposite of which is usually referred to as neuroticism – can be characterized as calm, relaxed, and even-tempered; individuals low in emotional stability, on the other hand, tend to frequently experience negative emotions, nervous tension, anxiety, depression, anger, insecurity, low self-esteem and ineffective coping (McCrae & John, 1992). What follows from this is that emotionally stable individuals are less likely to experience stress than emotionally unstable individuals. However, in situations or settings that are overall more likely to evoke the perception of stress, this effect may show more clearly. Organizational structure and information quality are assumed to represent such situations or settings the different manifestations of which hence imply differentially high stress potential.

A rigidly hierarchical structure appears to provide security for the organization’s members in that procedures of information exchange and decision-making follow clearly prescribed rules and are thus predictable. Hence, hierarchy is regarded as a structure associated with a low level of stress potential. Edge organizations don’t possess any prescribed lines of command that have to be complied with. This in turn means that they tend to convey relatively little sense of orientation for organization members implying a relatively high potential for the perception of stress. Individuals low in emotional stability may thus face greater difficulties with edge organizations than with hierarchy organizations so that teams the members of which have low emotional stability cannot take full advantage of a potential superiority of edge over hierarchical organizations.

Proposition 5a: Team members’ extent of emotional stability moderates the effect of organizational structure (edge vs. hierarchy) on (5aa) effectiveness and (5ab) efficiency in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with high levels of emotional stability than for those with low emotional stability.

Information that is entirely correct can be perfectly relied on for decision-making and problem-solving. However, collaboration based on pieces of information that turn out to contradict others or to be simply incorrect, imply a higher stress potential than perfectly reliable information. When having to deal with incorrect information, individuals low in emotional stability may thus feel more strained than emotionally stable individuals so that

the potential superiority of the effects of entirely correct over partly incorrect information may be larger for emotionally unstable than for emotionally stable individuals.

Proposition 5b: Team members' extent of emotional stability moderates the effect of information quality (correct vs. partly incorrect information) on (5ba) effectiveness and (5bb) efficiency in that the superiority of entirely correct information settings over partly incorrect information settings (see Proposition 2) is more expressed for teams with low levels of emotional stability than for those with high emotional stability.

Low emotional stability is also associated with a tendency for depression and low self-esteem (McCrae & John, 1992). Individuals with low emotional stability may thus be likely to experience greater stress when they expect to receive rewards based on their individual contribution to the team's performance outcomes rather than on the performance of the overall team. The extent of team member emotional stability is assumed to be negatively correlated with a potential superiority of the effects of collective over individual remuneration on team performance.

Proposition 5c: Team members' extent of emotional stability moderates the effect of remuneration structure (collective vs. Individual) on (5ca) effectiveness and (5cb) efficiency in that the superiority of collective remuneration over individual remuneration (see Proposition 3) is more expressed for teams with low levels of emotional stability than for those with low emotional stability.

Extraversion

Individuals high in extraversion are characterized as sociable, active, dominant, ambitious, but also impulsive, whereas introverts are described as introspective and self-preoccupied (Judge, et al., 1999). Due to their sociability, extraverts are likely to enjoy interactions with a large number of others whereas introverted individuals tend to focus on a smaller number of interaction partners.

Edge organizations allow for the largest possible number of interactions between involved individuals, but these may be able to make use of the full potential inherent in this structure only if most of the interpersonal links are enacted through interaction. Thus the extent of team member extraversion is hypothesized to be positively correlated with a potential superiority of the effects of edge over hierarchical organization structure on team performance.

Proposition 6a: Team members' extent of extraversion moderates the effect of organization structure (edge vs. hierarchy) on (6aa) effectiveness and (6ab) efficiency in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with high extraversion than for those low in extraversion.

Agreeableness

This personality factor has been linked to characteristics such as altruism, cooperativeness, nurturance, caring, and emotional support (Judge, et al., 1999; McCrae & John, 1992). Agreeable individuals trust others very easily which implies that they are less likely than individuals low in agreeableness to check the plausibility of every piece of information they are provided with. Thus, a high degree of agreeableness in a team may increase the assumed superiority of correct over partly incorrect information.

Proposition 7a: Team members' extent of agreeableness moderates the effect of information quality (correct vs. partly incorrect information) on (7aa) effectiveness and (7ab) efficiency in that the superiority of settings including entirely correct information over settings including partly incorrect information (see Proposition 1a) is more expressed for teams with high levels of agreeableness than for those with low agreeableness.

Agreeable individuals tend to easily agree to collective remuneration that distributes both rewards and risks equally among the participants whereas individuals low in agreeableness more strongly favor remuneration according to individual contributions to the team performance.

Proposition 7b: Team members' extent of agreeableness moderates the effect of remuneration structure (collective vs. individual) on (7ba) effectiveness and (7bb) efficiency in that the superiority of collective over individual remuneration (see Proposition 2) is more expressed for teams with high levels of agreeableness than for those with low agreeableness.

Openness to experience

This personality factor is characterized by intellectance and unconventionality, and individuals high in openness are described as imaginative, autonomous, and nonconforming (Judge, et al., 1999; McCrae & John, 1992). This implies that these individuals may not easily comply to traditional organizational structures of hierarchy. Thus, openness is hypothesized to increase the potential superiority of edge over hierarchical organizations.

Proposition 8a: Team members' extent of openness moderates the effect of organization structure (edge vs. hierarchy) on (8aa) effectiveness and (8ab) efficiency in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with high levels of openness to experience than for those with low openness to experience.

Moreover, individuals high in openness may find it easier to deal not only with new, but also unexpected, and perhaps incorrect, information. Openness may thus reduce the potential superiority of correct over partly incorrect information.

Proposition 8b: Team members' extent of openness moderates the effects of information quality (correct vs. partly incorrect information) on (8ba)

effectiveness and (8bb) efficiency in that the superiority of settings including entirely correct information over settings including partly incorrect information (see Proposition 2) is more expressed for teams with low levels of openness to experience than for those with high openness to experience.

Conscientiousness

This factor manifests in achievement orientation, dependability, and orderliness. Conscientious individuals are characterized as hardworking, persistent, responsible, careful, planful, and organized (Judge, et al., 1999). The diligence associated with this factor may enable high effectiveness when a large body of information is available. Thus, conscientiousness may enhance the potential superiority of edge over hierarchy when team performance is measured in terms of effectiveness. However, high diligence can often be enacted only at the cost of time. It thus appears plausible that, when performance is measured in terms of efficiency, conscientiousness may lead to substantial time consumption, so that it may be negatively associated with a potential superiority of edge over hierarchy.

Proposition 9a: Team members' extent of conscientiousness moderates the effect of organization structure (edge vs. hierarchy) on (9aa) effectiveness in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with high levels of conscientiousness than for those with low conscientiousness; (9ab) efficiency in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with low levels of conscientiousness than for those with high conscientiousness.

Conscientious individuals may also identify incorrect information more easily due to thorough analysis of the information. Thus, conscientiousness may decrease the potential superiority of correct over partly incorrect information. Again, this seems to apply to effectiveness whereas it may work in the opposite direction for efficiency.

Proposition 9b: Team members' extent of conscientiousness moderates the effect of information quality (correct vs. partly incorrect information) on (9ba) effectiveness in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with low levels of conscientiousness than for those with high conscientiousness; (9bb) efficiency in that the superiority of edge organizations over hierarchical organizations (see Proposition 1a) is more expressed for teams with high levels of conscientiousness than for those with low conscientiousness.

Trust

Trust in a team may be defined as the belief that an "individual or group (a) makes good-faith efforts to behave in accordance with any commitments both explicit and implicit, (b) is honest in whatever negotiations preceded such commitments and (c) does not take excessive advantage of another even when the opportunity is available" (Cummings &

Bromley, 1996; see also Mayer, et al., 1995). In virtual teams, trust is argued to be rooted in perceptions of teammates' abilities, benevolence, and integrity (Jarvenpaa & Leidner, 1999), following Mayer et al. (1995). The level of trust has been shown to be positively correlated with the willingness to information transfer among individuals, and with team effectiveness (Paul & McDaniel, 2004; Meyerson, et al., 1996; Newell & Swan, 2000; Ring, 1996).

Proposition 10a: Trust between team members moderates the effects of organization structure (edge vs. hierarchy) on team (10aa) effectiveness and (10ab) efficiency in that the advantage of edge organizations over hierarchical organizations decreases with higher levels of trust.

Proposition 10b: Trust between team members moderates the effects of information quality (correct vs. incorrect) on team (10ba) effectiveness and (10bb) efficiency in that the advantage of settings with correct information over settings with partly incorrect information decreases with higher levels of trust..

Proposition 10c: Trust between team members moderates the effects of remuneration structure (collective vs. individual) on team (10ca) effectiveness and (10cb) efficiency in that the advantage of settings with collective reward over settings with individual reward decreases with higher levels of trust.

Initial trust is often surprisingly high in teams (McKnight, et al., 1998) and deteriorates in the process of collaboration (Piccole & Ives, 2003). Reneging and vigilance of teams correlate with the loss of trust, behavior controls increase vigilance, and the perception of benevolence of team members positively correlates with the development of trust in team work (ibid.). Initial trust is determined by the disposition to trust, institution-based trust, and is influenced by cognitive processes. The behavior control mechanisms that are typical for controlling virtual teams, a team's level of vigilance, and the levels of initial trust influence a team's trust level and hereby its effectiveness and efficiency. Trust and team performance are found to be related as (initial) trust positively influences the willingness to interact and thus team performance, and as further trust is built through collaboration (Paul & McDaniel, 2004; Piccole & Ives, 2003).

Hierarchies seem to provide more stability, and thus the initial trust level in hierarchies is higher than in edge organizations. Hierarchies have more predefined behavior controls, and thus the loss of trust in the process of collaboration is expected to be larger in hierarchical organizations than in edge organizations. It is assumed that although teams may have high initial trust levels they may experience loss of trust in the process of collaboration. Based on this, it is assumed that the loss of trust is higher in hierarchical organizations than in edge organizations.

Proposition 10d: Hierarchical organizations experience a more unfavorable change in the level of interpersonal trust in the process of collaboration than edge organizations.

Reciprocity

Strong reciprocity is a predisposition to cooperate with others, and to punish (at personal cost, if necessary) those who violate the norms of cooperation, even when it is implausible to expect that these costs will be recovered at a later occasion (Gintis, et al., 2005). Strong reciprocity means to sacrifice resources in order to be kind to those who are being kind (strong positive reciprocity), and to punish those who are being unkind (Fehr, et al., 2000). Reciprocity is positively correlated with team performance as residual claimancy by team members can provide sufficient incentives for mutual monitoring, and thus support high levels of team performance (Carpenter, et al., 2007). The option of punishment makes team members contribute more consistently over a longer period of time (Gintis, et al., 2005). Strong reciprocity is norm-driven and – in contrast to altruism – not output-oriented (Carpenter, et al., 2007).

Proposition 11a: Reciprocity between team members moderates the effects of organization structure (edge vs. hierarchy) on team (11aa) effectiveness and (11ab) efficiency in that the advantage of edge organizations over hierarchical organizations decreases with higher levels of reciprocity.

Proposition 11b: Reciprocity between team members moderates the effects of information quality (correct vs. incorrect) on team (11ba) effectiveness and (11bb) efficiency in that the advantage of settings with correct information over settings with partly incorrect information decreases with higher reciprocity.

Proposition 11c: Reciprocity between team members moderates the effects of remuneration structure (collective vs. individual) on team (11ca) effectiveness and (11cb) efficiency in that the advantage of settings with collective reward over settings with individual reward decreases with higher reciprocity.

Altruism

An altruistic actor is unconditionally kind, i.e. the kindness of their behavior does not depend on other actors' behaviors. Altruism is thus tantamount to *unconditional* kindness (Fehr, et al., 2000). Altruism is output-oriented as the objective of altruistic behavior is to benefit another actor. Altruism is related to the notion of benevolence and helps to build social capital within a team or across teams. Benevolence and social capital are positively correlated with team performance (McKnight, et al. 1998, Dannecker & Lechner, 2007). With regard to moderating effects of altruism on the relation between the assumed independent variables and team performance it is suggested:

Proposition 12a: Altruism between team members moderates the effects of organization structure (edge vs. hierarchy) on team (12aa) effectiveness and (12ab) efficiency in that the advantage of edge organizations over hierarchical organizations decreases with higher levels of altruism.

Proposition 12b: Altruism between team members moderates the effects of information quality (correct vs. incorrect) on team (12ba) effectiveness and (12bb) efficiency in that the advantage of settings with correct information over settings with partly incorrect information decreases with higher altruism.

Proposition 12c: Altruism between team members moderates the effects of remuneration structure (collective vs. individual) on team (12ca) effectiveness and (12cb) efficiency in that the advantage of settings with collective reward over settings with individual reward decreases with higher levels of altruism.

Cohesiveness

Research has repeatedly shown positive effects of cohesiveness on team performance (Carless & De Paola, 2000; Carron, et al., 1998; Chang & Bordia, 2001; Cohen & Bailey, 1997). However, a distinction is often made between task-related and social cohesion since these phenomena may exert somewhat different influences on teams (Wellens, 1993). Social cohesion refers to the relationships between the team members and allows team members to enjoy working with each other and to be positive about coming back to work with their original team on a different task in the future (Chang & Bordia, 2001). Task cohesion is a more fact-oriented facet of cohesion and most notably implies a strong commitment of the team members to a shared goal (Carless & De Paola, 2000). Since both facets of cohesion appear to positively influence team performance it may also be observable that a high level of cohesion can somewhat mitigate the influence of factors that tend to make excellent team performance difficult. It is thus hypothesized that a potential superiority of edge over hierarchy may decrease if cohesion is high.

Proposition 13a: Task cohesion moderates the effects of organization structure (edge vs. hierarchy) on team (13aa) effectiveness and (13ab) efficiency in that the advantage of edge organizations over hierarchical organizations decreases with higher levels of task cohesion.

Proposition 14a: Social cohesion moderates the effects of organization structure (edge vs. hierarchy) on team (14aa) effectiveness and (14ab) efficiency in that the advantage of edge organizations over hierarchical organizations decreases with higher levels of social cohesion.

Similarly, cohesion may also mitigate the impeding conditions of partly incorrect information.

Proposition 13b: Task cohesion moderates the effect of information quality (correct vs. partly incorrect) on (13ba) effectiveness and (13bb) efficiency in that the advantage of settings with correct information over settings with partly incorrect information decreases with higher levels of task cohesion.

Proposition 14b: Social cohesion moderates the effect of information quality (correct vs. partly incorrect) on (14ba) effectiveness and (14bb) efficiency in that the advantage of settings with correct information over settings with partly incorrect information decreases with higher levels of social cohesion.

Finally, especially the cooperativeness and thus performance in teams with an individualized reward structure may benefit from a high level of cohesion. Task and social cohesion are hence hypothesized to decrease a potential advantage of collective over individual remuneration.

Proposition 13c: Task cohesion moderates the effect of remuneration structure (collective vs. individual) on (13ca) effectiveness and (13cb) efficiency in that the advantage of settings with collective reward over settings with individual reward decreases with higher levels of task cohesion.

Proposition 14c: Social cohesion moderates the effect of remuneration structure (collective vs. individual) on (14ca) effectiveness and (14cb) efficiency in that the advantage of settings with collective reward over settings with individual reward decreases with higher levels of social cohesion.

Research design

Our proposed research design focuses on the impact of C2 structures (edge vs. hierarchical organizations), the quality of the available information (correct vs. partly incorrect), and the utilized reward structure (collective vs. individual), as moderated by team member personality traits, team cohesion, trust, altruism and reciprocity. Figure 1 illustrates the research design, involving independent and dependent variables as well as the variables hypothesized to moderate the relationships between those.

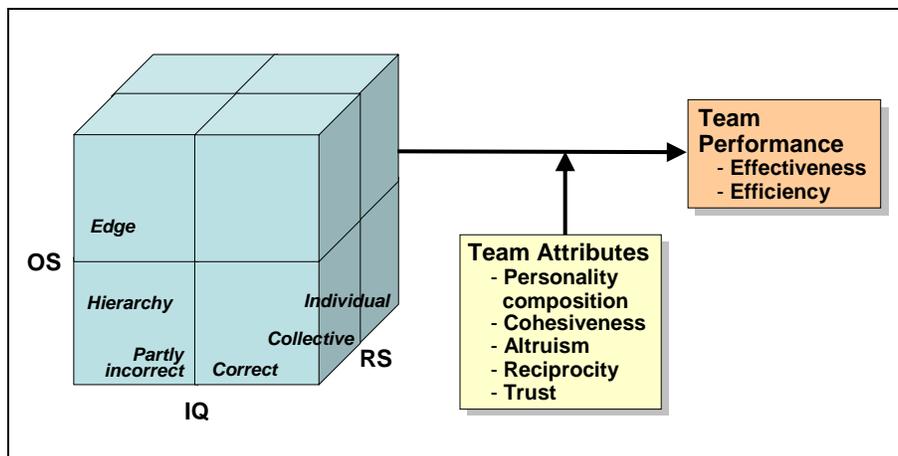


Figure 1. Hypothesized links between organizational structure (OS), information quality (IQ), reward structure (RS), team attributes, and team performance

Independent variables

It is planned to use a 2 x 2 x 2 experimental design to create eight experimental conditions. The three dimensions and their parameter values are as follows:

- Organizational structure: Hierarchical organization, edge organization;
- Information quality: Entirely correct vs. partly incorrect information;
- Reward structure: Collective vs. individual remuneration.

The different organizational structures (hierarchy vs. edge) will be operationalized by the experimental platform ELICIT (“Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust”) that has previously been used to assess team performance (Leweling & Nissen, 2007; MacKinnon, et al., 2007). Information quality will be operationalized in the simulation games by providing either entirely correct or partly incorrect information. To operationalize reward structure, participants will be informed that they will receive performance rewards either based on their individual performance, or based on collective (team) performance.

Dependent variables

It is assumed that the distinct parameters realized as experimental conditions exert differential effects on team performance measured in terms of effectiveness and efficiency. The teamwork simulation tool ELICIT is used to measure team performance. It supports locally distributed work and allows for the assessment of the quality and nature of interactions in teams. In ELICIT, effectiveness can be operationalized as the total number of correct identifications, and efficiency as the quotient of the effectiveness score divided by the time required to complete the task, and/or by the total of posted factoids.

Moderating variables

Characteristics of team members and teams as a whole are assumed to moderate the effects of organizational structure, information quality and reward structure on team performance. Specifically, it is assumed that moderating effects will be found for team member personality, trust, altruism and reciprocity, as well as for team cohesion in terms of social and task cohesion.

Personality and team cohesion will be assessed using questionnaires. To measure the Big Five personality factors, the German version of the ‘NEO-PI-R’ (Ostendorf & Angleitner, 2003) will be used. NEO-PI-R stands for Neuroticism-Extraversion-Openness Personality Inventory. Social cohesion will be assessed using the scale presented by Karau and Hart (1998), and task cohesion will be measured with four items adopted from Carless and De Paola (2000). These cohesion scales have been previously utilized by Huber et al. (2007), with very satisfactory scale reliabilities (Cronbach Alpha) of .86 for task cohesion, and .81 for social cohesion.

Variations of the Ultimatum Game and the Dictator Game (Güth, et al., 1982) will be used to measure trust, reciprocity and altruism. In a variety of game settings, these games have been found to enable effective measurement of the degree of cooperation, selfish-

ness, altruism and reciprocity (Bearden, 2001) and the effects on power asymmetry, or the search for power, and the degree of altruism (Bosco & Marcheselli, 2006; Büchner, et al., 2004).

Control variables

Since age appears critical for adopting new procedures and ideas, older individuals may face greater difficulties in performing a shift from traditional, i.e., more hierarchical, to more recent, e.g., edge, organizational structure. Conversely, older individuals generally possess richer experience and may thus have fewer difficulties in detecting and adequately processing misleading, since incorrect, information.

Gender may influence the effect of collective versus individual remuneration. Research has shown that, compared to males, females exhibit more of a collectivist than individualist orientation. Men tend to favor individualistically driven competition more strongly than women. Thus, female team members may find it easier than male participants to accept a collective reward strategy and perform adequately under those conditions.

Cognitive ability, in particular reasoning abilities, may influence performance in the kind of task that will be used in the proposed research. Thus, reasoning ability is included in order to control for its potential effects on performance and will be measured using the verbal reasoning subscale of the cognitive ability inventory ‘IST 2000 R’ (Intelligence Structure Test 2000) (Amthauer, et al., 2000).

Experiment design

In the previous section the research design with the three dimensions and the variables has been introduced. In this section the experiment design with the two games and the suggested experimental procedure are described in more detail.

ELICIT

The team simulation is conducted using the multi-player game ELICIT (“Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust”; also see Ruddy, 2007). In ELICIT, a team comprises 17 players connected and interacting through a computer network. The team task is to identify four components of an anticipated adversary attack – who, when, where, and what – based on information facts, so-called ‘factoids’. These factoids vary in their relevance for the problem solution: Whereas 25% are key (K) factoids that provide substantial information concerning the right solution, and 25% can be viewed as (only) supportive (S), 50% are simply noise (N) and thus do not carry any information that could be useful for the solution of the problem.

The ELICIT community provides a number of scenarios for the simulation game. However, the current scenarios do not include any definitely false information. Thus, to test the effects of different conditions of information quality, i.e., entirely correct (yet still

partly irrelevant) information and partly incorrect information, additional sets of factoids will be developed that comprise true, irrelevant, and also false facts.

In the course of an ELICIT run, more specifically through three waves of information distribution, each of the 17 players is provided with four factoids that they may, but need not, share with specified others or all fellow team members. This can be done by posting a factoid to one of the four websites available for the four aspects (who, what, when, where) that have to be identified, or sending a factoid to a specified team member. Ideally, team members share those factoids that in some sense appear relevant for the team to finally identify the four aspects of the adversary attack. The game which is usually played without any time constraints ends as soon as each team member has identified each of the four required aspects. For each correct identification a predefined score may be assigned to the team. The current functionalities of ELICIT may be extended by providing players with tools to comment on the factoids they share with other players in the team.

The game can be played in two different organizational settings: 'Hierarchy' (H) and 'Edge' (E). These two collaboration structures that represent only two of the various types of organizational structures, such as functional, divisional, matrix, and others, are depicted in Figure 2. In the Edge setting, all players have equal rights and options to communicate with any of their fellow team members and to work on one, two, three, or all four aspects of the task. Hierarchy is characterized by labor division in that sub-groups of three players each are responsible for only one of the four aspects (who, when, where and what). Each of the three players may only post factoids on the subgroup's website or send factoids to the subgroup's leader. Each of the four subgroup leaders, in turn, may as well only post factoids on the subgroup's website, but may not only send factoids to the members of their subgroup, but also to the team leader. This person collects factoids posted on the four websites and received from the four subgroup leaders to finally identify the four aspects (who, what, when, and where).

It has to be noted that in the current setting the exchange of factoids is the only means to interact as there are no chat or message exchange services provided by ELICIT. Team effectiveness can be measured in terms of the number of correct identifications, and team efficiency may be calculated as the quotient of effectiveness and either the time consumed by a game, or the number of factoids exchanged by team members.

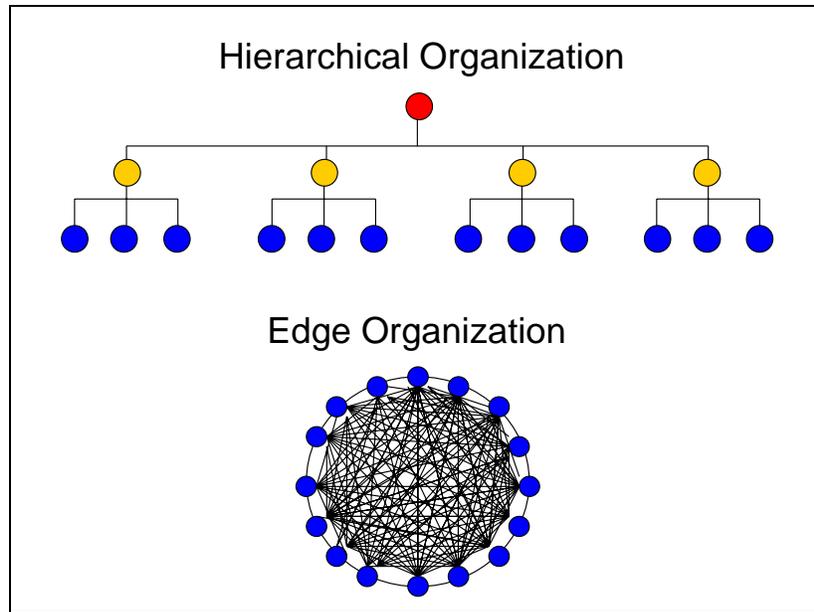


Figure 2. Organizational structures used in ELICIT

Ultimatum Game and Dictator Game

In the basic ultimatum bargaining game a predefined amount of monetary units (p) is divided among two players, P1 and P2, such that P1 (the allocator or proposer) proposes to give a specified share (x) to P2 (the receiver or acceptor), which means that he receives $p - x$ himself. P2 can then accept the offer, leading to p being split according to P1's proposal, or reject the proposal, in which case neither player gets anything (Bearden, 2001). Classical economic theory and game theory assume that agents are self-interested income maximizers. This would imply that P2 will accept any offer – since they would consider 'some piece of the pie' to be better than 'no piece of the pie'. Findings obtained from utilization of the Ultimatum game demonstrate that the protagonists' behaviors are influenced by culture, reciprocity, anger, fairness perceptions, and many other soft factors (for an overview see, e. g., Bearden, 2001).

The Dictator Game is a variant of the Ultimatum Game. In the dictator game, the proposer determines an allocation (split) of the amount of monetary units (such as a cash prize). The responder simply receives the remainder of the endowment which the proposer has not allocated to himself. The differences between allocation in the Ultimatum Game and Dictator Game illustrate the fairness and altruism of the allocator rather than reciprocity – as is the case in the Ultimatum Game (Eckel & Grossman, 1996).

The offer in the Dictator Game is higher when the receiver is perceived to be worthwhile. If the receiver is an established charity the donations is three times as high as in the 'base' case when the receiver is some (anonymous) student (Eckel & Grossman, 1996). The offer in a Dictator game is influenced by the performance of a receiver in some interaction preceding the Dictator Game. The offer is positively correlated with the effort of the receiver while punishment of allocators for recipients that underperformed in the pre-

ceding interaction is relatively mild (Ruffle, 1998). There is also evidence in the Ultimatum that the receiver's trustworthiness influences the allocation (Ruffle, 1998; Büchner, et al., 2004). Furthermore, the cultural dimensions individualism and power distance may influence both the allocator's and the receiver's behaviors. Oosterbeek, et al. (2003) hypothesize that individualism has negative effects on proposers' offers and that power distance, i.e., respect for authority, has a negative effect on responders' rejection rates and on proposers' offers. Finally, groups appear to act more rationally than individuals both in the roles of the allocator and the acceptor: They offer less and accept smaller offers than individual players (Bornstein & Yaniv, 1998).

Sample and measurement procedure

After the individual participants have completed the personality questionnaire each team plays a test run and two experimental runs of ELICIT. For the first and the second experimental run, the eight experimental conditions will be systematically varied, respectively kept the same, resulting in ten run1-run2-orders (experimental conditions) each of which will be played by at least two teams (see Table 1). Note that 'incorrect' means that a number of the factoids, but not all of them, are replaced by factoids carrying incorrect information. In order to obtain a reasonable sample size for each of the game variants, the number of variants needs to be reduced to those that appear most relevant. It is proposed to focus on 10 experimental conditions as listed in Table 1 and to involve 2 teams, each consisting of 17 individuals, in each of the 10 conditions.

	<i>1st run</i>			<i>2nd run</i>			
<i>Game</i>	<i>Organization Structure</i>	<i>Information Quality</i>	<i>Reward Structure</i>	<i>Organization Structure</i>	<i>Information Quality</i>	<i>Reward Structure</i>	<i>Change</i>
1	Edge	Correct	Individual	Hierarchy	Correct	Individual	E -> H
2	Edge	Correct	Collective	Hierarchy	Correct	Collective	E -> H
3	Hierarchy	Incorrect	Collective	Hierarchy	Incorrect	Collective	-
4	Hierarchy	Incorrect	Individual	Hierarchy	Incorrect	Individual	-
5	Edge	Incorrect	Collective	Edge	Incorrect	Collective	-
6	Edge	Incorrect	Individual	Edge	Incorrect	Individual	-
7	Hierarchy	Incorrect	Collective	Edge	Incorrect	Collective	H -> E
8	Hierarchy	Incorrect	Individual	Edge	Incorrect	Individual	H -> E
9	Edge	Incorrect	Collective	Hierarchy	Incorrect	Collective	E -> H
10	Edge	Incorrect	Individual	Hierarchy	Incorrect	Individual	E -> H

Notes: 'Game': Number of experiment setting, 'Change': change from run 1 to run 2

Table 1. Proposed gaming procedure

The focus is on conditions with partly incorrect rather than correct information for three reasons. First, a scenario with partly incorrect information better reflects scenarios in the real world scenarios. Second, partly incorrect information has not been considered in the ELICIT context so far. Third, and most importantly, it is assumed that incorrect information will increase the need for team interaction which in turn may make the differences between the effects of the experimental conditions on team performance more salient. Nevertheless, two ‘comparison basis’ games (Game 1 and 2) will be played with a scenario consisting of correct factoids only, to relate the results to those obtained by previous studies (e.g., Leweling & Nissen, 2007).

It is planned that at least two teams play each of the ten selected combinations of the 2x2x2 design, each team consisting of 17 individuals. Note that the experimental design is focused on the differences between performance in run 1 and run 2 in addition to absolute values. This reduces the dependency of the research results on the variations of the team members’ personalities and the need for a vast number of teams and team participants. Furthermore, this procedure allows for the assessment of performance increases or declines as experimental conditions change, respectively of learning effects, as experimental conditions remain the same.

It is proposed to proceed in the experiments as follows.

1. Measurement of personality factors, trust, reciprocity, and altruism by means of questionnaire;
2. Introductory briefing into ELICIT and assignments in regard to the reward structure (individual vs. collective) that will be employed;
3. Conduct of a training game with ELICIT and two ELICIT runs, each run being followed by an Ultimatum or a Dictator Game to assess trust, altruism and reciprocity; and,
4. Measurement of team cohesiveness by means of a questionnaire.

The link between individual and collective remuneration, ELICIT and the Ultimatum Game, respectively Dictator Game, is as follows:.

Teams playing under the condition of collective reward structure obtain an amount of money depending on their performance in an ELICIT run. This amount is split up such that 9 of the 17 the team players play the role of the proposer and the others the role of receiver according to the Ultimatum Game or Dictator Game. The players are randomly assigned whether they play Ultimatum or Dictator game and their roles in the Ultimatum and Dictator Game (one of the acceptors has to play this role twice).

When team players play under the condition of individual remuneration they all play the Ultimatum or the Dictator Game as the one that shares the pie (proposer) and as receiver such that each individual remuneration is to be shared with the team. The amount of money they receive depends on individual performance and the team performance in the ELICIT run before playing Ultimatum or Dictator Game. Again it is randomly assigned who is playing Ultimatum and who is playing Dictator game.

It is suggested to conduct qualitative analyses of records of interactions between team members to support the evolution of deep-level understanding of team processes.

Anticipated results and practical implications

The results of the research are expected to enrich our current understanding of relations between individual, organizational structures (such as edge and hierarchy), team building, robustness of teams vis-à-vis incorrect information, reward structure, team processes, and collaborative decision-making.

The limitations of the proposed research design are the ones that apply to all experimental designs: the transferability from the game setting to real world scenarios need to be discussed. The questionnaires to measure personality structure and attitudes are mostly standardized and well established. For ELICIT and the Ultimatum or Dictator Games research results exist to validate the outcomes of this study. Factors that have an impact both on the outcomes of the ELICIT and the Ultimatum or Dictator Game are the participants' familiarity with computer-supported collaboration, team cohesion, and in particular the authority assigned to the experimenters by the participants. Note that the research design can be extended to cover phenomena such as organizational learning, or to additionally analyze effects of different personality characteristics and attitudes.

Organizations of all kinds used to work in hierarchical modes and organizations are being redesigned in order to react more adequately and faster to external triggers. Flat or edge-like organizations or team-oriented work are typical modern organizational designs. Armed forces as well as companies adopt such organizational designs. Hierarchies, however, have developed an understanding of which individual characteristics and procedures enhance the capability to deal with ambiguous situations and incorrect information, and which effects reward structures have on individual, team and organizational performance. New information technology infrastructures for team collaboration or for decision support tend to require a redesign of organizational structure. Some of the questions that may be addressed by the implications obtained from the proposed research pertain to (a) whether these developments require new staffing strategies; (b) whether individual or collective reward structures should be given priority; (c) whether individual performance of, e.g., highly conscientious individuals, depends on organizational structure (hierarchical vs. edge organization); (d) whether extraversion generally benefits team performance; (e) whether robustness toward ambiguity depends on organization structure; (f) whether ambiguity tolerance is more important in edge than in hierarchical organizations; (g) whether one or more of the eight experimental designs used in the study particularly facilitate team performance and/or team cohesion; or (h) which organizational structure tends to enhance team cohesion when a team is confronted with incorrect information. Answers to these and further questions are expected to be identifiable based on the results of the proposed study. Specifically, the results of the proposed study are expected to allow drawing practical implications as to which individual characteristics may be particularly relevant in the process of personnel selection, how teams should be staffed, and how team members should be trained, depending on their individual characteristics, to collaborate most effectively given the organizational structures to be utilized to accomplish

particular tasks. The results should inform long-term personnel development strategies, and, even more fundamentally, contribute to the development of a new C2 culture and policy for meeting the challenges of the complex endeavors of the 21st century.

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